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Biomedical Science Education

A Clear and Present Trust: Distance Learning Assessment and the Academia Perspective

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Abstract

Higher Education systems are currently experiencing a new challenge as distance learning through the internet seems to attract the interest of worldwide prospective students. The Massive Open Online Courses (MOOCs) are the frontrunners of this online massive approach to formal education but a concern that is present, endangering their success, is the reliability of assessment and grading of such courses. This affects the interest and motivation of the students on such educational systems when they have education as the leitmotif for a profession. As society widely accepts orthodox Academia as the paradigm of sound assessment, especially regarding professional areas such as Medicine or Engineering, the perspective of the Academia should influence the societal trust on the online grading methodologies. A recent study explored the general perception of orthodox Academia regarding the most common online grading methodologies used in MOOCs and the 'comfort zone' of including such methodologies on orthodox courses. Departing from those results, this work explores how trustworthy those online methodologies are to Medical and Biomedical Professors from orthodox Academia, in which circumstances would they be willing to use such methods and the constraints they consider mandatory in order to assure the soundness of evaluation of their students, the recognition of the institution as valid evaluator, and the social acceptance of future medical and biomedical professionals.

Keywords: Distance learning; Online grading; Academic assessment; Medicine; Biomedicine

1. Introduction

Massive distance educational approaches meet several factors of resistance but unequivocally one of them is the suspicion that society, namely employers, and students themselves have regarding their reliability and prestige. Employers want to be reassured that the professionals resulting from Higher Education Institutions are indeed an asset and the students want guarantees that the diploma is worth the money and time spent on social and professional terms. There are extremely interesting and recent studies regarding the evolution and integration of online and/or distance learning methodologies within orthodox academia on near future [1].

However, the future risks never to go further than the present if all parts are not pledged to recognize excellence on the provided educational path.

At the core of this distrust, one finds the online grading methodologies. Distance learning, within an online context, has specific grading and assessment methodologies, namely when considering the fields of Sciences and Engineering, such as peer-review essays (*i.e.*, a themed essay evaluated by the peer students, through grading parameters given by the professor), peer-review tasks (*i.e.*, presenting solution to given problems, such as the elaboration of a medical protocol for a new therapeutics), or multiple-choice quizzes with limited duration time, similar to the analogous assessment tool but online [2].

As orthodox Academia has the respect and trust of both students and employers, it is a reasonable premise to consider that if orthodox academic courses incorporated one, or more, online grading methodologies that would demonstrate that classic Academia finds such methodologies as reliable. Thus, the answer to understanding if an online grading methodology is trustworthy at the eyes of society lies on the perspective that academic professors have regarding it and, in fact, there is already published work on the subject [3].

Following the above mentioned preliminary study regarding the perspective of orthodox Academia on online grading methodologies, this work aims at understanding how professors from the Medical and Biomedical fields perceive the matter, what is their opinion regarding the clash of these methodologies with soft skills assessment and practical hard skills, and their openness to the inclusion of such methodologies on orthodox courses. The choice of beginning with Medical and Biomedical professors, after the preliminary general inquiry, to analyze the perception of Academia on this matter is not fortuitous. These are two fields that affect deeply and intimately everyone and upon which the trust of society and employers is more bestowed.

2. Material and methods

Departing from the survey entitled *MOOCs and Evaluation: the POV of Professors*, a new survey entitled *Medical/Biomedical Education and Distance* Learning was developed and conducted using Google Surveys (2018) [3]. This survey was delivered directly to the institutional emails of Medical and Biomedical professors of several Higher Education institutions, through the indication of academic intermediates (*vide* acknowledgments). The survey had three main sections. The first regarded the personal and professional details of the professor, the second explored the perspective of the academic regarding the online assessment of soft and hard skills, using after each term a definition to avoid ambiguation (for example, the soft skill *communication* was defined as ‘efficient capacity to communicate with patients and colleagues, within medical ethics and with sensitivity’), and a third and final section concerning the ‘comfort zone’ of Academia respecting the inclusion of effective online grading percentage, *i.e.,* the maximum percentage accepted from an online methodology on orthodox courses final grade.

However, it was noticed a high reluctance of the academics to respond to the inquiry and, as such, attempts were made to understand this apathetic attitude. As it was indicated that some felt the need to expand and explain their opinion beyond the parameters of the inquiry, thus manifesting an uneasiness in doing the survey, a second research stage of personal interviews was added to the methodologies.

These interviews were made through email, and all interviewed professors had the same questionnaire. The specifics of the sample details, as well as the main results of the inquiry, are depicted in Figure 1. Table 1 presents a summary of the interviews conducted to three academics on three different stages of the professional path. Both will be discussed in the following section.

3. Results and discussion

This section is divided into two subsections, one pertaining the survey results and the other the data collected from the interviews.

3.1 Inquiry results: biomedicine versus *medicine points of view*

As depicted in Figure 1, the sample of thirteen individuals included academics from both Medical and Biomedical areas of expertise (30,8%, though belonging to the Medical/Biomedical context, did not choose one of the specifics areas of expertise indicated on the inquiry), with almost two thirds between 30 to 49 years, and the majority is Portuguese born. Almost half of the questionees has between 11 to 20 years as a teacher on Higher Education institutions, and most are from public Universities (76,9%).

Multiple choice quizzes with limited time duration are the single most chosen online grading methodology (38,5%), but it comes second to the preferred solution of the majority, a combination of peer-review essays, peer-review tasks and multiple choice quizzes with limited time (53,8%). The major reason indicated for these choices was that the methodologies were reasonably adequate, either online or on classical evaluation.

Five soft skills were proposed to indication of how adequate online assessment fitted their evaluation: Communication, already defined above; Commitment, *i.e.*, emotional disponibility for a project or mission; Stress management, *i.e.*, capacity to manage time and optimism during heavy demands; Problem-solving, *i.e.,* ability to apply analytical and emotional thinking in approaching new situations; and Autonomy, *i.e.*, ability to monitor own pace of work and assume responsibility for decisions. Problem solving and Communication were considered adequate to these online grading methodologies by the majority. Communication also was the soft skill considered more important while Stress management was considered the least important of the five proposed soft skills.

Also five hard skills were proposed to find how the academics regarded the adequacy of online grading methodologies to their evaluation: Pharmacology, *i.e.,* the scientific knowledge of drugs including their origin, composition, pharmacokinetics, therapeutic use, and toxicology; Anatomy, *i.e.*, the scientific knowledge of the human bodily structure of humans; Psychology, *i.e.,* the scientific knowledge of the human mind and its functions in several contexts; History of Medicine, *i.e.,* the scientific knowledge of the evolution of social perception and attitudes regarding illness and disease; and Surgery, *i.e.,* the scientific knowledge of treating bodily injuries or disorders by incision or manipulation. Only Psychology and Surgery were considered unfitted to online grading, being Surgery the most important and History of Medicine the least important hard skill, according to the point of view of the surveyed professors.

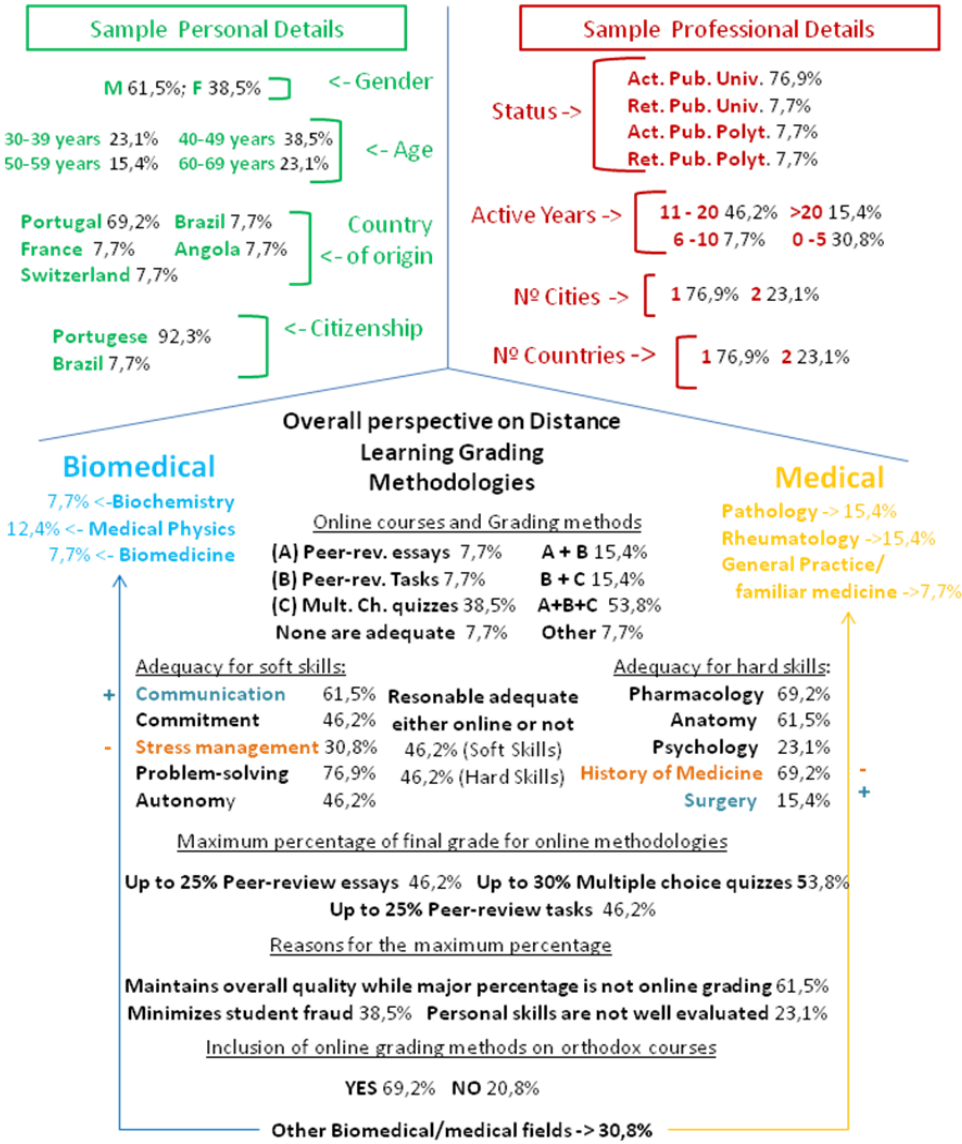

Fig. 1. Summary of the survey, divided into three parts, Sample Personal Details, Sample Professional Details and Overall Perspectives on Distance Learning Grading methodologies.

Status/ Expertise	**Guest junior lecturer/ Biochemistry and Environmental Health**	**Professor with aggregation/ Medicinal Chemistry**	**Retired Professor/ Rheumatology**
General opinion regarding online assessment	Programs and grading methods should be more versatile; Inclusion of online and other new grading methods	The inclusion should depend on the course unit, number of enrolled students and scholarly success	It is inevitable, at the present moment
Reliability: online *versus* non-online multiple choice quizzes	It is not measurable; if the evaluated skills and methodologies become more versatile, the question will be redundant	n/a	Personal interaction is different. Possibility: through remote video camera
Courses for which online assessment is unacceptable	In small classes, laboratory assessment does not need online methodologies	n/a	Units which require the presence of the patient, such as surgery
Online grading of soft skills	Some, as online research or forum debates, can only be evaluated online.Online and face to face soft skill grading should be complementary	Forum debate; Accountability and enthusiasm on tasks; More active role on the learning process	Soft skills cannot be evaluated in such a “remote” manner
Mandatory aspects to be studied before including online methodologies	Assess countermeasures against exam fraud; Assure internet access so that socioeconomic conditions are not a discriminator factor; Student circadian rhythms (could be personalized)	Assess the danger of poorer student-teacher and student/ student relationship; Estrangement of the student regarding the Institution; If the students rhythm are respected; student overload;	n/a
Inclusion of online grading on courses	Theoretical units would not need much adjustment, only experimental (hands-on) units	n/a	Rheumatology (and other units) is not feasible for online grading

Table 1. Summary of the interviews to Higher Education professors in medical and biomedical fields. Note: n/a signifies ‘no answer’.

Finally, two thirds would include online methodologies on their courses, though on average, near half of the questionees would establish up to 25% as the maximum percentage of the final grade for online methodologies, whether they were peer-review essays, peer-review tasks or multiple quizzes. The main reason to do so is the concern regarding the overall quality of the course, and, as such, the major percentage would still come from non-online grading.

3.2 Interviews: analysis per professional experience

The interviews explore not only three types of professional but the scope of biomedical fields of expertise, as the professional status of the academics ranged from a guest junior lecturer to professor with aggregation and a retired professor, while the fields of expertise were respectively biochemistry and Environmental Health, Medicinal Chemistry and Rheumatology.

In accordance with the survey results, there is a concern with the evaluation of the soft skills with online grading methodologies, but while the retired professor considers that it is not possible to evaluate such skills in a 'remote manner', the guest junior lecturer defends that inclusion of more versatile grading methodologies, online and/or otherwise, would not only make it possible but would make worries about student fraud redundant. Nevertheless, two of the academics recognize that some soft skills are only able to be evaluated through online methodologies, such as the communication capacity on online forum debates.

Concern was manifested that the inclusion of online grading methodologies would not take in consideration the circadian rhythms of the students, would diminish the human component on the pedagogical process (between student/student and/or student/professor) and even could cause socio-economic discrimination between students if equality conditions were not assured.

4. Conclusions and future perspectives

There is reasonable disposition to include online grading methodologies on orthodox Medical and Biomedical courses as long as two cumulative aspects are taken into consideration: (1) the maximum percentage of online grading does not exceed 25% of final evaluation; and (2) the course presents a more 'hard skill' nature, *i.e.,* a more quantifiable essence. The human interaction of the pedagogical process also needs to be studied further, not only to allow fairness on the student development but also to diminish the concerns of the academics regarding grading online methodologies. Finally, more versatile methods, that prove to maintain assessment quality while minimizing student examination fraud, are unquestionably one of the research avenues to be constructed during the process.

Acknowledgements

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Chemistry Teaching Methods

An Interdisciplinary Investigation into Complex Systems

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Abstract

In the last three hundred years or so, the scientific knowledge has allowed an outstanding technological development. Despite many efforts, there are still compelling challenges that must be won. We are unable to predict catastrophic events, such as earthquakes and volcanic eruptions. We struggle to avoid climate change and the warming of the Earth. We should exploit the energy and food resources without deteriorating the stability of the ecosystems and their biodiversity. There are still incurable diseases that must be defeated. We strive to predict the economic and financial crisis. Moreover, we would like to guarantee stability in our societies. Whenever we tackle such challenges, we deal with Complex Systems, which are the geology and the climate of the Earth; the ecosystems; the living beings, particularly, the human immune system and nervous system; the global economy and the human societies. In order to prepare the new generations of students to be ready to tackle the challenges that regard the Complex Systems, I have written a book titled "Untangling Complex Systems: A Grand Challenge for Science." This book is an account of a marvelous interdisciplinary journey I have made to understand the properties of the Complex Systems. I have undertaken my trip, equipped with the fundamental principles of physical chemistry, especially, the Second Law of Thermodynamics that describes the spontaneous evolution of our universe, and the tools of Non-linear dynamics. By dealing with many disciplines, in particular, chemistry, biology, physics, economy, and philosophy, I show that Complex Systems are intertwined networks, working in out-of-equilibrium conditions, which exhibit emergent properties, such as self-organization phenomena and chaotic behaviors in time and space. It is not possible to describe Complex Systems accurately from their ultimate constituents (i.e., atoms and molecules) due to computational reasons. Therefore, it is necessary to develop models. In my book, I propose the interdisciplinary research line of Natural Computing as a promising strategy to comprehend Complex Systems and win the challenges that humankind is facing.

Keywords: Complexity, Interdisciplinarity, Self-Organization, Chaos, Fractals, Natural Computing

1. Introduction

Two universal forces drive humanity to inquire into nature and gather rigorous and reproducible information about natural laws. The first one is the desire of satisfying our "epistemic curiosity" by trying to answer the question "Which is the origin of the beauty in nature?". The second one is the will of improving the psychophysical well-being of humans by solving practical problems. In fact, scientific knowledge has always promoted the technological development, and the purpose of technology is that of improving human well-being. Science and technology interact mutually through positive feedback actions (see Figure 1). To have an idea of how far science and technology have arrived, it suffices to say that, nowadays, we can observe astronomical events that take place billions of light-years far from the Earth and we can send robots in other planets of the Solar System, such as Mars. At the same time, we can detect atoms and subatomic particles; we can manipulate matter at the molecular level and engineer the DNA of the living cells.

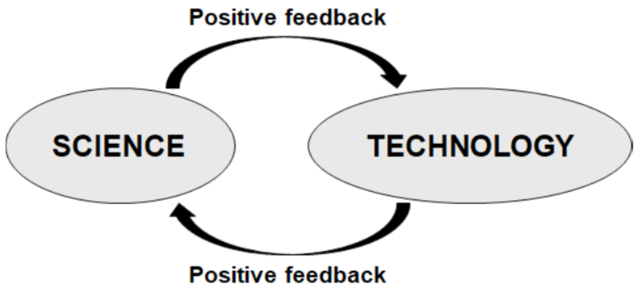

Fig. 1. Mutual positive feedback action between science and technology

Despite many efforts, there are still challenges that must be won. We are unable to predict catastrophic events on Earth, such as earthquakes and volcanic eruptions.

We struggle to avoid the warming of our planet. We want to exploit the energy and food resources without deteriorating the stability of the natural ecosystems and their biodiversity. There are still incurable diseases. We want to eradicate poverty from the Earth. We dream of predicting and avoiding the economic and financial crisis. We hope to guarantee justice and stability in our societies. Whenever we tackle one of these challenges, we deal with Complex Systems, such as the geology and the climate of the Earth; its ecosystems; the living beings, in particular, the human immune and nervous systems; the macro-economy, and the human societies. All these systems are so diverse from each other. However, they are all named as Complex Systems because they share some common features [1].

2. The properties of Complex Systems

Every Complex System is (I) a network that works in out-of-equilibrium conditions, (II) exhibits emergent properties, and (III) its behavior cannot be predicted, especially in the long term [1]. Any Complex System involves either inanimate matter or living beings or both.

2.1 Networks in out-of-equilibrium conditions

A Complex System is composed of many constituents, which often are diverse, if not unique. These constituents are strongly interconnected. Therefore, a Complex System can be described as a network. Such natural networks are maintained far from the condition of thermodynamic equilibrium by external and/or internal gradients of intensive variables, such as temperature, pressure, concentrations of chemicals, et cetera. Complex Systems that involve only inanimate matter are driven by force fields.

On the other hand, the behavior of a Complex System that includes living beings is information-based. In fact, a peculiarity of the living beings is that of exploiting matter and energy to encode, process, store, and communicate information.

2.2 Emergent properties

Complex Systems exhibit emergent properties. A property is emergent when it cannot be predicted even though we know all the characteristics of the elements of the system. The integration of the elements of a network originates properties that belong to the whole. The whole is more than the sum of its parts, as alleged by Aristotle. An example of an emergent property is the power of Complex Systems to self-organize in time and originate periodic processes. For example, a living being is like a house with clocks in every room and every corner, yet in one way or another, these chemical clocks synchronize. If we consider a single cell, we find some signaling, genetic, and metabolic processes that are periodic and strongly interconnected. These interconnections originate cyclic processes at the organ and physiological levels.

Many of these processes show circadian rhythms because they synchronize with the day and night cycle. Spontaneous periodic processes can also be encountered within an ecosystem. For instance, the relationship between predators and preys [2].

When the number of preys is high, the number of predators increases. If predators become too abundant, the number of preys start to decay. When the number of preys is too low, also the predators decrease. As soon as the predators are just a few, the number of preys start to regrow (see Fig. 2), and so on, cyclically.

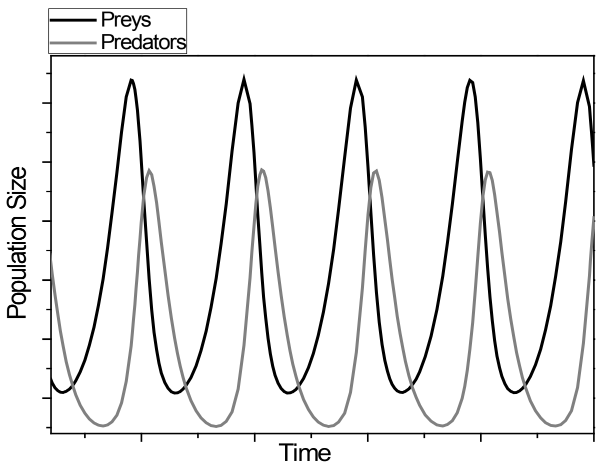

Fig. 2. Time evolution of the number of preys (black trace) and predators (grey trace).

We can find periodic processes also in economy. The business cycles are the spontaneous periodic variations of the GDP of a nation, which, after the phase of growth and the peak, always shows the phases of recession, depression, and recovery, in a cyclic manner [3]. Phenomena of temporal self-organization can also be discovered in a chemical laboratory [4].

Complex Systems can also exhibit the emergent property of spatial self-organization. An example is the formation of chemical waves [4, 1]. A chemical wave is the propagation of an autocatalytic reaction in an excitable medium. An example is fire. The fire is autocatalytic because the high temperatures that are reached in a fire feed the fire itself. The fire propagates in any space where there is fuel. In contrast with a physical wave, a chemical wave is not reflected because it crosses the same space only when fuel is somehow regenerated. A chemical wave goes through the same place only after a refractory period, required to regenerate fuel. For the same reason, when two chemical waves collide, they annihilate. Beautiful colored chemical waves can be observed in a chemical laboratory. Electrochemical waves propagate through the axons of the neurons. Electrochemical and mechanical waves propagate through the tissues of our hearts. They are responsible for the function of the heart as a pump. Calcium waves are generated in an egg cell when it is fertilized; they trigger the embryogenesis. Chemical waves are used by micro-organisms to communicate; et cetera.

Another example of spatial self-organization is the formation of ordered structures, such as animal markings, phyllotaxis, embryo, and dunes, all known as Turing patterns. They derive from the spatial competition between an autocatalytic species and its inhibitor, having appreciably different diffusion coefficients.

A chaotic dynamic is another example of an emergent property. A dynamic is chaotic when it is aperiodic, extremely sensitive to the initial conditions, and hence unpredictable in the long term. There are quantitative parameters that allow us to distinguish a chaotic from a stochastic dynamic, such as a positive Lyapunov exponent and a fractal correlation dimension of the chaotic attractor (for more information see [1]). In fact, a peculiarity of any chaotic dynamic is that of generating fractals. A fractal is a self-similar geometric structure, whose dimension is not necessarily an integer [1].

2.3 Unpredictability

Another property of the Complex Systems is that their behavior cannot be predicted, especially in the long term. Why? There are three principal reasons. First, if we try to describe any Complex System from its ultimate constituents, *i.e.*, atoms and molecules, we face exponential problems having large dimensions (see [1] for more details). We know from the theory of Computational Complexity that we cannot solve accurately and in reasonable time exponential problems having large dimensions.

Second, Complex Systems exhibit variable patterns. To deal with variable patterns, we collect, store, and process Big Data. However, we still need to formulate universally valid and effective algorithms for recognizing variable patterns.

Third, the measurements of the initial conditions of a Complex System are always affected by unavoidable uncertainties and errors. Therefore, if the Complex System exhibits chaotic behavior, its dynamic is unpredictable in the long term, by definition.

3. How to untangle Complex Systems

Aware of the limits we have in the description of Complex Systems, how can we face the Complexity Challenges? We need to improve the ways we collect, store and process information. There are two principal strategies to succeed. One strategy is by improving our current electronic computers. The other strategy is the interdisciplinary research line of Natural Computing. Scientists working in the field of Natural Computing draw inspiration from nature to propose new algorithms; new materials and architecture to compute; new models and methodologies to interpret the Natural Complexity. The fundamental rationale is that information can be encoded through the states of any natural system. For instance, in the field of Chemical Artificial Intelligence, the states and evolution of suitable chemical systems mimic the behavior of the human nervous system [5].

In conclusion, if we consider the humankind journey to discovering the secrets of nature, we can say that it has been punctuated by two revolutionary intellectual events.

The first one was the birth of philosophy in the ancient Greek colonies, during the 6^{th} century BC. The second one was the formulation of the scientific method, proposed by Galilei and Newton in the 17^{th} century AD, which is based on the experiments as tools for inquiring nature. Now, we are expecting a third revolutionary event that will allow us to untangle Complex Systems. This event seems close, but it is still unknown in its details. However, as Einstein rightly alleged, by learning from yesterday, living for today, and hoping for tomorrow, the important thing is that our students and we never stop questioning.

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Dealing with Students' Undesired Responses to Teachers' Oral Questions in Chemistry Classrooms: Exploring Effective Feedback Practices

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Abstract

The study explores chemistry teachers' ways of dealing with students' responses to teachers' verbally posed questions, responses that teachers regard as either undesired or incorrect. Actual teaching situations of three chemistry teachers were recorded, transcribed and interpretively analyzed. Semi-structured interviews with these teachers were also conducted to bring forth the teachers' inherent perceptions about their practice in relation to what was observed of the teachers in the actual practice. The study reveals up to eight different ways in which teachers react to students' responses that they (teachers) deem incorrect or undesired. These teachers' reactions/actions or behavior are discussed with respect to how they affect students' progressive learning. From the findings, an interactive-authoritative communicative approach is still dominant in science/chemistry classrooms. There is the need for in-service science/chemistry teachers to be supported in how to effectively use their classroom powers to support students' productive engagement with scientific matter.

Keywords: Chemistry teacher oral questions, Students' undesired responses, Effective feedback practices

1. Introduction

Research into teachers' classroom practices over several years has underscored the potential of teachers' oral questions in enhancing students' science learning [1].

To understand the important role of teachers' oral questions, one must characterize the context in which such questions occur [2]. This is so because teachers' oral questions are conceptualized as mutual constructions between the teacher and his/her students, and occur in teaching contexts that are continuously modified by both teacher and students [3]. Consequently, the nature of interactions between teacher and students influence the kind of benefits that come with the teachers' classroom use of oral questions [3, 4]. For example, teachers can pose oral questions during chemistry teaching, to which students can respond with single acceptable scientific views or with varied arguments. The teacher has a role to guide and maintain a productive exchange between him/herself and the students. Through these questions and answer interactions, that involve exchange of information and guided discussions, students have the opportunity to bring out their views/conceptions, receive feedback, adjust their wrong science conceptions, and hence learning [5-8].

Not all students' responses to a teacher's oral questions align with the acceptable scientific views. Quite often students come up with views that deviate substantially from the acceptable forms of scientific knowledge or from the teacher's pre-specified answers. Teachers react in different ways when responding to students' varied/ undesired or incorrect answers to teachers' questions. Some may want to trigger students' thinking and further students' making of reflections. This may necessitate teachers providing additional information to initial questions [5] and using prompts such as follow-up questions on clues that teachers notice in students' thoughts or feelings [4, 9, 10]. Some teachers might also decide to adjust their questioning to accommodate students' contributions and thinking [4]. Recent research on teachers' questioning practices however still indicates that the dominant nature of practice is such that teachers despite inviting responses from their students, they discount students' ideas in pursuit of pre-specified scientific views [4]. As such, students' varied views have little room for discussion. In this study, we explore how chemistry teachers react in questioning situations whereby the questioner considers students' responses to the posed oral questions incorrect or undesired. The aim is to underscore the kind of feedback practices effective in chemistry classrooms.

2. Data sources and analysis

Three chemistry teachers from different schools in Iringa Municipality in Tanzania were observed in actual teaching situations. These actual teaching situations were followed with a semi-structured interview with each one of the three teachers. Both the video-recorded actual teaching situations and the audio-recorded interviews were transcribed for analysis. All the three participants were qualified chemistry teachers with at least six years of teaching experience.

We drew on Gadamer's views regarding the interpretation of written text (behavior -verbal or non-verbal) [11], to analyze and develop an understanding of the different teachers' actions or behavior (verbal/non-verbal) in questioning situations that involved students' undesired/incorrect responses to teachers' questions. According to Gadamer, a person seeking to interpret a written text (verbal or transcribed) goes with preconceived ideas into the process of interpretation. It is through our prejudices that he calls "fore-structure" that an interpreter begins to understand. Having an awareness of our prejudices enables us to take account of them in the effort to hear what the text or the told stories say to us. In the process, we have to remain open for what the other person or text may tell us. We accept participants' stories as their individual realities, how they make sense of the world. Then we start to construct our own understanding of the participants' stories [12].

We thus read teachers' transcribed accounts (both from actual teaching and from interviews), and started to develop interpretations of what the different teachers' actions implied. The process involved first characterizing the context of the teacher's question, thereby analyzing the discourse resulting a teacher's question as well as the subsequent teacher and students' turns [2, 3, 9]. This made it possible to identify and characterize the various forms of actions, responses or behaviors (both verbal and non-verbal) performed by each one of the three participant teachers as they responded to their students in certain teaching situations involving undesired/ incorrect students' responses.

3. Results and discussion

There were altogether 16 questioning and answer incidents (that's, seven, five, and four questions for teachers 1, 2 and 3 respectively), where the teachers deemed students' answers/responses to their questions as incorrect/undesired. In characterizing the teachers' questions, we particularly focused on three question categories, facts-requiring, algorithmic, and conceptual question [13]. We also followed up the teachers' management (structural and procedural) questions aimed at either keeping classroom activities running or as follow-up questions/reflective tosses [2, 10]. Thus, 12/16 of the teachers' questions were facts requiring, conceptualized as questions with pre-specified answers. During these 16 questioning situations, the teachers, each reacted to his/her students' response in different ways in particular situations. Altogether, we identified and characterized eight kinds of teachers' actions, behavior or responses. These actions/behavior/responses, summarized in figure 1, could be classified based on whether they are characteristic of an interactive-authoritative communicative approach or whether they bend towards a dialogic form of classroom communicative approach [14-16]. Majority teachers' courses of actions were cutting across for all three teachers. There were only two actions unique to single teachers including, embarrassing students (teacher 1), and referring students to textbook material in a pseudo act (teacher 2).

The teachers' actions categorized under the authoritative classroom communicative approach depicted the teachers as exercising their enormous classroom powers during the teaching, and limiting students' responses to only those directions desired by the teacher. There was very limited (almost no) space for students varied views and the teachers simply rejected or ignored those students with views different from the pre-specified acceptable forms of scientific knowledge. The students could thereafter be seen assuming a passive role, and remaining silent for the rest of the lesson. On the other hand, in questioning situations where the teachers attempted to accommodate and followed up students' varied views (tending towards dialogic communicative approach), there was more talk and elaborated arguments from students. Students could be seen increasingly willing to contribute to the exchange that is taking place, as the teacher attempted to throw back probing questions to students.

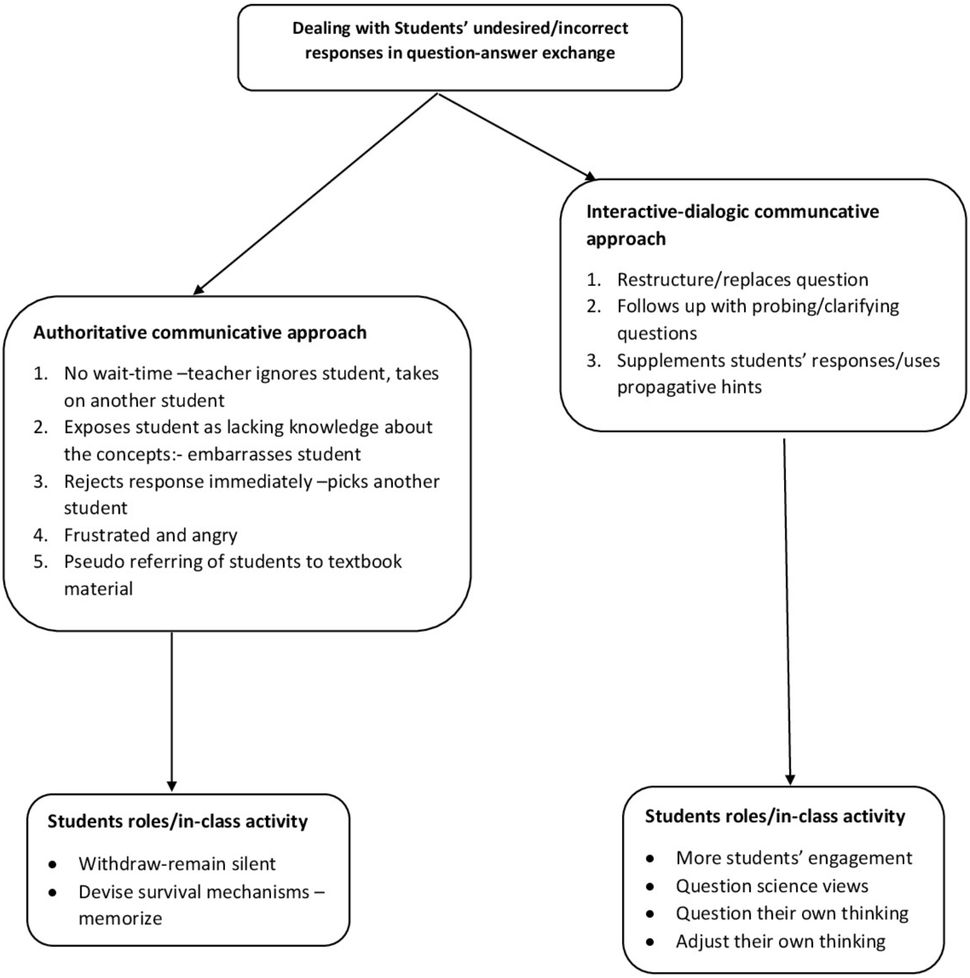

Fig. 1. Teachers' actions/behavior in response to students' undesired responses and the possible effects on students' in-class activity

Our analysis reveals that the teachers dominated most of the talk. There were very few instances, where the teachers in our study considered students' varied views.

The teachers seemed to lack knowledge about how to deal with students' views that do not align with the pre-established scientific facts. This challenge unfolds at a time when the chemistry school curricula in Tanzania emphasizes constructivist teaching approaches [17]. A successful constructivist teaching approach in chemistry classrooms implies that teachers are able to use their classroom powers to provide opportunities to students to contribute to their own learning [18]. Nevertheless, the teachers in our study instead used their classroom powers to guard themselves from classroom insecurities such as, to avoid situations where students could question the teachers' chemistry content knowledge. The teachers are afraid of being exposed as lacking on any of the teaching aspects (chemistry content, experimental procedures etc.). Thus, they only use questions to evaluate students' masterly of prior concepts, and to manage the classroom in a structured way. This is why from our findings; the teachers mainly used fact-based questions, which are useful but not sufficient for engaging students' in productive learning. With this kind of practice, achieving the objectives pertaining a competence- based approach to teaching as outlined in the Tanzania science teaching curricula [17], could still be far without first paying attention to these teachers' teaching related challenges and training needs. These preliminary findings from our study thus highlight the important role teacher education in Tanzania has to play, if the teachers are to adopt and implement inquiry-based forms of teaching. Important to note also is that, the teachers are to some extent (though very limited) able to provide some degrees of freedom to their students. The teachers restructuring/replacing questions during teaching, to accommodate varied views, as well as supplementing students' responses, and calling for more elaborated explanations (Fig. 1) portray this fact. This is a sign into the sought direction of practice and it can be a starting point for profession- development (PD) intervention programs for in-service teachers.

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Greening the Organic Chemistry Laboratory: Comparing Synthetic and Purification Techniques in Organic Process Development

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Abstract

Two undergraduate experiments are introduced that teach important techniques common to many teaching labs, but keep the learning within the context of the 12 prinicples of Green Chemistry. In this study, an experiment is described for the undergraduate organic chemistry lab which compares microwave-induced organic reaction enhancement (MORE) to that of more traditional synthetic procedures. MORE and traditional reflux procedures for nucleophilic aromatic substitution reactions on 1-bromo-2,4-dinitrobenzene as well as characterization by ^{13}C NMR and mass spectrometry are described. We are also currently developing a series of process oriented guided inquiry learning (POGIL) experiments whereby organic compounds will be isolated from an unknown mixture by column chromatography as well as liquid-liquid extraction and then the environmental factor (E factor) and process mass intensity (PMI) metrics determined for each of the separation techniques. Oral presentations by the class (where distinct synthetic and separation procedures are consistently observed to be quicker, easier, result in higher yields and "greener") leads to a discussion of general synthetic and purification methods and provides the impetus for students to research alternative methods, the 12 principles of green chemistry and green chemistry metrics.

Keywords: Chemical Education, Laboratory Instruction, Organic Chemistry, Green Chemistry

1. Introduction

The development of novel organic processes requires sufficient chemical background, a methodical and committed work ethic, and often months or years of time on the part of the practicing chemist. Because of this, when the scientific problem has been solved, it is often tempting for the chemist to continue work developing only the route that was 'discovered' rather than continuing to find a more environmentally friendly alternative. In an editorial in the journal Green Chemistry Letters and Reviews, [1] Haack notes that laboratory methodology leading to greener results is critical to current educational practice. Future chemists will decide whether chemistry will develop with sustainability as part of the focus, but only if they have a strong foundation on sustainability issues and the meaning of making green chemistry development decisions. The third annual American Chemical Society Green Chemistry Summer School participants noted that incorporation of a general knowledge of green chemistry should begin at the undergraduate level and continue through graduate course work. [2] These curricular developments are greatly facilitated by the fact that contemporary laboratory students have come to expect to be educated in an environmentally sustainable fashion. [3] Further, it has been noted that, rather than developing new techniques, achieving greener chemistry in many cases will simply require a redirection of current techniques. [4] There are a number of published experiments that demonstrate alternative, greener practices to students. [5], [6]

2. Curriculum development – organic synthesis

At the University of Winnipeg, we wanted to introduce our senior students to the modern synthetic technique of microwave heating and so we developed a nucleophilic aromatic substitution experiment which compares microwave heating to the traditional technique of reflux. [7] Table 1 shows average student results which demonstrates that microwave heating consistently gives greener results (higher yielding, greater atom economy, uses less power and less organic solvent) when compared to a traditional reflux synthesis.

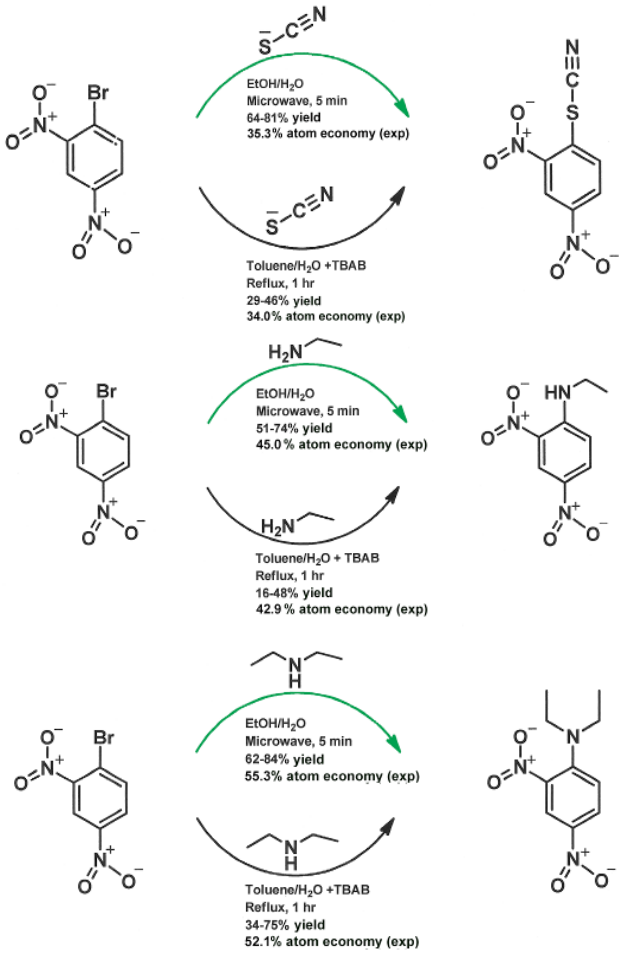
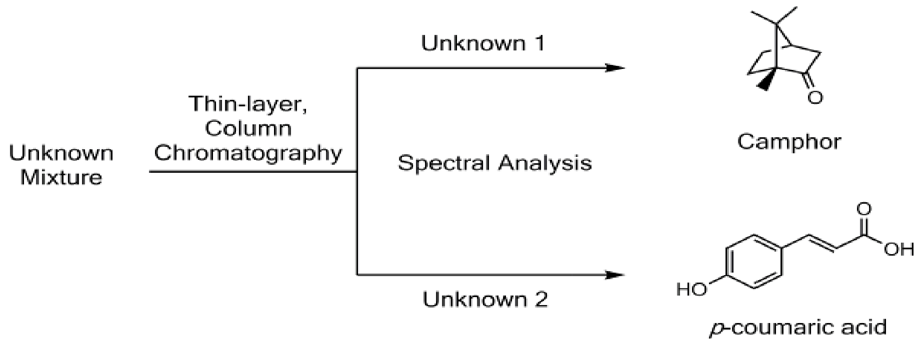


Table 1. Nucleophilic aromatic substitution reaction using each of three nucleophiles (thiocyanate, ethylamine, and diethylamine) comparing microwave-assisted procedures to traditional reflux heating techniques.

3. Curriculum development – organic mixture characterization

We have previously developed a guided-inquiry, upper-division undergraduate organic lab experiment which involves a complex separation as well as thoughtful NMR experiments and solvent selection. [8] The full characterization of the organic mixture in the figure below (85% camphor/15% *p*-coumaric acid) is relatively complex with a TLC visualization challenge (one of the components is observable under UV light while the other component requires a chemical visualization such as I_2 staining), column chromatography, as well as two different NMR challenges: (i) a complicated ^{1}H NMR and 10 carbon environments from ^{13}C NMR lead students to 2D COSY, HSQC and HMBC analyses to solve the structure of camphor, and (ii) after determining the basic structure of the second component, a ^{1}H NMR coupling constant analysis reveals that the E isomer of *p*-coumaric acid is present. We designed this experiment as a PBL exercise to ease the transition from the senior organic lab to the research lab environment.



We now propose a guided inquiry exercise that will demonstrate an alternate technique for the separation of the components of this mixture while using green chemistry metrics to show the importance of fully analyzing and comparing methodologies in choosing the best route in process chemistry development. The separation of the components is being investigated by liquid-liquid extraction under basic conditions (the *p*-coumaric acid will deprotonate to form a salt and thus become more hydrophilic while the camphor remains hydrophobic). Separation of aqueous and organic phases, neutralization of the aqueous *p*-coumaric acid salt solution followed by further organic extraction and work-up will yield the individual components. As a guided inquiry exercise, students will be challenged to develop an experimental scheme and then complete both the chromatographic and extraction separations of the unknown mixture in a prudent manner while recording a full inventory of all materials and energy expended as well as yields of purified products. Following full spectral characterization of all products, the concepts of environmental factor (E factor) and process mass intensity (PMI) metrics [9] will be introduced and determined for each of the separation techniques and students will then be guided to a discussion of all 12 principles of green chemistry. [10] For both green chemistry and economic reasons, it is estimated that PMI values are now used by over 67% of chemical companies while E factors are used by 48%.[11]

4. Conclusion

We introduce two experiments to the undergraduate organic lab that teach important techniques common to many teaching labs, but keep the learning within the context of the 12 prinicples of Green Chemistry. We propose that all chemistry labs be taught in this way. It is vitally important that chemistry students be familiar with green chemistry metrics since established journals such as *Organic Process Research and Development* now warn that "authors risk having papers rejected unless environmental impact and green chemistry principles are considered." [12] In order to change the mindset of the industry from economically driven development to sustainability driven development, new organic processes must develop in the hands of scientists that automatically put environmental considerations at the forefront.

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Investigating the Laboratory Experiences of Chemistry Teachers

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Abstract

The science laboratory is a distinct feature of science education. And laboratory or practical activities plays an important role in implementing the chemistry curriculum for students' understanding of the material world. Achieving the objectives of practical activities in the school curriculum depends on several factors that include teachers' goals, expectations, experiences and their pedagogical content knowledge. In this paper, we explored chemistry teachers' laboratory experiences in implementing laboratory activities. Specifically, features of laboratory-based activities that characterize teachers' practices, and factors that influence their choices to implement laboratory activities were examined. We adapted an online survey instrument to investigate chemistry teachers' laboratory experiences. A paper and pencil form of the instrument was administered to a sample of 155 chemistry teachers, but only 100 participants returned their questionnaires completed. These were coded and analysed. Findings revealed that the mean scores for student-generated research questions and the procedure to guide laboratory-based activities were lower compared to other features. While the frequency of teachers' use of laboratory activities was significantly high, the mean score of factors that teachers identified to have impacted on their choice or decision to implement laboratory-based activities was higher for the availability of chemicals, safety facilities, and laboratory glasswares. The implications of our findings for laboratory inquiry and recommendations are discussed.

Keywords: Teachers' experiences, Laboratory-based activities, Chemistry

1. Introduction

The science laboratory has long been described as a distinct feature of science education [1], [2]. It plays a central role in implementing science curricula for learners' understanding of the material world [3], [4]. And practical activities within the laboratory provide learners with first-hand demonstration of phenomena and *beginner-experience* of what it means to engage in scientific investigations [5], [6].

The relevance of laboratory activities underscores the attention it has continued to receive in several science standards, and recently in the *Framework for K-12 Science Education* [7], and the *Next Generation Science Standards* [8]. For instance, the NGSS document emphasized the need to engage students in scientific practices that include "asking questions, planning and carrying out investigations, analysing and interpreting data" in science learning [8], [9]. While these scientific practices may not necessarily take place within the science laboratory, the laboratory remains central to science learning; as activities therein can provide students with conceptual understanding and motivation to learn science [3]. In this study, laboratory activities are considered as tasks in which students are provided with hands-on experience as they observe, interact or manipulate real objects/materials to understand the material world [3].

2. Literature Review

Researchers have studied the barriers of teachers' beliefs [10],[11], science teacher knowledge [12], and the "impact of expense" on teachers' choices of laboratory activities [9], with an overarching goal to understand and reduce their impact for effective laboratory inquiry [13].

While there are barriers to effective implementation of laboratory activities, some teachers have continued to conduct laboratory inquiry, though, in form of "cookbook" experiments/structured or guided and open inquiry. This is possibly in their recognition of the fact that laboratory activities ought to take place in order to measure its impact on students' learning of science [9], [13].

Regarding barriers that influence teachers' choices to implement laboratory activities, Boesdorfer and Livermore [9] position links up well with the recommendations of the NRC's *Inquiry and National Science Education Standards* that teachers need necessary support to integrate laboratory inquiry in their instructional practices [14].

Research on teachers' beliefs and practices, their access to curriculum and instructional materials (laboratory apparatuses, glasswares, equipment, chemicals and consumables) that constitute barriers for implementing laboratory inquiry are well-documented [15], [16], [17]. However, studies that draw on teachers' laboratory experiences are not widespread. Advancing support for teachers' need requires research to understand how the availability of instructional materials influence their use of laboratory activities to promote students' learning. Therefore, we explored chemistry teachers' laboratory experiences in implementing laboratory-based activities that can help students develop conceptual understanding of chemical phenomena.

Research questions raised to guide the study are: 1. What features of laboratory-based activities are implemented by chemistry teachers in their instructional practices? 2. What factors influence chemistry teachers' choices of laboratory-based activities? 3. What alternative laboratory-based activities does chemistry teachers use in their classroom practices, and the reasons they use them?

3. Method

A total of 155 chemistry teachers drawn from public and private-owned schools in Ilorin, Kwara State. Ilorin is the State Capital of Kwara-one of the States in the North Central geopolitical zones in Nigeria. Of the 155 chemistry teachers who took part in the study, 74% were females and 26% were males. Only 100 participants returned their questionnaires filled. The teachers taught chemistry to senior school (SS 1-3) students. SS 1-3 are comparable to Grade 10-12 in countries that use grade system.

An online survey instrument developed by Boesdorfer and Livermore [9] to measure teachers' use of laboratory activities in their teaching practices was adapted and administered to the chemistry in a paper and pencil form. The original instrument was designed to have multiple items, Likert-scale, tick all that apply, and open-ended questions. However, we adapted the instrument to align with the context of study, and to ensure that teachers understand the survey items and can respond appropriately.

The instrument elicited teachers' response on the features of laboratory activities they implement in their instructional practices, factors that can possibly influence their choices of laboratory activities and the reasons for what they do during laboratory activities (for the original instrument, see [9]). To ensure the validity of the instrument, two science educators reviewed and provided feedback used to improve the instrument. The quantitative data collected for this study were teachers' self-report of laboratory experiences in implementing laboratory activities. The instrument was administered directly and retrieved from the teachers. Each teacher took about 15 minutes to complete the questionnaire. Upon completion, questionnaires were coded in Excel and export to SPSS v. 25 for analysis.

4. Results and Discussion

The results of the analysis and discussion of each of the three research questions are presented in the following sections.

Table 1 presents the mean scores and standard deviation of the features of laboratory-based activities chemistry teachers implement in their instructional practices. From the result of our analysis, higher mean scores indicate the activities students are engaged with *more often*. The results revealed that students engaged in laboratory activities where they work with chemicals, laboratory glass wares and apparatuses, follow a set of given instructions, take measurements and make observations. The teachers further indicate that students answer post-lab questions (M=3.89) and are required to wear safety equipment (M=3.73), discuss findings as a class. However, students are provided with research questions and required to support their conclusions with evidence more often than they make predictions (M=3.34), generate research questions (M=3.12) and develop or create a procedure to guide a lab-based activity (M=2.96). The teachers' responses to these items indicate that students carry out laboratory activities that require these skills only sometimes, but not often.

Table 1. Mean Score and Standard Deviation of Laboratory-based Activities Implemented by the Chemistry Teachers

Statement	Mean (N=100)	*SD*
Students work with chemical substances (e.g., HCl, NaOH).	4.20	0.817
Students work with laboratory glasswares and apparatuses.	4.24	0.854
Students are required to wear safety equipment.	3.73	1.120
Students discuss findings as a class.	3.73	0.983
Students follow a set of given instructions.	4.16	0.992
Students make predictions.	3.34	1.139
Students take measurements.	4.07	1.008
Students make observations.	4.07	0.913
Students generate research questions.	3.12	1.216
Students create a procedure.	2.96	1.127
Students are provided with questions to guide investigations.	3.66	1.291
Students are required to support conclusions with evidence.	3.66	1.148
Students answer post-lab questions.	3.89	1.145

The features of lab-based activities with higher mean scores shows that teachers engage their students with regular hands-on experience of chemical phenomena.

The extent to which these hands-on experiences align with current best practices as articulated in science reform standards and the NGSS document remains unclear [8], [14]. Classroom observations as further probes of how teachers enact lab-based activities would have provided a deeper insight. However, we will assume that these activities are not the traditional laboratory activities. This result is consistent with the report of Boesdorfer and Livermore [9] where majority of the chemistry teachers engage their students with laboratory experiments. The lower mean scores for students-generated research questions and developing a procedure to guide an experiment further queries our assumption that the laboratory activities teachers claim to enact may as well be traditional in nature. However, researchers have maintained that engaging students to ask investigable questions are the real drivers of scientific investigations [18], but majority of the chemistry teachers admitted that students are provided with research questions in laboratory activities.

To answer research question 2, Table 2 present factors that teachers considered to influence their choices of laboratory-based activities in their instructional practices.

Teachers indicated the availability of chemicals or substances as a factor that impacted their decisions the most. Others include laboratory glasswares (e.g., beakers, graduated cylinders), safety equipment, available procedural instructions and comfort in laboratory setting. Factors with lower mean scores such as funds for waste removal and for materials are reported to rarely affect the teachers' choices to implement laboratory-based activities. For other factors with mean score >2.5, it suggests that such factors influenced teachers' choices of the laboratory-based activities to implement.

Table 2. Mean Scores and Standard Deviation of Factors that Influence Chemistry Teachers' Choices to Implement Laboratory-based Activities

Factor	Mean (*N*=100)	*SD*
Safety equipment	3.19	.896
Available chemical substances	3.41	0.754
Laboratory equipment (e.g., pH metre, analytical balance).	2.98	0899
Laboratory space	2.92	1.002
Laboratory glasswares (e.g., beakers, conical flasks, graduated cylinders)	3.21	0.891
Available laboratory procedural instructions	3.11	0.90
Adequate preparation time	2.99	0.847
Class time	2.99	0.916
Available safety warnings	2.94	0.930
Available materials that can be borrowed	2.50	1.020
Available waste removal instructions	2.37	0.895
Funds for waste removal	2.34	0.945
Funds for materials	2.71	0.913
Comfort in laboratory setting	3.08	0.992
Others (if any)	2.90	0.992

Teachers' indications of availability of chemicals or consumables, glasswares, safety facilities and the comfort of the laboratory settings as factors that influence their choices of lab-based activities suggest that where these are not readily available, laboratory activities may not likely to take place. The implementation of lab activities, to a large extent, depends on the availability of materials. The nature of these factors require that school administrators provide teachers with necessary and consistent support in terms of supplies of consumables and equipment, and of course, professional development in its different forms [14]. since teachers indicated procedural instructions as barrier to laboratory activities, we may infer that the initial teacher education may not have given adequate attention to teachers' preparation in terms of designing and enacting laboratory activities.

To answer research question 3, Table 3 presents the mean scores and standard deviation of alternatives to laboratory-based activities that chemistry teachers engage their students with. A higher mean score for teacher demonstration shows is an indication that it is the most frequently used alternative to laboratory-based activities that chemistry teachers revert for non-availability of laboratory facilities and consumables. The frequency of teachers' demonstration is reported to be more than three times *per* term (M=3.24). They also engage their students 2-3 times in the analysis of provided data (M=2.61). Other alternatives such as film experiments (M=2.27), simulated laboratory experiment (M=2.45) and other videos are not usually carried out up to three times *per* term.

Table 3. Mean Scores and Standard Deviation of the Alternative Activities Implemented by Teachers

Non-laboratory-based activities	Mean (N=100)	*SD*
Filmed experiments	2.27	0.633
Analysis of provided data	2.61	0.723
Simulated laboratory experiments	2.45	0.642
Teacher demonstration	3.24	0.818
Other videos	2.40	0.735

Table 4 provide reasons why teachers implement alternatives to laboratory-based activities. The chemistry teachers indicated that they conduct non-laboratory-based activities to complement for students' learning if the activities require lesser materials, considered more valuable and for the financial implications. However, less than 50% of the teachers choose these non-laboratory-based activities for preference or time factors, safety restrictions and easy of assess to relevant materials.

Table 4. Percentage Distribution of Reasons for Implementing Non-laboratory-based Activities

Reason	*Percentage
I use them because they are more valuable to students' learning	42.00
I use them because I prefer them	24.00
I use them because they save time	12.00
I use them because they require fewer materials	71.00
I use them because they save money	63.00
I use them because there are no safety restrictions	4.00
I use them because it is easier to access necessary materials	3.00
I use them to supplement my other classroom activities and lessons	69.00

*Note. *Percentages do not total 100 since the participants selected as many reasons as possible.*

Our definition of laboratory-based activities suggests activities that gives priority to student-centred learning of science. However, the indicated alternatives to laboratory-based activities that chemistry teachers often revert to cannot be considered to reflect this idea for students' understanding of the material world. The result in Table 4 invoke a reason to question whether the hands-on experiences that students are engaged in during practical work are not traditional or laboratory inquiry or reform-based [8], [14]. While chemistry teachers indicated that their choices of alternatives to laboratory-based activities was because such activities require fewer materials and as supplemental for learning, more than 50% of the teacher opted for these alternatives during their instructional practices for the reason of material cost. This result contradicts the findings of Boesdorfer and Livermore's [9] study, where monetary reason has less impact on teachers' choices of non-laboratory activities. We assume that what accounted for this difference is that not much funding is provided in the government's yearly budget for education.

5. Conclusion

The study explored the laboratory experiences of chemistry teachers in order to understand the nature of activities that characterize their laboratory activities during instruction and factors that often informs their choices of laboratory-based activities. Although teachers claim to engage students in laboratory-based activities, these activities seem to have a semblance of guided inquiry or traditional laboratory activities for the fact that teachers provide students with research questions to guide their experiments. While we may not completely label these experiments as "cookbook," we can as well conclude that the laboratory activities implemented for students' learning of chemistry does not seem to reflect the development of skills and practices advocated for in science reform documents [8], [14]. The barrier of funds for laboratory materials often influence teachers' choices to revert to alternatives of teacher-led demonstration and analysis of provided data. While we may not have explored the impact of teachers' training on laboratory use, the evidence that teachers require procedural instructions to implement laboratory-based activities is a deficit in teachers' knowledge that requires support through professional development programmes.

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Educational Strategies

A Certification Framework for managing digital skills according to DIGCOMP2.1

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Abstract

This paper describes in detail a Certification System that outlines the rules, procedures and management for carrying out the certification of a specific subset of competencies of the DigComp 2.1 (the European Digital Competence Framework). It establishes specific requirements for the process used, tools of assessment, grading and certificate awarding procedures. The system is composed of a Framework that maps Competence Areas/Competences to digital-specific skills and describes how questions and answers for two complementary certification tests are derived. The system also contains a grading system for mapping the points gathered from the test to a DigComp certification level. The Proficiency Level is calculated for each Competence independently based on the results of both tests using a 'fair' algorithm. For each Competence, the set of skills that corresponds to the Proficiency Level certified is awarded. A case of applying the framework in a pilot that promotes learning of digital literacy through learning national cuisines and cultures is briefly presented. Seven Competencies from Competence Areas 1,2 and 3 of DigComp 2.1 are used in this pilot and trainees are tested by a set of 86 pilot-specific questions.

Keywords: digital competence development , evaluation, certification system, DigComp 2.1

Introduction

The frequent use of ICTs in work and in our lives increases the need to develop the appropriate set of competencies such as processing complex information, problem-solving, communication etc in order to seize the possibilities of effective ICT usage [1].

Along with that, the Organisation for Economic Cooperation and Development (OECD) consider that there was the demand of development for effective strategies for getting skills right including digital literacy that helps countries to measure their national digital skills [2]. So, the Joint Research Centre (JRC), a centre that support EU policies, developed in 2013 a user guide with a set of recommended digital competences that someone needs and helps stakeholders to measure the level of digital competence in the common framework named DigComp [3]. This tool could be used as self-evaluation form in digital competences or a framework to set learning goals in ICT training opportunities. Also, it offers a reference that stakeholders could be used to plan, design, evaluate and certificate via (using) education and training offers [4]. After that, two updating versions were published in 2016 and 2018. The differences concern updates in vocabulary, enrichment descriptors and examples of uses in all dimensions that can be used for instructional planning for education, training, assessment, and certification. This paper aims to describe the development of a certification system for Digital Competences (LinguaCuisine Certification System v.1.2) which participants develop in one project called The LinguaCuisine project.

Many of the needs of LinguaCuisine project addressed are improving basic digital skills, specifically digital Competence, engaging digitally marginalized groups (including refugees and migrants) with technology and certifying and assessing levels of digital Competence. The LinguaCuisine Certification System v.1.2 (LCCS) outlines the rules, procedures and management for carrying out a certification of a specific subset of competencies of the DigComp 2.1 framework. The certification system's perspective is the establishment of a new certification system adapted in the guidelines of DigComp. In detail, this paper has derived in following sections: In the first section we mention the DigComp 2.1 framework, in the second section we describe the context of the LinguaCuisine Certification System v.1.2 that was used and in the third section outline the structure of this certification system.

DigComp and LCCF

The Digital Competence Framework for Citizens (DigComp Version 2.1) [5] has 5 dimensions: 1) Competence Areas (CA) identified to be part of digital Competence 2) Competence descriptors and titles that are pertinent to each area 3) Proficiency levels for each Competence with eight Proficiency Levels for each Competence have been defined through learning outcomes (using action verbs, following Bloom's taxonomy) :

Level 1: Foundation- Simple Tasks performed with help

Level 2: Foundation- Simple Tasks performed with autonomy and guidance when necessary

Level 3: Intermediate- Well defined, routine tasks

Level 4: Intermediate- Well defined, non-routine tasks

Level 5: Advanced- Different tasks and problems

Level 6: Advanced- Most appropriate tasks

Level 7: Highly Specialised: Complex problems

Level 8: Highly Specialised: Complex problems with many interacting factors

4) Knowledge, skills and attitudes applicable to each Competence and 5) Examples of use, on the applicability of the Competence to different purposes. The current version of the LCCS certifies digital and specific skills derived from the subset of Digcomp 2.1 (the orange background color of cells in Table 1)

Structure of the Certification System

The Certification System is comprised of the following parts: a) LinguaCuisine Conceptualization Framework (LCCF), b) Certification tools c) Grading Methodology and d) Certificate Skills award.

a) LinguaCuisine Conceptualization Framework (LCCF)

The framework uses the 5 dimensions of DigComp v2.1 and a subset of Competence Areas to provide a mapping of the competences, the generic digital skills, LinguaCuisine-specific examples of use and questions/answers for the two tests used for certification. It is used to derive appropriate certification questions that cover all basic skills at all levels. Scoring functionality is used to calculate the score of the certification and assign a trainee to a PL for each Competence under examination.

The design of the certification tools requires in turn the design of questions that assess the skills of every Competence Area and Competence included in the LCCF.

Digital skills can be either generic or related to the use of LinguaCuisine applications or methods. Both categories of skills need to be mapped to the specific competences of DigComp. There is a one to many (1-N) relationships between a Competence and skills. Moreover, skills are Proficiency Level – specific, that is, a skill is mapped not only to a Competence but also to a specific Proficiency Level as well. These skills are called PL-Skills (Proficiency Level Skills). The Examples of use, along with the PL-Skills are used to derive questions and answers for the certification tools. The skills are described using the specific terms of each Competence and PL, having in mind the goals of each Competence. Terms such as “identify”, “find”, “explain” and others that appear in the descriptors of a Competence in DigComp 2.1 are used to describe the skills and then to derive the examples of use (Table 2). High Level skills (HL-skills) are internal to the design process of the LCCF. Questions conceptually group the assessment of skills from different PLs based on the semantic resemblance of the descriptors that correspond to each PL. Semantic resemblance is expressed in the descriptors when the same clause is used for performing tasks and the only difference is the type of the action, e.g. ‘identify’ for PLs 1 and, ‘explain’ for PL 3 and ‘illustrate’ for PL 4. Moreover, HL-skills used for the design of Test II questions where the trainee must be given a specific task in a specific context (scenario) to perform and be rated by the trainer. Specific scenarios define, in a concrete way, the goals to be achieved and at the same time allow the trainee to focus on what is assessed and not in secondary tasks that are not under assessment.

b) Certification Tools

The certification tools include two tests of different type, Test I and Test II. They are designed to assess the PL of a Trainee both by way of a certification test (Test I- a multiple choose quiz of 49 questions) and by observation and rating by a tutor (Test II- observation sheet including 37 assessment tasks). As concern TEST I, each competence is generally assessed by the same number of questions. A minimum of 4 questions and a maximum of 8 questions per Competence are used and there are six (6) possible answers in each question: four options correspond to the four PLs and two options to false answers. In TEST II, a question gives exactly four choices to the trainer. One of the choices is standard and corresponds to Proficiency Level 1 behavior: ‘Can do with assistance’. The other three choices depend on the Competence and skills under assessment. Test II is designed to assess each Competence using 5-8 questions.

c) Grading Methodology

It provides the scoring ranges and algorithms for calculating the total score for each Competence assessed by the certification tools. The scoring strategy assigns a numeric score to a Competence, but this must be transformed into a grade on some scale so as to derive a decision about the Proficiency Level.

The basic idea behind this transformation is that a threshold of more than 50% of the maximum score (>50%) of a Proficiency Level must be obtained for the Competence to be assigned at that level. The maximum score of a Proficiency Level i in a set of k questions assigned to a Competence is calculated by the product:

$$MaxScore(i)= k*i, \text{ with } i=1,2,3,4$$

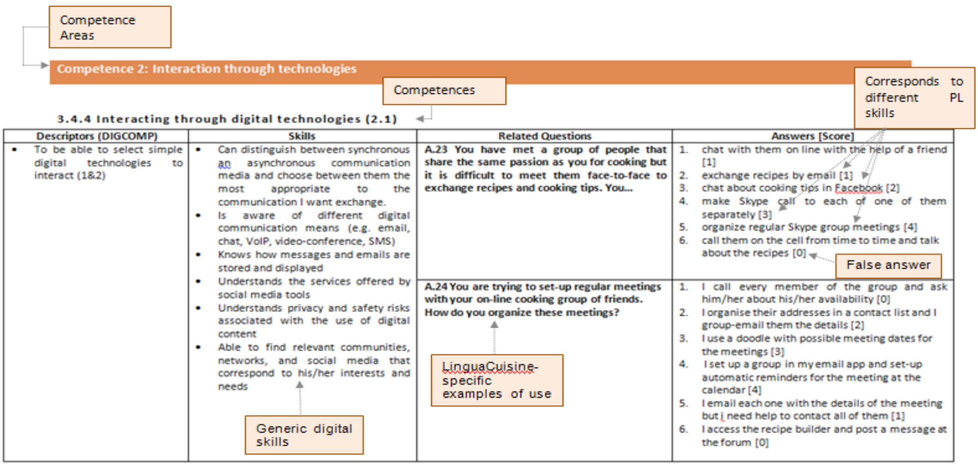
This result is easily calculated since an answer that corresponds to Proficiency Level i is awarded with a score of i points. Both tests use the same scoring method and they are designed to complement each other.

d) Certificate Skills award

The Certification System awards certificates based on the Proficiency Level that was calculated for each Competence. Thus, each time a trainee is certified for a Competence, a specific set of generic and LinguaCuisine-specific skills award is produced.

Competence Areas (CA)	*DigComp Competencies*	*Proficiency Levels*	*Developing Competencies*	*Examples of Use*
Information and data literacy	1.1 Browsing, searching, filtering data, information and digital content	1 2 3 4 5 6 7 8 Foundation Intermediate	**Knowledge, skills and attitudes that apply to each Competence**	**Examples of Use** LinguaCuisine-specific examples of use
	1.2 Evaluating data, information and digital content			
	1.3 Managing data, information and digital content			
Communication and collaboration	2.1 Interacting through digital technologies			
	2.2 Sharing through digital technologies			
	2.3 Engaging in citizenship through digital technologies			
	2.4 Collaborating through digital technologies			
	2.5 Netiquette			
	2.6 Managing digital identity			
Digital content creation	3.1 Developing digital content			
	3.2 Integrating and re-elaborating digital content			
	3.3 Copyright and licences			
	3.4 Programming			
Safety	4.1 Protecting devices			
	4.2 Protecting personal data and privacy			
	4.3 Protecting health and well-being			
	4.4 Protecting the environment			
Problem solving	5.1 Solving technical problems			
	5.2 Identifying needs and technological responses			
	5.3 Creatively using digital technologies			
	5.4 Identifying digital competence gaps			

Table 1. The DigComp framework and the LCCF



3.4.4 Interacting through digital technologies (2.1)

Descriptors (DIGCOMP)	Skills	Related Questions	Answers [Score]
• To be able to select simple digital technologies to interact (1&2)	• Can distinguish between synchronous an asynchronous communication media and choose between them the most appropriate to the communication I want exchange. • Is aware of different digital communication means (e.g. email, chat, VoIP, video-conference, SMS) • Knows how messages and emails are stored and displayed • Understands the services offered by social media tools • Understands privacy and safety risks associated with the use of digital content • Able to find relevant communities, networks, and social media that correspond to his/her interests and needs	**A.23 You have met a group of people that share the same passion as you for cooking but it is difficult to meet them face-to-face to exchange recipes and cooking tips. You...**	1. chat with them on line with the help of a friend [1] 2. exchange recipes by email [1] 3. chat about cooking tips in Facebook [2] 4. make Skype call to each of one of them separately [3] 5. organize regular Skype group meetings [4] 6. call them on the cell from time to time and talk about the recipes [0]
		A.24 You are trying to set-up regular meetings with your on-line cooking group of friends. How do you organize these meetings?	1. I call every member of the group and ask him/her about his/her availability [0] 2. I organise their addresses in a contact list and I group-email them the details [2] 3. I use a doodle with possible meeting dates for the meetings [3] 4. I set up a group in my email app and set-up automatic reminders for the meeting at the calendar [4] 5. I email each one with the details of the meeting but i need help to contact all of them [1] 6. I access the recipe builder and post a message at the forum [0]

Table 2. A Case of the mapping skills to competences and to Proficiency Levels (PL) in TEST I

Conclusions

The certification system has been designed so that it can be applied to assess LinguaCuisine trainees. However, the framework could be used to map Competences to general skills and extract examples of use that will, in turn, produce tests that are appropriate for a variety of scenarios. So, it is extendable since more Competence Areas and Competences can be added and therefore the appropriate generic skills can be derived and mapped to them. The context can also be changed and Examples of Use can be designed to fit new requirements.

Acknowledges

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Development of Creativity Using a Method of "Intuitive Aesthetics": Results of En Plein Airs (Vilnius, Lithuania, 2018)

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Abstract

The article is devoted to the problem of development of creativity of science teachers. Development of teachers' creativity is one of the most significant challenges in success of innovating in education. There are a large number of studies on issues of teachers' creativity development, but not enough attention is being paid to the development of methods which would help teachers to identify and step out from the stereotypes that hinder their creativity. Impact of the "Intuitive Aesthetics" method was researched in the project for Lithuanian painters. 40 well-known Lithuanian painters took part in two En Plein Airs held in Vilnius (Lithuania) in 2018. The "Intuitive Aesthetics" method included four interactions: 1) seminar on art psychology, mindfulness and embodyment; 2) practice for developing skills of reflection; 3) live painting; 4) independent painting. The article presents the results of the research showing how the "Intuitive Aesthetics" method helped to change stereotypes of creativity of painters, and it can be considered for further research as a method for development of creativity of science teachers as well as teachers in general. The method also contributes to the development of teachers' abilities to better identify the needs of children and expectations of parents and make needed decisions in complex situations of today's world. Awareness of the maturity helps teachers to cope with the challenges of the time, better understand the request of children and their parents. Direct response allows flexibly change the interaction in difficult situations, as well as to see the consequences of the changes in practice.

Keywords: Authenticity, Creativity, Art, Development of painter's personality

1. Introduction

Development of teachers' creativity is one of the most significant challenges in success of innovating in education. There are a large number of studies on issues of teachers' creativity development, but not enough attention is being paid to the development of methods which would help teachers to identify and step out from the stereotypes that hinder their creativity.

The study of creativity in relation to personal characteristics of contemporary artists is one of the most significant problems of modern psychology of art as well.

It is difficult to trace the connection between creativity, personal characteristics and features of the paintings, as far as it is necessary to combine several psychological methods of research and art history techniques of analysis of the works of art. In this article, we apply an interdisciplinary scientific and practical approach that combines the competence of the psychologist-researcher, psychologist-practitioner and art historian to study the impact of the method "Intuitive Aesthetics" to change stereotypes of creativity.

2. Literature overview

Analysing the art from the perspective of the identity of the artist, contemporary Italian artist, philosopher and psychologist A. Meneghetti offered his concept of the creative process. Therefore the level of development of the artist's reflection is getting particularly important [1].

It should be noted that the sphere of artistic creativity (as well as artistic perception) is a zone of responsibility of mainly unconscious forces of mental activity, therefore there is still no criterion defining creativity of artists in either the psychology of art, or in art history. The creativity is based on intrapersonal factors, such as vitality, reflexivity, self-esteem of living standards, health, tone [2].

A. Meneghetti in his works identifies two types of art: the art of projection and the art of epiphany. The art of projection is perceived as a pathological or existential problem of the artist. Almost all contemporary artists reproduce stereotype, and criticism emphasizes it, but does not see it. Artists who have achieved an understanding of their own affective and existential problems are able to be mature and create "playing the lyricism of being" [1].

R. Balčiūnienė and G. Šeputis concluded that negative images come from the media, which gives rise to serious behavioural problems among young people and leads to a loss of creativity [3]. Considerable preliminary work is needed to educate a person. How do we help our children regain the desire for perfection? We have to speak with them about existential things – about life, death, loneliness, and meaning.

These questions cannot "dissolve". We need a program that will work in educational institutions. The conclusions of R. Balčiūnienė and G. Šeputis about the necessity of work with the system of education and upbringing of artists, the necessity of understanding of beauty was used in the practice of en plein air.

3. Methodology of Scientific and Practical Work

Based on the review of the existing literature, we highlighted the main aspects that we worked with when conducting plain air with artists. Attention was focused on working with overall formations, which in psychology are defined as complexes and on live action techniques, which allow distinguishing the action of the world of life from the projection of stereotype and neurosis.

The development of the method "Intuitive Aesthetics" was based on the assumption that the current life situation is reflected in the work of artists as it is subjectively perceived by the author him/herself. Two hypotheses were put forward: about changes in the judgments and creativity of artists after participating in the en plein air and about the allocation of 4 stages of creative growth.

The first part of the method “Intuitive Aesthetics” was a seminar class with artists on the topic of intuitive aesthetics, including work on the awareness of the organismic criterion. The second part was a en plein air itself, which included several practical exercises.

In the process of the en plein air, questionnaires were filled in (40 participants), in which the artists gave answers to questions about what art meant for them. During the second en plein air, artists (20 people) answered the questions twice: before classes and after classes.

To confirm or refute the hypothesis about the stages of creative growth of artists, based on method “Intuitive Aesthetics” 10 people gave answers to the questions of the “Existence scale” psychodiagnostic method by A. Längle [4].

4. Discussion

Thus, the intuitive aesthetics was presented in the form of work in the lecture hall, a new vision of the beauty of Vilnius and participation in the en plein air.

The hypothesis of changes in the opinions and works of artists was proved in the course of the second en plein air based on the method of “Intuitive Aesthetics”.

20 people attended it, two surveys were conducted (primary and repeated) and a deeper analysis of the participants’ works was carried out. It was revealed that the en plein air had a positive impact on all artists, which was expressed verbally and in the works. After the contents analysis of the responses, the following was found:

- 30% of the participants changed their attitude to self-expression;
- desire for reflection appeared in 20%;
- 20% of participants have new understanding of art.

4 stages of art understanding art were identified on the basis of the content analysis. The first is the stage of self-expression (Fig. 1), it provides an opportunity for a creative response to the challenges of life. The stage of reflection is connected with the emotional living of the meaning of art, i.e. implies awareness of whether art is produced. The selection stage is the possibility of a conscious choice of a certain dynamics in art. And the stage of responsibility implies following the chosen dynamics in the work and full awareness of what the spectator gets when meeting with the works of the artist.

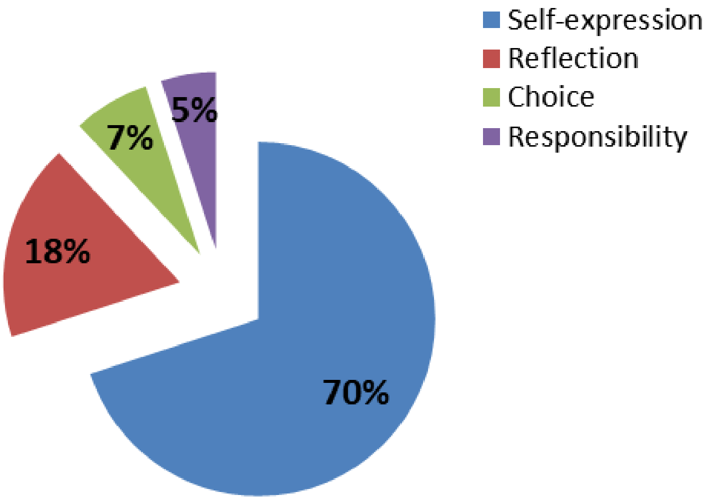

Fig 1. Stage of the understanding of art (N=40)

One of the tasks that we set for ourselves was the awakening of reflection.

Reflection supports and clarifies the action. Through the definition of art and analysis of the works of artists, we have identified four stages of art, which artists undergo in their work.

We 4 stages not only in verbal answers, but in painted works of participants. The majority of the plain air participants found themselves at the stage of reflection in the work. Unfortunately, the young painters of the en plein airs were closed for the change most of all (Fig. 2).

Fig. 2. Stereotypes in the works of young artists

Partial changes were recorded in the works of one young artist. A vivid manifestation of two tendencies of stereotypes: from the interpretation of the form in the spirit of pop art and neo pop art to the perspective of the model of Jan Vermeer and the vision of fashion models – it was not difficult to notice. During the en plein air she painter abandoned the methods found.

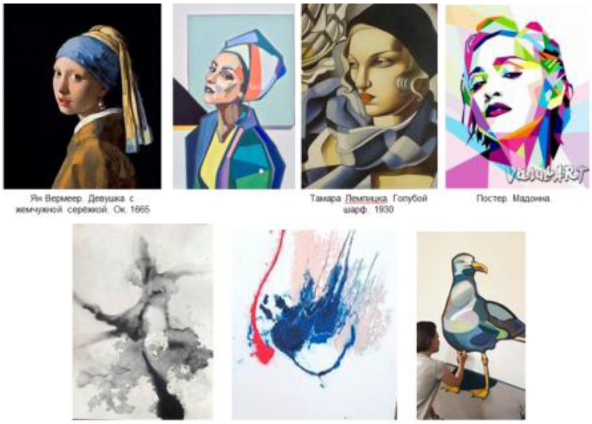

Fig. 3. Stereotypes and changes in the works of the artist

A great master took part in one of the en plein airs, with a well-established author's style, whose works are strongly influenced by the paintings of M. K. Čiurlionis, expressionists and artists of the East.

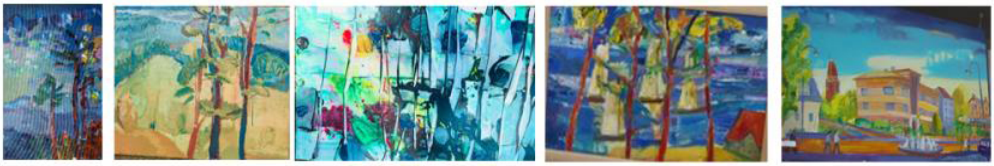

Fig. 4. Changes in the works after the en plein air

After participation in the en plein air, the works of painter afterwards contain great compositional clarity, the colour of the works becomes more and more luminous and calm, and there appears the beauty of the depicted place (Fig. 5).

Considerable changes took place in the works by another painter. The compositional solution was found in the painting of the action, the colour – in the work with watercolour, and the image of the location of the leaves – in the task with black watercolour (Fig. 6).

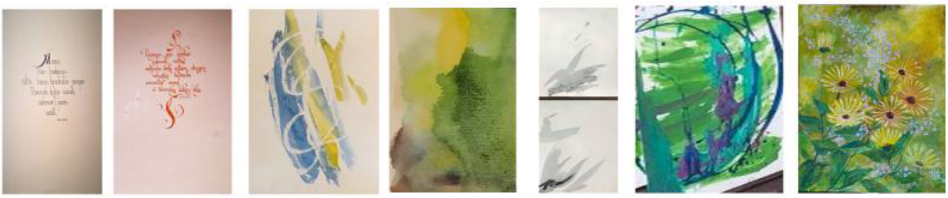

Fig. 5. Comparison of the artist's works before and after the en plein air

There is a conscious choice of positive dynamics and a desire to follow it after participating in the en plein air. We are witnessing the fourth stage of the attitude towards art – the stage of responsibility.

We can point out several groups of artists:

- artists who have found new techniques for themselves, partly or completely got rid of stereotypes – 15%;
- artists who have been able to see and create an alternative to stereotype in their work, but have not yet been able to realize this into their work – 35%;
- artists who have partly changed their stereotype, but returned to it after the en plein air – 15%;
- artists, who reproduced their stereotype in the en plein air – 35%.

The selected groups correspond to the stages of the formation of understanding of art and the awakening of a conscious attitude to their own creativity.

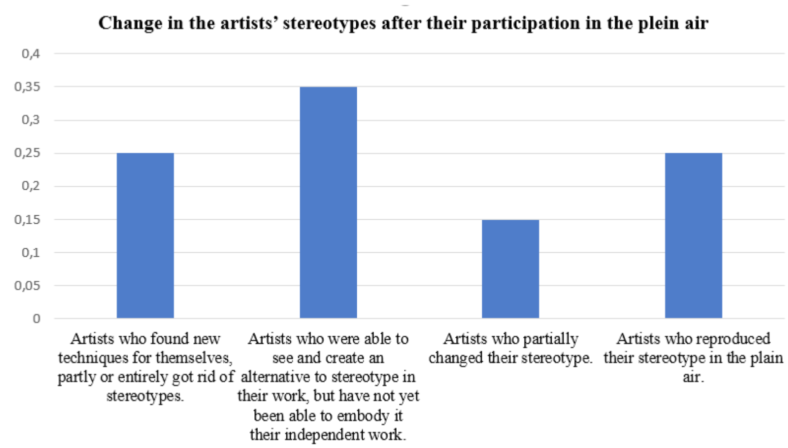

Fig. 6. Change in the artists' stereotypes after experience of "Intuitive Aesthetics" method in the en plein air

The hypothesis of the allocation of 4 stages of understanding of art was proved in the analysis of works and the allocation of four groups of artists. These data were verified by the results of the answers to the "Existence scale" test (N=12). It was found that the average indicators on the scales of the methodology only correspond to the average values for the test presented by the authors, but also fall in resonance with the data of the analysis of the works of artists.

5. Conclusion

Thus, both hypotheses were proved: about changes in creativity (judgments and creativity of artists) after the en plein air and about the allocation of 4 stages of creative growth of artists. The method "Intuitive Aesthetics" used in the en plein air can be considered as psychological authenticating counselling of artists that help to step out from stereotypes in creative process. The artist needs mental order and creative health. Mental order means the ability to recognize one's own unity of action (conscious and unconscious) and make a choice towards positive art.

The novelty of the experimental research conducted in conjunction with the practice of live action provides a new method "Intuitive Aesthetics" for working with artists, the relevance of which is manifested in the creation of a completely new contemporary art.

"Intuitive Aesthetics" method can also be considered for further research as a method for development of creativity of science teachers as well as teachers in general. The method also contributes to the development of teachers' abilities to better identify the needs of children and expectations of parents and make needed decisions in complex situations of today's world. Awareness of the maturity helps teachers to cope with the challenges of the time, better understand the request of children and their parents. Direct response allows flexibly change the interaction in difficult situations, as well as to see the consequences of the changes in practice.

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Development of Leadership Mindset Using a Method of "Live Living"

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Abstract

The article is devoted to the problem of developing a novelty-bringing leadership mindset of directors of secondary schools. Leadership mindset empowers school directors to bring novelty in schools including science teaching. However, studies show that school directors demonstrate high level of stereotypical thinking which impedes novelty-bringing leadership in their schools. Recent study of HAI.LT institute showed that directors and deputy directors of secondary schools demonstrated high degree of stereotyped thinking. The study in 2018 included 31 directors and deputy directors of Lithuania's secondary schools. There was conducted a study of the personal characteristics of leaders in education - school principals in Lithuania. It showed that there is a high degree of adherence to stereotypes, low internality. Conformism and unwillingness to take responsibility were at the first place among the values orientations.

HAI.LT institute designed "Live Living" method to change stereotypical thinking and develop novelty-bringing leadership mindset. The method was tested prior and after the leadership training program for 44 business leaders in the period from 2013 to 2015. The method included cinematology, psychotea, authentication counseling, etc. activating direct experience neural networks (responsible for novelty behavior), instead of default mode neural networks (responsible for stereotypical behavior). The study revealed that training using method "Live Living" brought changes needed for novelty-bringing leadership mindset formation. The changes were observed in business leaders' value orientations, importance of independence of action, stimulation, conformity, responsibility and internality, influence of stereotypes.

Those studies suggest that special leadership training program with the methods of experiencing life situations (direct experience of Live Living) is necessary not only for leaders in business, but for education system too. The study suggests that the method "Live Living" can be used for development of novelty-bringing leadership mindset of directors of secondary schools as a part of HR policy, programs for management development, etc. Development of leadership mindset of school directors allow them to create the school for the generation of the future.

Keywords: Leader, Consciousness, Authenticity, Innovation

1. Introduction

Leadership mindset empowers school directors to bring novelty in schools including science teaching. However, studies show that school directors demonstrate high level of stereotypical thinking which impedes novelty-bringing leadership in their schools. Recent study of HAI.LT institute showed that directors and deputy directors of secondary schools demonstrated high degree of stereotyped thinking.

The leadership in the sphere of business can be a flagship for school leadership in the context of rapid changes, since business leader has to cope with more and more challenges every year reaching business targets. A successful company today is a company where all employees have leadership mindset: they are creative and independent, goal oriented and feel responsible for the success of the company, not depending on their level. The epoch of global changes brings new tasks to managers and requires new approaches to their solution.

2. Previous Studies Review

The modern scientific approach to leadership implies an era of change, the internal environment of organizations is changing with the surrounding reality. [1]. The ability of the leader to respond in an adaptive manner to the emerging difficult situations is associated with the willingness to apply new strategies to overcome life situations.

Leaders with more developed self-regulation abilities are more successful, they are able to make effective decisions in a high-risk situation. A leader is a personality – a vector, the operational center of a variety of relationships and functions [2]. It is noted that it is important for the leader to have a deep and constant contact with the positive basic core of his own personality (Onto “In-se”). In onto-psychology, an organization is called the leader’s “social body” [3].

Self-regulation – the development of leadership potential – organizational changes – this is the scheme on which authentication counseling of leaders is based. The leader has a special mindset: he/she is able to implement the project and coordinate the actions of other people, based on the novelty of the situation. According to the study by the Corporate Executive Board (CEB), 66% of firms have programs on identification and promotion of employees with high potential. However, the top-managers of only 24% of firms consider such programs effective [4].

For the formation of personal qualities of a leader, it is necessary to take into account the latest research in the field of neuropsychology: the existence of two main neural networks of the brain – the constant activation network (default) and the direct experience network (successful). For the development of creativity of the leader, it is necessary to change the default mode system which blocks the potential [5].

In order to break out from automatic reactions of the brain and create novelty, leader needs to reflect on his/her emotional reactions that arise in situations of real life – live living. For this purpose, special leadership training programs are being developed in which the methods of experiencing life situations are applied (cinelogy and psicotea – spontaneous theatre).

3. Study's conclusion

Thus, techniques for experiencing life situations can develop leadership qualities when they are included in the programs of work with leaders. AUTHENTIQUS program of consciousness leadership is a modular training program conducted by the HAI

LT institute since 2011. In the course of work, participants expand the boundaries of their thinking, restore the integrity of consciousness and get rid of the negative influence of personal and social stereotypes, change the default mode system to the direct experience system. The personal characteristics of the leaders were measured before and after the training: value orientations at the level of behavioral priorities, locus of control, stereotypical beliefs, motivation of decisions.

3.1 Methods of Research

1. The method of S. Schwarz for studying the value orientations of an individual is a scale.
2. The technique of G. Rotter "The level of subjective control" in various areas of life: family relationships, work, interpersonal relationships, health and illness.
3. "Test for the identification of stereotypical beliefs" (by Vilius Adomaitis)
4. "Motivation of decisions" test.

The obtained data was processed in Excel and the statistical package SPSS. Statistics. 20. The non-parametric Wilcoxon criterion was used for the analysis to compare dependent samples.

The study of the personal characteristics of the leaders involved 44 people enrolled in AUTHENTIQUS program of consciousness leadership. The purpose of the study: a comparative analysis of the psychological characteristics of participants before and after participation in the program. The results showed that after passing the program, participants had a statistically significant change in value orientations (Fig. 1), the participants began to value more the ability to make decisions independently.

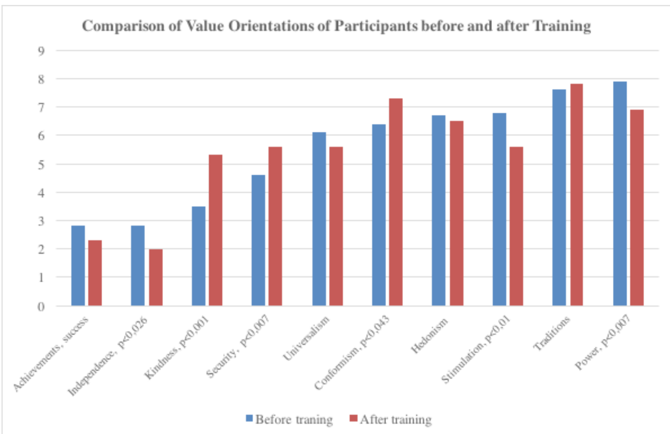

Fig. 1. Comparison of Value Orientations of Program Participants (N=44)

The results suggest that the value of autonomy became more significant. Conformism also got into the top three less significant values.

The second indicator measured before and after the program was the “locus of control”. There are two types of locus of control: external and internal. Internality/ externality in the field of achievements means attributing responsibility for one’s own success or destiny. Internality/externality in the field of failures – a person is responsible for his failures himself, or shifts responsibility to others.

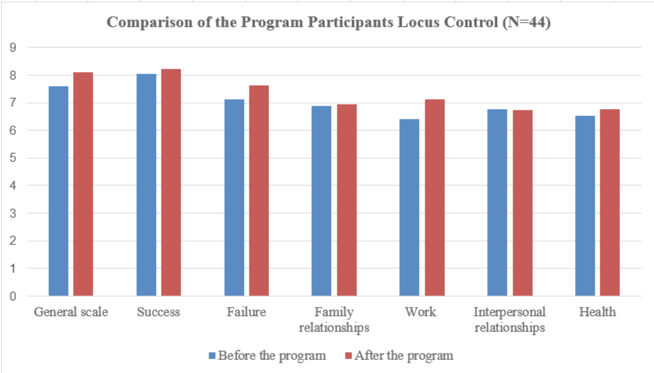

Fig. 2. Comparison of the Program Participants Locus Control (N=44)

The overall internality of the participants (Fig. 3) increased significantly after the training from medium to high. This suggests that the program participants began to take more responsibility for their lives.

The test on identification of the stereotypical beliefs by V. Adomaitis (developed at the Department of Onto-psychology of St. Petersburg State University) also showed changes.

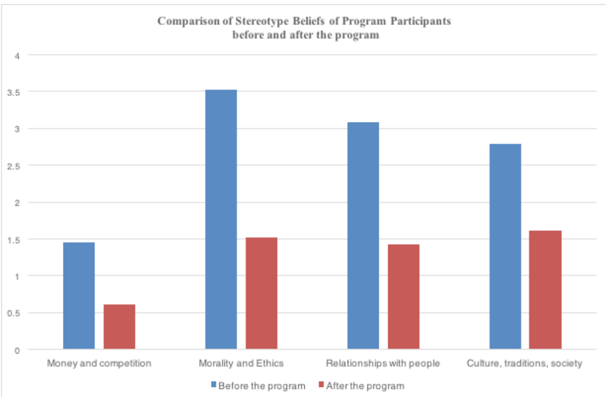

Fig. 3. Comparison of Stereotype Beliefs of Program Participants (N=44)

At the end of the program, the percentage of stereotyped responses significantly declined in all categories, decrease in the stereotyped thinking is an indicator of leadership development (Fig. 3).

The “Motivation of decisions” test also showed significant changes compared to its indicators before the program.

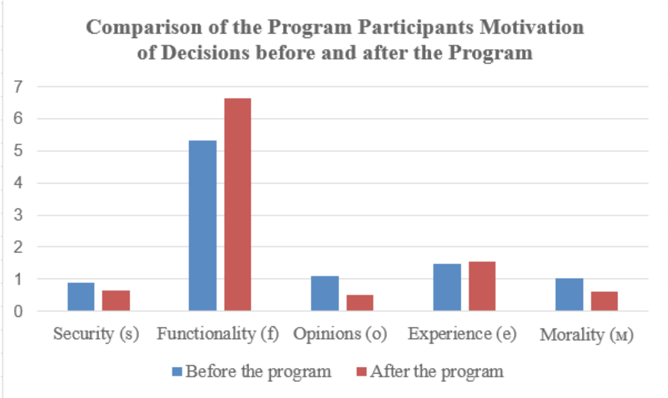

Fig. 4. Comparison of the Program Participants Motivation of Decisions (N=44)

Participation in the program further strengthened the existing trends: the significance of the functionality of the result increased, and the significance of the opinions of others and moral criteria became even lower (Fig. 4).

4. Conclusion

Studies presented in this article suggest that special leadership training program with the methods of experiencing life situations (direct experience of Live Living) is necessary not only for leaders in business, but for education system too. The study suggests that the method “Live Living” can be used for development of novelty-bringing leadership mindset of directors of secondary schools as a part of HR policy, programs for management development, etc. Development of leadership mindset of school directors allow them to create the school for the generation of the future.

The major aspect is the development of the so-called direct experience neural network which develops the potential, instead of the default mode neural network, which blocks the potential. The development of the leaders’ potential (the work of the direct experience neural network) is indicated by the changes obtained by comparing the results before and after the program.

The study proves the need for theoretical and practical training for leaders and teachers with application of special techniques. Leadership training programs develop creative thinking and provide skills for the behavioral use of creativity in business and educational practice.

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Development of Non-Native Speech Relying on Language Isomorphism

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Abstract

In order to master a non-native language it is important to know set isomorphic units, and these are mainly systems expressing semantic universals. Mastering these systems is seen as a link that is vital for full development of students' speech, which presupposes full development of both speech and thinking. Each language system has a set of isomorphic units, including the ones used for expressing semantic universals. Among such isomorphic systems we can name the units, combined by the ability to express defining, comparative, temporary, spatial, causal, object and other meanings. In languages the above-mentioned semantic universals are expressed by system units of different levels - lexical, word forming, morphological and syntactic. There is no doubt that set language units, capable of transmitting a certain linguistic universal are unique for each specific language. However, there is a diversity of forms of expressions, and for expressing a semantic category set language units may be used, each of them bringing with it co-meanings, understanding which is compulsory for full development of speech. But isomorphism that is considered productive in the aspect of methodology may be observed not only in language systems expressing structurally semantic categories. For example, isomorphism covers multi-level syntactic systems that have the function of expression, in particular, those that are based on the phenomenon of syntactic homogeneity. That is why work with similar groups of language units in conditions of study of a non-native language becomes especially important for the development of active and passive vocabulary means to form adequate skills for decoding perceived non-native speech and for development of skills of free expression of thoughts. Building effective techniques of study of isomorphic means of non-native language in interrelation with correlating constructions native for language learners presupposes taking into consideration of three equivalent components: 1) particular features of students in groups, the level of their possession of non-native language, possible goals of training defined by them; 2) specificity of means of expression of isomorphic groups in both languages as an object of training; 3) efficiency of known training techniques for a certain teaching method. The main concepts of developed techniques are: study of isomorphic designs of non-native language in interrelation, which assumes implementation of principle of inter-subject connections; functional approach to the study of isomorphic constructions; relying on students' first language. To be included in the active vocabulary isomorphic means not only have to be perceived by students without any special work based on most important principles of methodology. Definition of content of training in isomorphic constructions as means of development of students' non-native speech is based on communicative *value of constructions selected for study; selection of constructions that are most frequently used and are aesthetically significant is quite justified. Development of bilingual speech relying on the system of isomorphic designs, transmitting certain semantic universals is intended to improve quality of students' connected statements, increase accuracy, correctness and expressiveness of speech.*

Keywords: isomorphism, language universals, Russian as a second language

Development of non-native speech relying on the system of isomorphic units implementing certain semantic categories is predetermined by provisions of unity of language and thinking as well as unity of content and form in language and specifics and organic connection of language and speech, as well as concepts that have paramount value for lingual didactics. Babaytseva V.V. defines isomorphism in language as similarity (but not identity) of language units of different levels in meaning and function if they are different in form (structure), as for isomorphic phenomena, she defines them as similar facts of language and speech, belonging to different levels of language system. [1; 50]

A language system has a set of isomorphic units used for realizing certain semantics, for example, expressing semantic universals. Among such isomorphic systems we can name the units, combined by the ability to express defining, comparative, temporary, spatial, causal, object and other meanings [2].

But isomorphism that is considered productive in the aspect of methodology may be observed not only in language systems expressing structural and semantic categories. The systems capable of transmitting pragmatic potential: expression and motion, are also isomorphic. In languages the above-mentioned semantic universals are expressed by system units of different levels-lexical, word forming, morphological and syntactic. Systems of language units of different levels, capable of transmitting certain language universals are unique for each language. The stated diversity of forms of expression of various categories predetermines the existence of some co-meanings, understanding which is compulsory for full development of speech, that is important when studying a non-native language.

Generalization of data of modern linguistics and results of my own observations confirm the assumption about the isomorphic nature of language means, participating in transmission of semantic categories in Russian, Ossetian and English speech.

Isomorphic constructions expressing one semantic category differ in structure, function, frequency of use, stylistic marking, semantic nuances and degrees of expressiveness; these differences must be considered when selecting material for training. Constructions expressing meaning of one type in the given languages differ in presentation and mismatching of certain language forms of semantic realization.

Mastering isomorphic systems expressing semantic and pragmatic meanings is seen as a necessary link for full development of both native and non-native speech. Relying on multi-level means of expression of one type of semantics for full development of speech implies analysis of shades of meanings and specificity of function of studied relative units presupposes full development of both the students' speech and thinking. This type of work becomes especially significant in conditions of teaching a non-native language, when it is important to develop both active and passive language means for the formation of skills of adequate perception of non-native speech and for development of skills of free expression of students' thoughts.

Building effective techniques of study of isomorphic means of non-native language in interrelation with correlating designs native for language learners presupposes taking into consideration of three equivalent components: 1) particular features of students in groups, the level of their possession of non-native language, possible goals of training defined by them; 2) specificity of means of expressing isomorphic groups in both languages as the object of training; 3) efficiency of known training techniques for a certain teaching method. Comparison was most important for the definition of specificity of isomorphic means of expression one meaning as an object of training, which allowed us to state the following: each isomorphic group both in the Russian and Ossetian languages represents a system, the elements of which belong to different levels of the language. In other words, ways of expression of certain meanings in both languages are isomorphic, i.e., one type of relations (for example, temporary ones) can be transmitted both with lexico-phraseological and grammatical means [4].

Effective formation of skills of production and perception of speech in non-native language defines the need for taking into consideration the specificity of the students' native language [3], it is important for prognostication of appropriateness of relying on transposition and possible occurrence of interference; in the context of everything mentioned above the role of comparative analysis in teaching process is seen as being of paramount importance. Comparative study of isomorphic means in the Russian and Ossetian languages allowed us to notice the presence of both common and different features in relative systems in both languages. We have stated the closeness of structure of syntactic constructions in the Russian and Ossetian languages, the isomorphic nature of means and the wealth of ways of expressing certain relations in both languages. Thus, there are isomorphic means both in Russian and in Ossetian.

On the one hand, the system of means of expression of relative meanings in Russian and Ossetian is related in structural and logical similarity and the isomorphic nature of the members of this system. This circumstance is, no doubt, capable of considerably facilitating the mastering of studied language means of non-native Russian language. However, there is no full semantic and grammatical conformity between relative units in the languages under consideration, which can create barriers in the process of learning this material by the students. This fact explains the need for exercises on translation and comparison. Everything said above, undoubtedly, creates the possibility of relying on skills of perception and production of native speech for the formation of appropriate skills in the studied language. However, our attention was drawn to the existing differences in the compared language subsystems, since they are the reason for occurrence of interfering errors in speech, thus requiring the teacher's special attention.

Analysis of linguistic and stylistic nature of isomorphic groups allows us to determine the volume of information to be studied at the lessons on non-native language. Definition of contents of training in isomorphic constructions as means of development of non-native Russian speech is based on communicative value of constructions selected for study, the selection of constructions that are most frequently used and aesthetically significant is quite justified.

Application of isomorphic system used for expression is also very productive. Since expression, understood as a strengthening function is more expressed on syntactic level [5], it appears to be quite relevant to place stress on means of expression, which include lexical, word forming and syntactic ones. In the first place those based on the phenomenon of syntactic homogeneity: lexico-syntactic (gradation, antithesis) and actually syntactic (period, syntactic parallelism and others). The phenomenon of syntactic homogeneity is inherent in a simple extended sentence, as well as in complex sentence and super phrase unities. This makes it possible to organize rhetorical figures on the basis of simple and complex sentences and complex syntactic whole (CSW). Here we deal with the phenomenon of syntactic isomorphism, covering syntactic units of different levels. For example, gradation can be organized by homogeneous parts of a sentence, homogeneous predicative parts of a complex sentence, parallel sentences in CSW and fragments of a text (fairy-tale «Ivan Vodych and Mikhail Vodych», «Fairy Tale about the Turnip» and others). Doing tasks in certain sequence - from observation of examples in context, editing imperfect texts, studying of differences between constructions of different levels to creating examples on a model and independent production of texts with constructions under study - have all shown their efficiency [6]. It seems quite relevant to connect the study of system of expression of certain semantic universals in the aspect of speech development with the existing classification of toposes.

It is possible to illustrate the phenomenon of isomorphism on the example of category of comparison.

Interestingly enough, such language palette of expression of comparative relations is characteristic of many languages. As observation has shown, languages (Russian, Ossetian and English) feature a branched system of means of expressing comparison on different levels: lexical, word forming, morphological and syntactic. Most frequently used are such means expressing comparison as: steady comparisons, word-formation models with the meaning of comparison, prepositional-nominal combinations with the meaning of comparison, isolated phrases with the meaning of comparison, complex sentences with comparative subordinate clauses, asyndetic sentences and complex syntactic whole with comparative relations between its parts. For several years the author together with her colleagues has been teaching individual groups of semantically and stylistically inter-connected units of language, specializing in expressing a certain semantic category, in higher educational institutions of North Ossetia and were able to confirm the efficiency of assumed principle.

Conclusion

The system of teaching linguistic means expressing certain semantics as a system while studying a non-native language should be developed with consideration of ranking difficulties of training and with understanding of need for gradual formation of language and speech competence. The focus of this methodical system is on the formation of skills of correct and relevant use of data units in the students' Russian speech and that is achieved through consequent study of semantics, structure and stylistic significance combination of given constructions in the Russian language and their interchangeability [7].

Observation and analysis at work with texts becomes of paramount importance, students should have «the opportunity to analyze the above-mentioned concepts in various contexts of literary works, feel their associative links with other words, their emotional fullness» [8].

A two-stage system of training is expedient: at the first stage students should learn to identify these constructions in a text, be able to define their semantic proximity, at the second one they should be able to use these constructions in their own speech in the non-native language. It is important to teach students correct use of studied constructions in speech.

Effectiveness of these training techniques is explained by its consideration of specificity of isomorphic groups in the Russian language (in accordance with which the goal, task, place and contents of training in regional high school have been defined); theoretical information and speech exercises, aimed at teaching functionally stylistic awareness of isomorphic means have been organically incorporated in the syllabus.

One of the most important conditions of the efficiency of the system in foreign language audience is taking into account the perception of object of training by the students – non-Russian language speakers, i.e., specific regularities of formation of language and speech skills. Development of students' speech relying on the system of isomorphic constructions, transmitting certain semantic universals, on proposed methodology is intended to improve the quality of students' connected statements, the constructions used by the students language will become more diverse, the accuracy, correctness and the expressiveness of students' speech will improve.

The main concepts of the techniques developed by us are:

Study of isomorphic constructions of the Russian language in interrelation, with accent on possible means of expression of one meaning, with the analysis of these differences in the system of the studied language and in comparison with similar means in the native language.

Functional approach to the study of isomorphic constructions; study of language units in the context of texts of different style and genre accessories with the analysis of shades of meanings, functional and emotionally expressive connotations.

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Escape Rooms as a Way to Teach Magnitudes and Measure in Degrees in Education

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Abstract

In this communication we show the results of an activity proposed to students in the graduate degree in Early Childhood Education and in the graduate degree in Primary Education relative to the content unit of measurement. In this activity we simulated a situation similar to those presented in "escape rooms", in which they had to overcome a series of challenges in a limited time. These challenged were based in the magnitudes present in the Early Childhood Education and Primary Education curricula, such as length, area, volume, mass and time. These challenges involved mathematical manipulatives (such as Cuisenaire rods, hollow geometric bodies and weighting scales) to show how to use them and inspire their use in students' future teaching practice. The main objective of this activity was to show a different way of treating these contents, instead of the traditional one, which in most cases is reduced to the instrumental dimension of mathematical knowledge. In addition to this, each group had to work cohesively to be able to advance in the challenges, favoring a cooperative learning. This resulted in a greater motivation and participation by students.

Keywords: mathematics, measure, escape room, student motivation, teacher training

1. Introduction

The work we present in this paper answers to the necessity of enhancing students' motivation towards mathematics in the degrees in Early Childhood Education and Primary Education. Professors carried out an escape room experience based on contents about magnitudes and measure.

One of our objectives for this activity was to offer an experience to the students in which they had to work in a collaborative way, departing from the usual student workflow in which they split the whole task into separate parts and then join it back together, often not making any sense whatsoever.

Challenges designed involved the use of mathematical manipulatives and were focused to encourage students to get out of their comfort zone in their future teaching.

2. Escape rooms in education

Nicholson defines escape rooms as “live-action team-based games where players discover clues, solve puzzles, and accomplish tasks in one or more rooms in order to accomplish a specific goal (usually escaping from the room) in a limited amount of time” [2]. Success in solving these challenges is achieved by a cohesive group with communicative and organisational skills, in which members thoroughly explore every nook of the room and think critically and outside the box.

In order to have a team with these capabilities, which every person could have, a heterogeneous group is desirable.

Sánchez defines educational escape room as a creative learning environment that can be designed for any level and makes use of characteristics of escape rooms in addition to the elements and objectives of education [4].

Escape rooms as iterated before, are composed of puzzles and tasks. Wiemker, Elumir & Clare [5] stablish that these puzzles “need to act in concert with one another while providing a diverse set of challenges”. This characteristic enables cooperation between group members as everyone can contribute with their set of skills. Every task follows a circular pattern, or a “game loop”, as they define it: first, a challenge is presented; then a solution must be found, which can be hidden in objects around the group; and finally, a reward is obtained from overcoming the task.

Wiemker, Elumir & Clare [5] also establish four questions regarding design elements to be considered in order to evaluate whether a task is adequate or not:

- Is the puzzle integrated into the storyline?
- Are the clues to the puzzle logical?
- Can the puzzle be solved using only the information within the room?
- Does the puzzle add to the atmosphere to the room?

In the educative environment, as of late, some platforms have appeared to make things easier for educators. One of these platforms is BreakoutEDU [1], which offers teachers a variety of both physical and digital resources to create escape rooms.

As for advantages of using these kinds of experiences in education, Nicholson [3] states that enables active learning and social constructivism. The time limit also provides an unexpected benefit: students need to approach contents in a completely different way as they would in a traditional one. Finally, Nicholson claims that “they are a natural match to the learning environment of the classroom and the types of activities that students already do”.

There are also drawbacks to this approach of classwork. Often, if incorrectly designed, tasks can be focused only in opening boxes, which doesn’t differ much to traditional classroom exercises. And a clear disadvantage is the additional work that this requires to the teacher.

3. Teaching measure and magnitudes through escape rooms

This experience was carried out in three different classes of the graduate degrees in Early Childhood Education and in Primary Education, during the topics of measure and magnitudes. In this part of the subjects, topics such as length, area, volume, time and mass were addressed.

Having a considerable number of students in each class, the classical approach of escape rooms – this is, confining them in a closed room – was not possible, so other alternatives had to be considered in order to offer a similar experience. Having a single group with the whole class was immediately discarded, due to the possibility of only a few students working through the solutions and the rest doing nothing. So smaller groups were required. Due to the lack of physical space, two approaches were contemplated: the first one involved giving the students a compressed folder with password-protected pdf files. The password of these documents were the answers to the previous challenge. The other approach used the learning management system of the university, in this case, Moodle, setting the challenges to only appear if the previous one was solved correctly, introducing the answer. These two methods facilitated the labor of the professors, who did not have to approve manually of the answers and could provide hints to any groups that were stuck.

3.1 Suggested activities

In this section we show a few of the challenges that were proposed to the students. The ones left out in this paper are variations of the ones below.

Length: One of the challenges proposed was to obtain the length of a table when shown a series of Cuisenaire rods laid upon one of its sides. In addition to test the knowledge in this topic, this activity assessed whether the students knew how to use this mathematical manipulative.

Fig. 1. Cuisenaire rods to show length

Area: In this task, students were asked to compute the area of a set of floor tiles located near the classroom. This evaluated if they could correctly measure these tiles with a measuring tape or ruler and the knowledge of the formulae of different polygons.

Volume: In this category, we proposed two activities with different perspectives.

The first implied the exact calculation of the volume of an object, using the pertinent formula. In particular, the object was a cube hold by a statue near the classroom.

Fig. 2. Statue with the cube to measure

The other activity involved the use of direct comparison of volumes given four hollow geometric bodies, which had to be arranged from smallest to largest. This could be done by filling them with water in a restroom nearby.

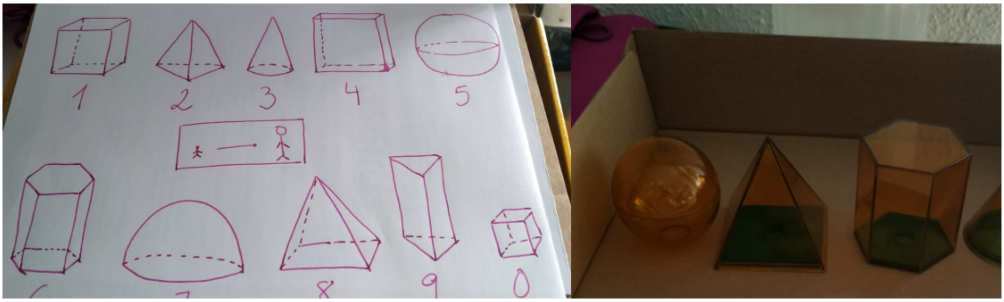

Fig. 3. Hollow geometric bodies

Mass: In this case, there also were two different challenges posed. The first one, was a riddle in which the students had to obtain the mass of a number of objects given the weight of several sets of them. This assessed their reasoning skills involving this magnitude. The second activity tackled a similar problem, but in a manipulative way, using a kitchen scale and bags with pebbles in them.

Fig. 4. Kitchen scale to measure bags with pebbles

Time: Regarding this magnitude, several problems were proposed with various wordings to test the ability of operation and reasoning with time frames.

3.2 Student opinions

Once the escape room was over we let the student express freely about this different experience. Immediately after finishing that class, they reflected their positive views regarding this kind of activities, as well as enhancing motivation towards mathematical problem solving. In order to obtain concrete evidence of these opinions, students filled an anonymous survey about the activity, its strengths and weaknesses and the changes they would make. In these reflections, we can appreciate the positive impact that Escape Room activity had in them.

- "It's a way to learn and assimilate concepts which are different to the usual ones so, in my opinion, it's more fun." (Student from Degree in Early Childhood Education)

- “I liked it a lot. The best of the subject (the rest has been good too)”. (Student from Degree in Primary Education)
- “The playful environment that it creates and the stimulation to reasoning”. (Student from Degree in Early Childhood Education)
- In addition to the positive aspects of this activity, some of the students wanted to express in their feedbacks some of the weaknesses they had noticed:
- “It was sometimes a bit stressful because we saw other groups who were very fast and our group was slower, but at the end we finished and we had fun.” (Student from Degree in Early Childhood Education)
- “Some of the test were a bit annoying because they weren’t exact amounts.” (Student from Degree in Early Childhood Education)
- Some students would like to repeat this proposal in the rest of the subjects of the degree, while others consider that doing it more often would turn it from a success to a failure.
- “I would do more topics with this format.” (Student from Degree in Early Childhood Education)
- “As a complementary activity like a review I think it’s a good idea. [...] If the idea is to build the whole subject around it, replacing the theoretical classes, I think it would become a failure.” (Student from Degree in Primary Education)

4. Conclusions

In this communication we have focused on presenting a didactic proposal about an escape room for future teachers. We have described some of its activities and the comments of the students concerning its development.

We can conclude that it has been possible to reach the main objective, which is being able to work on magnitudes and measurement in an innovative way, without reducing to the instrumental dimension of mathematical knowledge.

In addition, the development of the proposal has favored communication among students. To achieve it, we had to create a self-validating engine, favoring a cooperative learning and promoting confidence between peers. As a result, we enhanced future teachers’ motivation and participation in their initial training. Students have been aware of the benefits of escape rooms as a new way to teach, which not only encourages a playful environment but also a good level of reasoning in each of the activities is estimated.

As for difficulties, most of them involved proper use of measuring instruments and precision in the different measurements.

In terms of proposals to improve this experience in the following years, as Nicholson [3] proposes, instead of students being the subjects of the escape room, we are studying the option of having them create the escape room, so as to increase engagement in the activity and assimilate better the topics discussed.

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Features, Mechanisms, Evidences: A Path through the Scientific Theory of Evolution

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Abstract

This work presents the design and the results of a learning unit about evolution. The project has been realized in a second year of a technical secondary school in Italy and it was designed after some reflections on frequent misconceptions in the theory of evolution. The students were asked to answer a questionnaire with eleven statements with a 4-point Likert scale. The results show that there is no association between the theory of evolution and the scientific nature of the theory itself: students do not recognize the evidence, characteristics, predictions and models as parts of the scientific method. Therefore, a 10 hours learning unit on the evolution – aimed at analyzing it with the tools of the scientific method – has been designed. Particular attention in the construction and evaluation of the activities was given to the observation and the argumentation. Moreover, with regard to naive knowledge and misconceptions, it was decided to select some main points relating to the mechanisms, characteristics and evidences of evolution as scientific theory. With regard to the former, natural selection, speciation and adaptation have been addressed. Then, some work has been done to destroy the ideas that evolution is linear and is aimed at improvement by using fossils and other proofs. The unit was designed and implemented using inquiry-based strategies, brainstorming, laboratory activities and using the flipped classroom in some moments.

Keywords: Evolution, scientific method, argumentation, fossils, adaptation, misconceptions

1. Introduction

Evolution is often associated with naive knowledge, as observed both in teaching activities and from evidences in teaching research [1]. These convictions, which are formed during formal, informal and non-formal learning – re-emerge every time one tries to accurately illustrate Darwin's theory. Therefore, at all educational levels one has to collide with a considerable baggage of preconceptions and errors [2].

Furthermore, this subject allows a spiral reflection on some nodal points of scientific teaching. It refers to both the knowledge and the scientific competences involved.

The idea behind the module presented here is to be able to use this core concept in science education to build a path that stimulates scientific thought, developing logical and critical thinking and ability to rationally observe reality, without prejudices, dogmatisms and false beliefs. We are firmly convinced that this approach to science will make the citizens more aware and active in the community.

2. Objectives and methodology

The Unit presented here has been it has been realized in a second year class of a touristic technical institute, about 15 years' old students.

The all path is aimed at the awareness of the phases and the tools of the scientific method paying attention to few nodal goals:

- explanation of some common misconceptions regarding the theory of evolution, aiming at the reconstruction of knowledge;
- cure for the awareness of scientific language vs. common language;
- use and recognition of the scientific method in the specific field of the theory of evolution.

Each of these points was then analyzed and dealt with one or more teaching strategies; above all, the practice of scientific argumentation, which was the guiding thread of the course in the classroom, starting from the initial questionnaire up to the final check.

The table below shows the learning objectives schematically divided in terms of core concepts:

Core Concepts	The student will be able to
Evolution theory	Learn about Darwin's theory and recognize the historical and scientific role of Darwin's study
Features	Understand that it is not linear, it is not aimed at improvement
Mechanisms	Recognize: natural selection, speciation, adaptation
Evidences	Know fossils
Evolution of species	Study the phylogenetic branch of hominids

Table 1. Core concepts and objectives

With this structure in mind, the learning design was aimed at tackling a selection of common misconceptions in this context: the linearity of evolution, the teleological vision, the tendency to complexity, the role of randomness.

To start with, a few months before beginning the module, a questionnaire was submitted to the students, created on the basis of a similar one proposed in a US study of 2015 aimed at identifying the most common misconceptions among students of high school who have not yet undergone a biology course [3]. Considering the diversity of cultural background, the questionnaire has been adapted and reduced, and has been proposed to 57 students of the two-year course (aged 14-15) of the High School 'Elena di Savoia' of Naples, where the author taught at that time. This allowed having a vision of the preconceptions and also of the prerequisites that it was necessary to resume in the introductory meeting, and the result was an opportunity to choose the direction in which to develop unity. Below is the questionnaire as well as the answers, where first column refers to the class (2A) in which this design was realized.

Indicate if you agree or disagree with the following statements, specifying one of the following options, with the corresponding letter: a) disagree; b) partially disagree; c) partially agree; d) totally agree; e) I do not know.

	STATEMENT	2 A (15 students)					Total (57 students)				
		a	b	c	d	e	a	b	c	d	e
1	Scientific evidence indicates that dinosaurs and humans lived at the same time in the past.	9	5	1	0	0	36	11	7	0	3
2	According to the theory of evolution, humans evolved from monkeys, gorillas or apes.	0	0	15	0	0	1	0	31	23	2
3	The Earth is old enough for evolution to have occurred.	13	2	0	0	0	24	12	1	2	18
4	The scientific methods used to determine the age of fossils and the Earth are reliable.	0	0	0	15	0	0	1	39	16	1
5	The environment determines which traits are best suited for survival.	0	0	14	1	0	0	0	28	27	2
6	Evolution always results in improvement.	7	1	5	1	1	8	12	28	6	3
7	Members of a species evolve because of an inner need to evolve.	0	0	2	10	3	0	6	27	19	5
8	Evolution is a totally random process.	9	5	0	0	1	19	15	13	0	10
9	Traits acquired during a lifetime of an organism – such as large muscles produced by body building- will not be passed along to offspring.	0	0	3	10	2	5	6	13	31	2
10	It is called the evolution *theory* because it has not yet been experimentally proven.	0	1	3	8	3	2	7	28	12	8
11	The same is valid for Einstein's *theory* of Relativity.	7	7	0	0	1	22	16	10	0	9

Table 2. Initial Questionnaire

3. Learning Design

Phases	Lesson (time)	Topic	Methodology	Materials/ Tools	Location
Phase 1: Warm-up and experimentation	1 (1h)	Introduction to the topic by debating what is already part of class knowledge. Reflection on • common language vs. scientific language • characteristics of a scientific theory	Brainstorming Discussion Game	Padlet[4] Comics by Micron[5]	Classroom/ multimedia Classroom Home
	2 (1h)	'Fossils teach us history'	Laboratory	Pedagogical Lab at Museum of Paleontology in Napoli	Museum of Paleontology[6]
	3 (2h)	Students can reflect on the concepts of adaptation, contingency and natural selection through guided exploration to the natural selection app. Theory of Evolution	Laboratory Flipped Lesson	Natural selection app[7] Student worksheet Textbook	Computer lab Home
Phase 2: Fix and consolidate the concepts	4 (1h)	Reflections on previous ideas Theory of Evolution	Discussion Formal lesson	Blackboard/LIM/ MindMap Textbook	Classroom
	5 (1h)	Work on scientific method: to argue. Work on the misconceptions: linearity of evolution.	Solo work, Group work Discussion	Worksheet [8] Worksheet	Classroom Home
	6 (1 h)	Work on methods: "What emerges from the past?" The giraffe's nerve	Discussion Flipped lesson	Digital presentation What emerges from the past?[9] The giraffe's nerve[10]	Classroom/ multimedia Classroom Home
	7 (1 h)	Ardi: investigating a 4.4 million years ago skeleton to reflect on similarities and differences between humans and apes	Discussion	Ardi Skeleton[11]	Classroom/Multimedia Classroom
3: Evaluation	8 (1 h)	Final assessment		Initial Questionnaire	Classroom

Table 3. Synthetic table of the learning design with phases, lessons, topics as well as materials and tools

4. Phases Description

Phase 1

This part has been devoted to an initial brainstorming, also reminding the initial questionnaire submitted a few weeks earlier. Then, it has been chosen to plan a trip to the local Museum of Paleontology [6] as a starting activity, to motivate and involve students. Also a laboratory has been realized: " Fossils teach us history", in which students could touch fossils, make hypothesis and discuss.

Next lesson is centered on adaptation as a result of natural selection and its relations with the biotic and abiotic mutations and factors of the ecosystem. To this end, an activity has been prepared based on a simulation on the evolution of rabbit populations developed by the University of Colorado through the Phet platform [7].

The aim is to recognize and use the proper methods of the scientific approach:

- analyze the observations to formulate reasoned explanations;
- evaluate the validity of models of scientific investigation;
- propose modifications to a model;
- communicate valid and supported conclusions from the observations.

In particular, it is possible to change the environment (equator or arctic), introduce selection factors (food or wolves), mutations (fur color, tooth length) and visual data on rabbit populations are quantitatively translated on real-time graphs. Experimental aspects have a relevant space in the process and in this phase we move from qualitative to quantitative observation-analysis of collected data, reading of graphs and tables, recognition of relevant variables.

Then, as a flipped lesson, some references have been selected to study the Evolution Theory.

Phase 2

This phase starts with a formal lesson and a discussion on Evolution Theory, then the following meeting are devoted to work on

- argumentation: materials of this activity has been adapted from a study by Lima-Tavares *et al.*, [8] The teaching inspiration is a series of texts that address some observational cases, for each of which two statements are proposed that offer two interpretative keys different from the phenomenon. Students are invited to discuss them in groups and to choose one of the two positions.
- methods: sixth moment of this path is inspired by material used in training contexts, available on the site 'Pikaia, the portal of evolution' [9]. Specifically, the LABevo section, an evolution teaching laboratory edited by Marcello Sala, presents a wide selection of screenplays in the form of digital presentations that can be used directly or modifiable. A laboratory on the evolution of whales, 'What emerges from the past?' [9] has been chosen to discuss adaptation to aquatic life, forms of transition, the functionality of organs and structures. In a spiral approach, then, we return to adaptation, natural selection, role of fossils, putting them together in an inquiry-based approach. What students are asked at this point is to apply in an operative context what has already been discussed or studied previously.

A YouTube video was used as a reflection material for the home, which refers to a classic example found on many textbooks: the lengthening of the giraffe's neck. Once again, there is a way to reflect on the relationship between the structures and the functions of the tissues and the role that natural selection has played in this modeling.

The video [10], created by Richard Dawkins on the recurrent laryngeal nerve of the giraffe, was shot during the Darwin Day of 2009 (bicentenary of Darwin's birth), when the biologist spent the whole day with a team who dissected a recently dead giraffe at the zoo.

The last meeting before the verification was designed to address once again one of the most frequent misconceptions in this context: "the man descends from monkeys", second question of the questionnaire proposed at the beginning of the activity. It has been used material from a portal for educational resources in the life sciences of the Howard Hughes Medical Institute. The chosen topic, based on the fourth lesson of the Holiday Lectures on Science 2011 by dr. Tim White, is Skeletons reveal human and chimpanzee evolution [11]. Once again we describe a phylogenetic tree, in particular that of men, and refer to fossils as tools of the scientific method to determine the evolutionary relationships between organisms. The differences in the bones between the eyes, teeth and pelvis are presented and the deductions can be drawn. Moreoverm it is proposed to apply this procedure to a very well preserved fossil of Ardipithecus Ramidus, a hominid found by the team of dr. White in Ethiopia in 1994, comparing it to human and chimpanzee skeletons and finally placing it in the right branch of the phylogenetic tree.

Phase 3

Last lesson is dedicated to the evaluation in the form of re-elaboration of the initial questionnaire. Students are asked to answer the questions in the questionnaire again, but this time with open and reasoned answers in light of the learning path.

5. Conclusions

An ex-post evaluation was made to highlight the strengths and weaknesses of this learning unit, Strengths:

- Predicting an activity outside the school has been strongly motivating for the students: in general the relaxed atmosphere of a field trip made the students more inclined to participate, with particular reference to the students who usually remain taciturn and solitary;
- Preparing structured activities for students makes the activities more effective (for example, having a student worksheet that guides both the teacher and the student through the learning path of the lesson);
- Providing frequent moments of group work or for sharing opinions and outcomes has been constructive: these moments contribute to self-awareness and help students not to stop at the request to express their opinion or to argue it;
- Preparing lessons that include different tools and supports: alternating texts with video, online simulations, digital presentations allows you to attract different types of intelligence and keep the attention always alert.

Weaknesses:

- The main negative note was the estimate of the times in the design phase on a double front: underestimation of the time required for the discussion of work at home and similarly for the times to be devoted to group moments;
- Introducing new tools, used only in this unit, has slowed down the activities and did not give the desired results. One refers, for example, to the request to construct a conceptual map, to transcribe one's own opinions; it is only a constant and repeated use of tools and methodologies to ensure that they constructively contribute to learning and are not just a diversion.

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Formation and Control of Skills of Listening and Pronunciation in Teaching Russian as a Foreign Language

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Abstract

The article deals with the formation and control of audio-lingual skills at the stage of pre-university training in teaching foreign students the Russian language as a means of communication in the social, educational and scientific field.
Control is an integral part of the educational process in any educational institution. Control in didactics is a test of students' knowledge, skills and abilities. Rational and effective management of student learning is impossible without a clear, scientifically organized system of control.
Pronunciation skills from the point of view of the tasks of teaching oral and written communication in a foreign language in terms of control should be understood as correct automated pronunciation of sounds and combinations of sounds, correct stress and intonation of statements in the process of speech communication. Prosody – the melody, stress placement and rate of speech - takes a special place in speaking. A special aspect of correct pronunciation is mastering Russian intonation, including familiarity with the main types of intonation constructions (IC) and their use, the rules of syntagmatic articulation, the concept of IC center and its place in a sentence, with the tone movement on the IC center. Students usually make a lot of mistakes in intonation, thus disrupting communication.
As it turned out, the common mistake in studying Russian intonation is the lack of necessary lowering of tone on the stressed and non-stressed parts of IC-1, which creates the impression that the statement is incomplete and therefore there is a violation of the communicative types of sentence (narrative, interrogative).
In conclusion we can claim that it is prosodic skills - the skills of correctly performing prosodic operations that should be the object of control of pronunciation.

Keywords: audio-lingual skills, stress, syntagmatic articulation, intonation constructions

1. Introduction

Study of any foreign language presupposes mastery of the sound system of the language, presence of audio-lingual skills – it is a compulsory condition of communication in any of its forms. That is why it is necessary to stress the importance of formation of both components of sound pronunciation skills:

- the auditory one, which enables us to differentiate elements of oral speech and correlate them with certain meanings;

- the pronouncing one, thanks to which the sound, accent-rhythmic and intonation part of an utterance is carried out. The methodical work on setting and correction of pronunciation is more often carried out at three stages of training: introductory phonetic-grammatical course, accompanying course and corrective phonetics course.

Requirements to the level of audio-lingual skills depend on the aims and conditions of training.

The first acquaintance of foreign students with the main features of Russian articulation base occurs at pre-higher institution stage training at lessons of introductory phonetic-grammatical course (IPGC), which is calculated on 10 lessons.

The purpose of the course is to introduce students to the main features of Russian articulation base, teach them correct Russian pronunciation: free transition from articulation of apical sounds to articulation of velar ones; forming of mechanism of pronunciation of hard/soft sounds; achievement of free transition in pronunciation from hard to soft sounds and vice versa; having mastered the articulation of voiced and deaf consonants, to teach to pronounce words, containing these sounds freely; to teach reading groups of consonants and vowels in words and collocations. During the course we solve tasks of training accentuation and rhythm of Russian words and word combinations. Mastering of Russian intonation is carried out on the base of small communicatively significant dialogues and monologues [5]. There are seven basic intonation constructions in the Russian language (IC). At the elementary stage of training foreign students meet with IC-1, IC-2, IC-3, IC-4, IC-5 and with the remaining ones – at the advanced stage [1]. After 10 lessons of introductory phonetic-grammatical course there is a test, which includes a syllabic dictation, a record of familiar words, narrative, interrogatory and exclamatory sentences, reading of syllables, setting stress in familiar words, reading a text with familiar words (50-60 words). Accompanying phonetics course aims at removing difficulties of work at new lexical and grammatical material. Selecting material on phonetics the teacher needs to consider language phenomena, which can cause difficulty with foreign students.

The corrective course serves to improve audio-lingual skills and takes into account the already formed features of audio-lingual skills of native speech. Identification of similarities and discrepancies in the systems of native and studied languages is very important for the formation and control of audio-lingual skills.

2. Methodology

The formation of audio-lingual skills at pre-higher institution stage is held in two aspects: the aspect of training of general knowledge and the aspect of training in future specialty, which is called scientific style of speech (SSS). This aspect, as well as the aspect of general knowledge of the Russian language, consists of introductory linguistics, elementary and first certificate levels. For the formation and improvement of audio-lingual skills in the aspect of scientific style of speech we use exercises from the textbook compiled by a team of authors. [7].

On audio level the system of work on improvement of audio-lingual skills on the SSS material we take the same themes as the ones that are used at the level of training of general knowledge of language, for example, in vocalism: 1) front vowels of medium and upper rise ([э-и], молекула лития, расте́ние - расти́тельный, жгутик эвглены, реснички парамеции); 2) top rise vowels of front, middle and back rows ([и-ы-у] ли́тий - желе́зо - рту́ть; атомы ли́тия - атомы желе́за - атомы рту́ти; моле́кулы ли́тия - моле́кулы желе́за - моле́кулы рту́ти); 3) vowels of the back row of the top and middle rise [о-у] йод - ртуть). In consonantism: 1) voicelessness - sonority, (се́ра - азот, серебро - золото кислород, водород, углерод; входить в состав,); 2) hardness – softness of consonants and free transition from hard consonants to soft ones and vice versa (тело амёбы, тело эвглены, выделительная); 3) single focus-double focus consonants (семь- шесть, золото - железо, простейшее); 4) fricative - affricates (семь - цифра, семнадцать, тысяча, процесс, цитоплазма, свет - цвет); 5) affricates - occlusives (двадцать, двенадцать, цитоплазма - тело, свинец- ртуть, процент); 6) hard and soft fricative (шесть - вещество); 7) soft occlusive - affricate (тело - четыре, тело парамеции); 8) velar occlusive and fricative (кислород - хлор, хлорная кислота) [7, 8].

During listening sessions the formed audio-lingual skills provide the adequacy of understanding the received information. Absence of such skills in listening can lead to distortion of the perceived information or to complete misunderstanding. In order to form audio-lingual skills as a basis of development of all types of speech activity at the elementary stage we offer special tasks aimed at forming and controlling skills of adequate perception of words, word combinations and sentences as well as skills to correlate sound and graphic images of words, which undergo position and combinatorial changes in speech flow. The listening and reading tasks first offer individual words, then word combinations and texts.

- Read. Mind your pronunciation. Write and memorize words.
- Listen. Read. Pay attention to the stress and reduction.
- Listen and read the text. Mind your pronunciation.
- Listen. Read. Repeat, without looking into the book. Mind the intonation: pay attention to the intonation center in the question and in the answer. Remember, that in a question the voice rises on the intonation centre of the phrase. In the answer the voice falls on the information centre of the phrase.

For the development of audio skills and writing skills students are offered the following tasks:

- Listen. Write the dictation. The teacher dictates and checks the dictation himself. The dictation, written on the blackboard by one student, is checked by the whole group under the teacher's supervision.
- Listen and write words and sentences in abbreviated form. Read what you have written.

The objects of control of the formation of audio-lingual skills during the study of introductory course on scientific style of speech as well as at the training of general knowledge are the skills of pronunciation on audio level, test of skills of using accent and rhythmic models of separate words and word combinations and the skills of applying correct intonation in sentences:

- Listen and mark stress in the words. Determine, in what pairs of words the stress is fixed: моле́кула – моле́кулы, число́ – чи́сла, кле́тка – кле́тки, бело́к – белки́;
- What accent and rhythmical scheme татаТА́, ТА, таТАта, ТА́тата, ТА́тата, таТА́та татаТА́ corresponds to the words: нау́ка, вещество́, фтор, хи́мия, ма́рганец, просто́е вещество́;
- At training and control of intonation the student should choose from two sentences the one, which corresponds to what they have read (the narrative or interrogative sentence).

Вода – простое вещество. Вода – простое вещество?

In the basis of training of Russian pronunciation on scientific style of speech material lies one of the basic concepts of modern techniques of teaching Russian as a foreign language-textocentrism. Audio-lingual skills should be formed not only on the level of words, word combinations and sentences, but also on the level of the text.

A foreign student should understand oral text on hearing, be able to record it on hearing, read it correctly, with a certain speed, reproduce the text with correct pronunciation. At training Russian pronunciation on scientific style of speech material large work on syntagmatic division should be conducted. The skills of division of written text into syntagms, united pronunciation of syntagms with increasing degree of prevalence as well as the skills of adequate perception of syntagmatic division in oral speech are formed. Students gradually get acquainted with different types of syntagms and possible variants of their lexical and morphological structure.

The following types of syntagms are studied: subject, predicate, object, attribute, adverbial modifier and various types of mixed syntagms. For example, the syntagm of the subject or predicate, consisting of one word: Амёба/ – животное. Then we give syntagms consisting of two words: Амёба – простейшее животное. Then we introduce syntagms consisting of noun in the Nominative case + noun in the Genitive case: тело амёбы, тело эвглены, органелла движения. Then occurs spreading of syntagm due to its lexico-grammatical filling: noun in the Nominative case + adjective + noun in the Genitive case: тело простейшего животного. Then the analysis of syntagmatic division of a phrase and its intonation is done.

Prosodic skill at reading presupposes the ability to read and divide a text into the following units:

- syntagm, matching the division of sentence into parts (groups of subject, predicate, adverbial modifiers etc.), into word combinations (verbal, nominal);
- sentences of various structural and semantic types (various models) – simple, complex, compound with various subordinate clauses;
- sentences of various communicative types – question, request, statement etc.;
- components of actual division – theme and rheme.

To control the audio-lingual skills in reading the following forms of work may be used.

- reading aloud of graphically submitted printed text or group of sentences;
- reading to oneself and doing exercises in specified time;
- repeated reading aloud of one and the same passage each time stressing a new logical predicate [2];
- expressive reading of a text, which requires mastery of the whole complex of audio-lingual skills as well as the control of formation of all components of their operations. Reading represents the process, consisting of reading techniques and understanding what you have read. Acquiring skills of reading techniques is basically connected with reading aloud (in chorus and individual).

Reading aloud students should not only understand the contents of the text, but also transmit it to other listeners.

Reading skills should ensure the perceptive processing of the written text, decoding of optic signals into semantic units.

Exercises, aimed at producing these skills, are based on pronouncing elements that get more and more complex-letters, combinations of letters, word combinations, syntagms, sentences, microtexts. Beginning with the level of words, reading such elements should be combined with the establishment of the meaning of the spoken text.

During the control of formation of reading techniques great attention is paid to the speed of reading. Educational program in the Russian language as a foreign one has requirements in reading at every training stage (elementary, basic, first certificate).

At elementary level the volume of the given text is 250-300 words, the number of unfamiliar words – 1-2%, reading time – 20 min.

For basic level the volume of the text is 600-700 words, the number of unfamiliar words – 3-4%, reading time – 30 min.

At first certificate level the volume of the text is 900-1000 words, the number of unfamiliar words is 5-7%, reading time – 30 min. Recommended reading speed – 40-50 words a minute at learning reading; 80-100 words at reading with the purpose of general familiarization with the contents [3].

In speaking the following skills become the object of checking:

- putting correct verbal stress;
- correct choice of rhythmic and intonation model for phrases of different structure to transfer their communicative intentions to the listeners (request, order, request for information);
- correct choice of rhythmic and intonation model for expression of actual division –definition of the given and new (theme and rheme) in a message, emphasizing the main information of the text with the help of logical stress;
- correct division of the text into semantic segments, correct semantic division of the text;
- correct syntagmatic division of phrases in accordance with grammatical organization of statements and the speaker's communicative task [4].

Thus, there is no doubt that without the formation and control of audio-lingual skills, which are the foundation of all types of speech activity, it is impossible to prepare foreign students for social, everyday communication, educational and scientific sphere, or for professional training in Russian higher education institutions.

3. Conclusion

- Audio-lingual skills are the base, the foundation for all types of speech activity: listening, speaking, reading and writing. Without the formed audio-lingual skills in the Russian language it is impossible to form the communicative and speech competence for foreign students to participate in social, everyday and educational sphere of communication.
- Significant work on the formation of audio-lingual skills along with grammatical and lexical skills should be conducted at lessons on general knowledge and scientific style of speech taking into account the interfering influence of the students' native language.
- Setting Russian pronunciation on the general knowledge material and the material of teaching scientific style of speech the concept of level organization of the phonetic system of the Russian language is fundamentally important. Students comprehensively master the sound, accent, rhythmic and intonation peculiarities.
- There should be permanent control of pronunciation skills of foreign students not only by the teacher, but also self-control with the help of recording pronunciation on dictaphone and further analysis of mistakes. Such form of

control gives possibility to estimate one's level of mastery of pronunciation and determine difficulties, emerging in conditions of speech environment.

- The formation and control of audio-lingual skills should be done at all stages of teaching the Russian language on up-to-date lexico-grammatical material, corresponding to the aspect and substantive content.
- Automation of audio-lingual skills has great importance for the solution of the main task of a foreign student-studying at the main faculty, where they are supposed to listen to lectures, read and understand unadapted texts in their major specialty in the Russian language, participate in colloquiums, various seminars and conferences.

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How to Form Creative Learners in Science

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Abstract

Creative learning involves meaningful learning, ownership of learning, control of learning processes and innovation when new understanding is realised. In order to produce learning situations where creative learning is achieved, teachers have to create trustful atmospheres where students are allowed to think and discuss without critical evaluation of the teacher. It is also important to create practical exercises in which theoretical models are processed and connected to observations. During many years we have tried to develop courses in science with the goal to promote students to become independent learners and explorers out of their own prerequisites. Different methods and designs of teaching have been investigated and the variation of the student's creative learning was observed. To continue this development, we here are investigating a chemistry course. Chemistry involves considerable amounts of abstract thinking. Further, as many students had bad experiences from school this was a challenge. 17 preservice teacher students were trained by one teacher to become independent and creative in their own learning of chemistry. The course of 10 full days over three weeks included practical activities mixed with discussions in groups followed by discussion with the teacher in order to connect theory with practical exercises. The students wrote short reflections after each week answering the questions: What do you take with you from your own learning processes and/or in meeting other's learning processes? What surprised and/or amazed you most? The three reflections where analysed by qualitative methods scoring demonstrations of professional development, process thinking and learning processes. Our results showed that students negative to chemistry changed their opinion and enjoyed thinking of phenomena in everyday life with chemical perspectives. All students expressed the importance of practical exercise and group discussions in their own learning. The reflections contained detailed chemical explanations, concepts used properly and were describing their learning processes. They also used their experiences when they discussed how to design teaching situations. Thus, the design of the course promoted creative thinking and deepened their understanding of chemistry.

Keywords: Creative learning, preservice teacher students, chemistry education, reflections

1. Introduction

It is important for teachers to establish an environment for creative learning that allow students to think and discuss without critical evaluation. This can be done by changing from teacher-centred to student-centred teaching and learning where students are responsible for their own learning [1]. Creative learning emerges when learning is meaningful, self-motivated and innovative [2]. Teaching should be inquiry based and connect observations to theoretical models for students to create their own knowledge [2]. By asking questions and solving problems during inquiry, students can make connections between theories and practise [2]. Another important aspect of creative learning is that students are engaged, collaborate with others and enjoy exploring further [1], [3].

We have tried to develop courses in science in order to achieve students becoming independent learners. A variation of methods and designs of teaching have been investigated and the student's creative learning was analysed [4], [5], [6], [7]. To further develop creative teaching, we have been investigating a chemistry course. Chemistry involves considerable amounts of abstract thinking. Further, as many students had bad experiences of chemistry from school this was a challenge.

2. Course description

17 preservice teacher students for year 4-6 were trained by one teacher to become independent and creative in their own learning of chemistry. The course of 10 full days took place over three weeks. During these weeks, students were working on different experiments to get an understanding of molecules and mechanisms in nature. Students were studying and working with questions in a Science textbook in English as well as a textbook on chemistry education in Swedish during the campus free days. The emphasis was included practical activities mixed with discussions in groups followed by discussion with the teacher in order to connect theory with practical exercises. The teaching started with a short introduction to the subject and the concepts that had to be investigated in the first experiments. Students made observations and discussed the outcome of the experiments in small groups sitting in small islands in the course lab while the teacher supervised and listened to the discussions. Finally, the teacher discussed with all students allowing them to describe what they have understood followed by a summary of the theory behind the concepts by the teacher. The course also included a guided visit to the Vasa Museum in Stockholm showing the chemistry around a wrecked ship from 17th century saved sixty years ago. The students wrote short reflections after each week answering the questions: What do you take with you from your own learning processes and/or in meeting other's learning processes?

What surprised and/or amazed you most? These questions have been developed since 2011 by us as being successful for written reflections about learning processes.

The students were assessed through a written exam.

3. Methods

The three reflections were analysed by qualitative methods scoring demonstrations of professional development, process thinking and learning processes. The analysis was focused on six categories: A. changed attitude towards chemistry, B. connection to everyday life, C. importance of practical exercises for learning, D. importance of group discussions for learning, E. chemical descriptions using concepts and F. connection to future profession as teacher.

4. Results

4.1 Analysis of student reflections

The first week many students expressed their negative experience of chemistry at school and that they were more interested now and found it meaningful (Fig. 1, A reflection 1). At the end of the course students described how they will teach as professional teachers (Fig. 1, F reflection 3). Also, a few students reflected on chemistry as school subject and learning in more general terms at the end of the course.

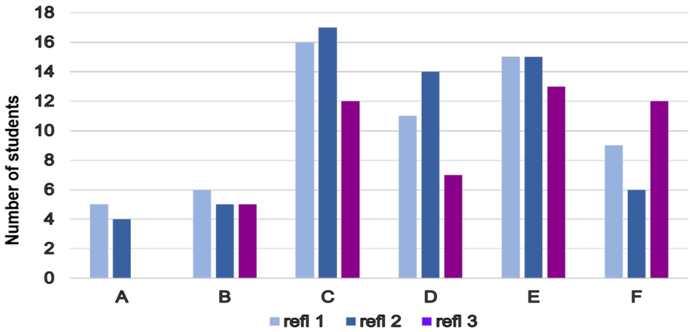

Fig. 1. The graph shows the number of students using categories A-F in each reflection (refl. 1-3.)

A	changed attitude towards chemistry
B	connection to everyday life
C	importance of practical exercises for learning
D	importance of group discussions for learning
E	chemical descriptions using concepts
F	connection to future profession as teacher

A	B	C	D	E	F
29%	59%	100%	94%	100%	65%

Table 1. Total number of students referring to the categories A-F in the three written reflections (n=17)

Table 1 show that all students described experiences from the exercises in the lab using chemical concepts and explanations. The students found that practical work is very important for their learning. Most students also refer to the importance of group discussion for their understanding of models and theories in chemistry. This agrees with the definition of creative learners that group discussions and practical activity enhance creative learning [1], [2]. Already after one week many students already used concepts correctly when describing a phenomenon that surprised them. The analysis also showed that two thirds of the students were confident enough in chemistry to teach the subject in their future profession. Already after the first week the atmosphere in the lab was very joyful and open and the teacher and students had good and trustful relations. Students were describing how they by formulating different hypothesis and explanation to each other are helping others to understand the abstract models.

4.2 Example of the different categories from the reflection

A. ”What surprised me the most is my understanding of the subject of chemistry. During my schooling, both I and others have had a very difficult relation to chemistry. Partly because we did not find the subject interesting, that the educator did not introduce the subject in an interesting and proper manner and that the subject's various terms made us feel negative to make an effort during the chemistry lessons.”

B. “Learning from the place (the Vasa Museum), on the spot, gives a lot. You get links to other things related to reality. What you learn is not just school knowledge”.

“I saw the logic, which made me realize that I know a lot of chemistry without having reflected on the fact that it is actually chemistry. I have mixed mustard vinaigrette countless times without reflecting on that it is a mixture that is made possible by just the mustard when it acts as emulsifier and disperse the fat into small, small droplets which then creates the emulsion.”

C. “I bring with me the importance of experimenting and thinking for myself, in order to be able to approach an understanding of different phenomena in the chemistry world. With the opportunity to do, observe, think and discuss, one can “carry” the knowledge. When performing different types of experiments that give similar results, you can see patterns and get to learn to observe carefully.”

D. “It has been interesting to work in groups. This is something that has benefited me positively because I do not have much knowledge about the subject of chemistry in general. By having socialized with others I have learned about new knowledge and thoughts and other things that I did not think about. I have more or less succeeded in contributing new ideas and thoughts while my group managed to raise me and make me more comfortable to actually dare to say what I think and feel.”

E. “An example of this is when we today talked about emulsion and how emulsifiers work, and then fed back to digestion and bile which in the body works just like emulsifying agent. In this way, understanding becomes deeper in both the biology and chemistry topic.”

F. “Everything we do in the class is not just about studying for an exam. I see a pattern in the whole, I assume the teacher's assignment at the university is to show a working method for us which we will later do the same with our students at school. We should be able to convey that it is important to cooperate with their classmates in order to gain a deeper understanding of the topic. It is not the result that is most important at the examination, but the knowledge about what you have learned and what you can teach later.”

5. Summary

Our results showed that students negative to chemistry in the beginning of the course changed their opinion and enjoyed thinking of phenomena in everyday life with chemical perspectives. All students also expressed the importance of practical exercise and group discussions in their own learning. The reflections contained detailed chemical explanations, using concepts in a proper way, describing their learning processes during the course. They also used their experiences from the course when they discussed how they will design teaching situations in chemistry as future teachers. A teaching primarily based on curiosity both on the subject but also in widening the perspectives in corporation with the students in order to promote their personal relation and understanding of the subject content. Thus, the design of the course promoted creative thinking and deepened their understanding of chemistry.

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Problem-Based Learning: Prolearn4ALL Project Contributions

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Abstract

Problem-Based Learning consists of an active strategy that involves students as a central part of knowledge processes. In this educational strategy, students face daily problems, search for viable, and properly founded solutions. In this research, after presenting a specific problem, it is important to analyse and reflect on previous approaches on the issue, looking for new information that will allow them to describe the state of the art and identify already existing solutions. After selecting all significant information, participants discuss new purposes to solve the initial problem. In this process, the teacher is a moderator, helping students in this sequencing procedure that results in different solutions to be tested and to create new problems. The Learning Products for ALL (ProLearn4ALL) is a project that intends to impulse Higher Education toward reflections and solution purposes to respond to this question: How can we create awareness in Primary School children toward inclusion and help them to respect diversity, especially regarding disability? Therefore, this project intends to create a new pedagogical kit with ludic products for ALL children, allowing them to understand and respect disability characteristics. Higher Education students from different areas (Education, Arts and Communication) have been involved in several activities, from conception to prototype development, facing, in each part, a new problem different from the previous one. Their contributions, in any activity, improved this project, allowing the work team (students, teachers and researchers) to reflect on the best ideas and to produce a kit with ludic and pedagogical books and games. This shared work developed students' motivation to learn, increasing reflection skills and empowerment for the resolution of problems, projecting those practices to their future work context.

Keywords: Educational strategies, Problem-based learning, Higher Education, ProLearn4ALL

1. Introduction

The fast evolution of technologies has revolutionized society in its various dimensions, in the sense that temporal-spatial frontiers are being crossed, which facilitates the access of any individual to all kinds of information. The demands of the current society refer to the need for rethinking the educational paradigm [1], since young people need learnings that meet their life experiences.

Besides the challenges derived from political and economical pressure, the role of the teacher has also been a concern in the field of education [2], just like the prevalence of a rigorous organizational and functional system and an educational regime based on the transmission of content [3].

In order for students to reach significant learning, it is important to modify the teachers' educational line of thinking, who should abandon routine practises and assume an autonomous and proactive position, respecting the students' characteristics, interests and profiles [3].

There is still a gap between the educational and professional contexts, when it comes to training and preparing students for the carrying out of future practises, becoming essential for the teaching institutions to consider the existing barriers, in order to overcome difficulties [4].

Thus, it is relevant to provide a coherent learning with the evolution of the network society, which allows tracing innovative educational paths, interactive and student-centred, because if there is no alteration in the educational processes, the students will feel demotivated and disinterested [1] which contributes to school failure.

"Multidisciplinary approaches to higher education are being introduced by institutions that see valuable alternatives to a traditional, singular degree path." [2, p. 9].

Following this line of thought, and with the aim of presenting a pedagogical approach which is integrative in various areas of knowledge, this article aims to describe an educational strategy based on the Problem-Based Learning (PBL), in which students of the Polytechnic Institute of Leiria, Portugal, were integrated in the project ProLearn4ALL, which intends to seek possible solutions to real problems.

2. Problem-based Learning as an Educational Strategy

"The need for individuals with the capacity and courage to solve societal problems is growing exponentially." [4, p. 71], so it becomes essential to adapt educational strategies to the current needs [1]. Thus, active learning emerges as a strategy that allows the reflection of daily problems, which enables to develop several competences, namely interpersonal and social [5], placing the student in a central role, as they build, rebuild and create their own form of understanding the concepts [6].

In this perspective, the higher education institutions have been making efforts to promote pedagogical changes in order to motivate the students to actively acquire knowledge [2]. However, it is necessary to create work conditions that enable the interaction with peers and stimulating learning contexts [6], productive spaces of practices and experiences that give the student the responsibility for their learning [5].

These educational strategies allow the aggregation of new knowledge to the existing one, making learning a dynamic and meaningful process [6] that contributes to increase students' satisfaction and motivation to acquire knowledge [7].

However, for these strategies to become effective, it is necessary to adapt to the different roles: the student should take on a central role in their learning, and the teacher should guide this process, since "There is a need for mentoring and coaching as students work through complex problems to explore new frontiers and gain concrete skills." [2, p. 7]. Hence, the teacher shall become a facilitator of the learning process, in order to allow the student to seek alternative solutions to the non-routine problems arising from daily needs [8].

The Problem-Based Learning (PBL) emerges as a pedagogical strategy that enables active learning through the resolution of issues that arise in real contexts [9], since the student is encouraged to research, gather and analyse data that allows them to reflect on the decisions to make in order to solve problems [10].

Based on these premises, Yew and Goh [9] consider that, a student that experiences this type of strategy can retain the knowledge and apply it in the long term, since when confronted with a certain problem they need to find adequate answers, allowing them to later create analogies in new contexts that need different solutions. From the implementation of PBL in educational management contexts, Hallinger and Bridges [11] highlight six major characteristics: (1) the starting point is a problem and not the theory; (2) learning is based on a problem that may arise in the student's future professional practices; (3) learning is based on the problem and not on curricular concepts; (4) the student is responsible for their learning; (5) learning arises from the carrying out of group work and not from lectures; (6) the students present potential solutions to the problem, obtain qualitative feedback of their work.

Ulger [8] presents the cyclical process of problem-based learning related to the experimental study that he conducted, but illustrates well the various phases that constitute it (Fig. 1).

This iterative process has as its starting point the presentation of the problem, on which the students should research the information that allows them to describe the state of the art and identify existing solutions. Thus, it is possible to identify the needs that will allow the conducting of new researches that are more detailed and a joint reflective discussion. This cyclical character generates brainstorming of ideas that may culminate in suggestions for potential solutions. The teacher, as moderator of this sequential process, poses questions to the students, instead of giving the solutions, encouraging the creative and reflexive thinking, which contributes to generating possible solutions that can be tested, enabling to identify new problems.

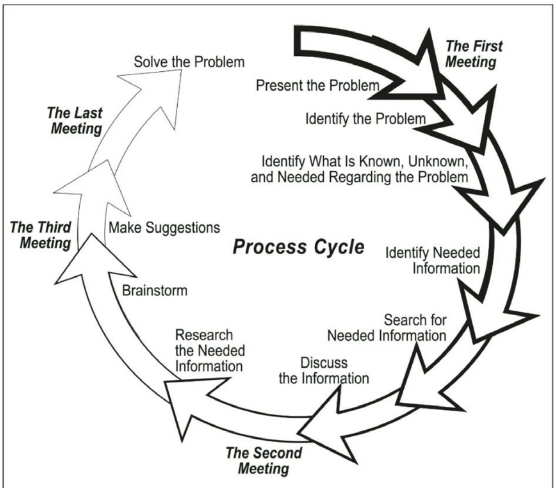

Figure 1. PBL Process Cycle

Fig. 1. Cyclical process of problem-based learning [8, n.p.]

3. ProLearn4ALL Contributions to a Problem-Based Learning

The ProLearn4ALL arises from the need to create awareness in Primary School students to the problem of exclusion. Thus, in order to encourage positive attitudes towards people with disabilities and promote social inclusion [12], this project aims to create inclusive ludic-pedagogical products that increase the children's knowledge on the characteristics of the various areas of disability.

The project is developed by the Polytechnic Institute of Leiria (School of Education and Social Sciences, School of Arts and Design, Inclusion and Accessibility in Action Research Observatory – CICS.NOVA.IPLeiria-iACT and the Research Laboratory in Design and Arts) with the partnership of the Polytechnic Institute of Coimbra (School of Education of Coimbra), and *the Cooperativa de Ensino e Reabilitação de Crianças Inadaptadas* (CERCILEI) and Municipal Hall of Leiria. The team consists of fifteen teachers and researchers and a scholarship holder and includes the active participation of students from various study cycles in Higher Education (Higher Professional Technical Courses, Undergraduate Degrees and Masters Degrees) in various areas of knowledge (education, arts and design).

With the purpose of creating ludic-pedagogical products that are accessible to primary school children, and that approach the four disability domains (hearing, intellectual, motor and visual), some initial questions were made, such as: What type of characteristics should the pedagogical products have in order to become accessible to ALL primary school children?; Which production processes are more efficient to create high value products that are accessible and innovative?; In what way can the use of the products increase knowledge for Special Educational Needs and promote inclusion among primary school children? These questions made it possible to establish objectives: Gathering data on innovative and accessible ludic-pedagogical materials that exist in the market; Developing conceptual proposals for innovative and accessible ludic-pedagogical products; Developing the design and illustration for the obtained proposals; Producing the respective prototypes; Testing the prototypes in primary schools; Reformulating the final products and validating them with specialists in the areas of inclusion and accessibility [13].

ProLearn4ALL has, as a great premise, problem-based learning, in which every phase of the project the starting problem was introduced in the form of a question:

How can we create awareness in Primary School children toward inclusion and help them to respect diversity, especially regarding disability? The general lines of the project do not provide solutions, but rather the incentive to look for answers.

The interactive process (Fig. 2) is not closed, so in all the phases, depending on the knowledge that the students acquired and the respective proposals presented, the products created may vary in their concept or form.

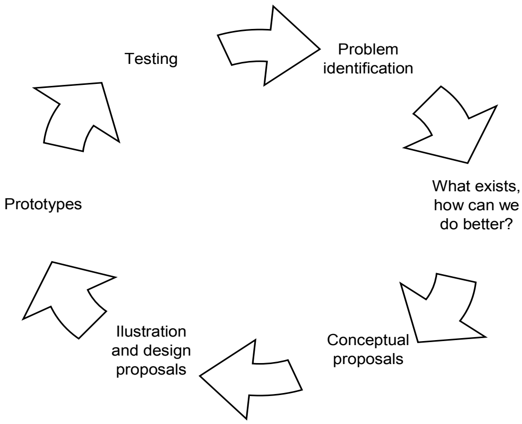

Fig. 2. ProLearn4ALL – Cyclical process (adapted from 9, n.p.)

In the first phase, Master degree students were invited to elaborate researches on existing accessible ludic-pedagogical products. Various board games adapted to people with visual disability, multi format books, videos with interpretation in Sign language, among others, were found. The literature review was used as a basis to the students of undergraduate degrees in the area of education, who working in a team, formulated conceptual proposals for accessible ludic-pedagogical products and in some cases even created prototypes. From these proposals arose tactile books, sound games, games of physical activity, among others.

The proposals of these students were reviewed by colleagues in the area of Illustration and Design which then started the third phase, in which they needed to find solutions that allowed the products to be attractive, but accessible to the children's diversity.

After defining the design options, the fourth phase was started, in which prototypes were created, considering all the alterations that occurred in the previous phases.

This phase had a longer than expected duration, since after the creation of the tests, many times the product was found to be ineffective regarding the accessibility, and a reformulation was necessary.

Currently the project is in its fifth phase, in which we aim to test the products in the primary schools. This work will be elaborated by students of the Higher Education who will be, in a near future, primary school teachers. After this phase, data will be collected which will allow us to evaluate the products and to analyse if a new reformulation will be necessary.

4. Final reflections

"As higher education continues to move away from traditional, lecture-based lessons toward more hands-on activities, classrooms are starting to resemble real-world work and social environments that foster organic interactions and cross-disciplinary problem solving." [2, p. 9]. The potential of problem-based learning stands out, since it encouraged the involvement of students whose contributions resulted in valid proposals that served as a basis for the creation of resources.

The fact that it is a project with a direct application in a real context allowed for an active and significant learning, which contributed to the participants' motivation, increasing their reflexive skills and empowering problem resolution in future situations.

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Project Based Learning, its Realization and Influence on Pupil's Learning

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Abstract

Project based learning (PBL) is one of the organizational forms of teaching in line with the ideas of the founder of pragmatic teaching John Dewey. However, the word "project" is often overused and features many school activities that do not meet the principles on which PBL is based. From the above information, it is clear, that realizing PBL instruction in accordance with its original principles involves a detailed examination of its methodology by the teacher. Project instruction is primarily based on group work. The pupils' teams solve the themes that are associated with their everyday life. These topics must have an inter-subject character. The specific topics of PBL must be based on the interests of pupils themselves. The aim of the paper is to monitor the implementation of PBL in science lessons in the Czech, with respect to the original philosophy of PBL instruction formulated by John Dewey and the PBL methodical pillars. The data was obtained through semi-structured interviews and the attendance method. It has been found that teachers often fail to comply with the PBL methodology. The subject of our research was the extent to which teachers respect the idea of project-based learning with respect to the initial pillars defined by Dewey, defined by Dewey. The results of the interviews were recorded in tabular form.

Keywords: Project based learning, Realization of project based learning, Secondary school, Biology education

1. Introduction

The first ideas about the design of the PBL were based on the criticism of the Herbart school, the basic model of teaching in America and Europe at the turn of the 17th and 18th centuries [5]. In connection with the criticism of the Herbart school, the PBL began to be implemented to the school education. The roots of PBL can be found in the United States of America at the turn of the 19th and 20th centuries in the pragmatic pedagogy of John Dewey [2], [5]. The principles of PBL can be found by authors, compare e.g., [2], [3], [8], [10], [11], [12]; the works of the authors show an emphasis on the interdisciplinary character of PBL. The principles of the work are the team solution of situations, problems or activities related to pupils' lives. All the sub-activities and methods used during the work on the school project must then lead to the creation of the final product. This is either visual or written and is properly reflected and evaluated in the final.

At present, PBL is very popular in Czech education, as is evident from school education programs that are based on the requirements of the Framework Educational Programs [1]. Although design education is often found in schools at present, the question remains whether the term "project" is implemented in the teaching process in accordance with the principles of this organizational form [10]. Another question remains whether there is no confusion between PBL and Problem based learning [9].

According to Thomas [12], we base our research on the following PBL pillars: a) PBL must be a central form of teaching, so it is not possible to repeat or practice the already studied substance; b) PBL must be planned in conjunction with the interest of pupils, so the teacher should not think of the subject himself without any interaction with pupils; c) The subjects taught through PBL should be of an interdisciplinary character; d) The output of PBL should be a realistic product, it should go beyond school boundaries, only presenting pupils' results is not the required output; e) PBL theme should be authentic in line with the world in which we live, that is, the pupil's everyday life.

PBL is very closely linked to the internal motivation of pupils, if the teacher respects the pillar regarding the choice of the subject of project instruction by the pupils themselves, this teaching is very effective [9].

2. Aims and methods

The aim of the paper is to present how PBL is methodologically included into classes in observed schools in accordance with the principles of PBL pillars. There were 3 research questions: How do the selected teachers take into account the pupils' interests when designing the PBL? Is the principle of the interdisciplinary character of PBL respected? What benefits do teachers see in PBL for pupils' learning?

The data was obtained using a qualitatively designed study, with semi-structured interviews and participating observations. The selection of respondents was done by studying information on the realization of project instruction in science subjects on the website of the Prague grammar schools. Selected were grammar schools, where PBL featured in the School Educational Program. The school directors contacted by the authors connected them to the certain teacher who was involved in the project teaching in natural sciences. These teachers were subsequently approached and the term of interview and participating project observation was agreed. Finally, four teachers were recruited to carry out the research.

The semi-structured interview method was selected for personal contact with the respondent and thus the possibility of obtaining authentic answers with the possibility of asking if necessary. The conversations were recorded on the recorder with the consent of the teachers. The open encoding method was used to evaluate semi-structured interviews. In addition, the method of participating observation was used, when the author was present at one or several hours during project instruction at the grammar schools. A record sheet was used to record the research data, which was used to obtain more accurate information about the design and course of PBL.

The method of participating observation was evaluated by qualitative analysis and subsequent description of the phenomena and processes observed in their context.

3. Results and their comments

The results of the semi-structured interviews are presented in the Table 1. In the table, we use codes from the open encoding method, according to which the interviews were evaluated. In the fourth column, we provide the entire sentences with the answers given by the teachers.

Teacher (T)	**Sources of information regarding the implementation of PBL**	**Who initiates topics for PBL**	**Influence on pupil's learning in the opinion of teachers**	**Inter-disciplinary character of PBL**	**Way of PBL output**
T I.	practice from university internet	both the teacher and the pupils	*Pupils learn to formulate questions and search for answers.*	no – only biology	oral presentation of the results
T II.	internet	pupils	*PBL links pupils' own experiences and the topic of lessons.*	no – only biology	practical demonstration + subsequent processing on posters
T III.	internet	teacher	*Pupils practice and fix the topic discussed in previous hours.*	no – only geology	oral presentation of the results
T IV.	inspiration from lessons of colleagues magazines internet	teacher	*Pupils learn to collaborate and communicate in a group through their own activities.*	no – only biology	oral presentation of the results

Table 1. Results of semi-structured interviews and participating observations

From the data results, it can be stated: only one teacher said that "his pupils have absolute freedom to choose the subject", that is, "the theme stems from their current interests". In one case, the teacher replied that "the theme was left to the pupils' interests", but on the basis of the participating observations of the PBL, it emerged that the teacher commissioned the topic; the pupils had only the freedom to choose some subtopics.

The result of PBL is not realistic and usually ends with a mere presentation of the results before the class and the teacher.

In all four cases, PBL lacked an interdisciplinary character; three projects concerned biology, one geology.

On the basis of the participating observations, it was found out that PBL are repeated, practically practiced, or extended topics from previous lessons.

Teachers often use already prepared suggestions on PBL acquired from the Internet, books, and his colleagues.

4. Discussion and contemplation

PBL is currently very widespread, among other things due to the introduction of Framework Educational Programs that emphasize activating methods and forms in teaching [1], [10]. From the results, it is possible to see the fact that the supervised teachers integrate the project teaching into their hours, but without deeper study of its methodology and principles.

However, this is not in line with the principles of PBL that can be traced to a number of designers, compare e. g., [5], [10].

The interviews also showed that teachers are inspired by each other. This can be assessed positively. However, they also accept mistakes, including the presentation of pupils' results without any concrete further output.

On the other hand, it is commendable that an organizational form such as PBL is incorporated into Czech schools, since any change from frontal education can cause curiosity and interest in pupils.

Although there are many literature presenting ready-made project ideas, which can lead teachers to be only mechanically taken over and implemented in teaching, we consider it is necessary to adapt these finished materials to the current conditions in the every single classroom.

Considering this fact and also one of the above mentioned pillars that project instruction stems from the interest and motivation of the pupils themselves, it is advisable to subject already prepared materials to criticism and at least minimal transformation for the class. This pillar can be considered as one of the most important, as pupils are always much better motivated if a topic arises from them themselves [11].

5. Conclusion

The paper presents the issue of PBL, an organizational form of teaching, in accordance with the original methodical pillars defined on the basis of professional literature. At present, the word project is used in many connotations, which can lead to misinterpretation of PBL in schools. The main objective was to map the methodology and implementation of PBL on selected Prague grammar schools, using the method of semi-structured interviews and the method of participating observation.

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School Resources for Situations Involving Religious Matters

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Abstract

This contribution discusses the analyses of the resources used by teachers to deal with school situations related to religious matters in secondary schools in Brazil and France. The constitution of resources for teaching does not come only from professional experience, mainly in the Brazilian case, where there are no official rules or prescriptions. On the other hand, there are many prescriptions concerning secularism (laïcité) in France. Thus, it is questioned: are the prescriptions used as resources in France? What are the resources mobilized by teachers in situations involving the religious question in Brazil? Are they different? Why? Our supposition is that the resources used in teaching practices are consistent with the plurality of references that constitute teaching identity. Based on ethnographic interviews with eighteen teachers in the State of São Paulo and the same number of teachers in Lyon, 109 situations involving the religious question were collected. The resources used by the teachers in those situations were analyzed. In this article we are going to discuss the fact that most resources used by Brazilian teachers came from personal experience, while French teachers mobilized professional resources. The discussion we propose explores the close association between socio-cultural configuration characteristics, available resources and social comprehension of the interface between religion and education.

Keywords: Teaching Practices; Religion; Teacher Training; Resources; compared education study

Teaching practice is a set of actions that results from the accumulation of professional and personal knowledge and values that are built through exchanges, training and experiences. It is defined not only by the visible actions of the individual, but also by what he/she thinks and the way he/she expresses himself. Teaching practice is reaffirmed by the professional group in the process of professional socialization and by the institutional group, in which ways of being, acting and thinking are legitimized or rejected by peers. In this perspective, teaching practice is individual and collective and can not be disconnected from a whole (FRANCO, 2016) [1], since it is seen as “resonance and reverberation of mediations between society and classroom” (p. 548). Thus, in addition to interacting with colleagues in the profession, the teaching practices are built in conjunction with interaction with students.

As a social institution, the school is porous and therefore reflects what happens in society. In this communication, we will be interested in the school situations that involve the issue of religion. More specifically, we question the resources used by teachers to manage situations involving religious issues. We understand resources as elements used in situations, which can be incorporated/internal to individuals (such as competencies and dispositions) or external to the actor involved in the situation (such as human and nonhuman actors).

This is an approach of compared education, identified here as the crossing of several paths: interdisciplinarities, articulation between macro, meso and micro social levels for the understanding of educational processes lived by the actors in their social contexts (FRENAY, 2008) [2]. However, we take care of starting from the micro (teaching practices) to arrive at the macro (social) so as not to run the risk of constructing a false reality, as Thévenot (2001) [3] warned. In addition, it is not intended to make a generalization of the two countries, since it is a study located in an economic capital (São Paulo) and the third French city (Lyon), each with very specific characteristics that do not represent the country in which they are located.

It is assumed that the resources used by the teachers are guided by creativity composed of the diversity of understandings and by references to the sacred, which would characterize a domestic logic in the Brazilian case, and in the French case, alludes to a secular order linked to elements of common interest, which would represent a civic logic.

To verify these hypotheses, we asked for the 38 Brazilian and French teachers interviewed to describe their school situations involving the religious question. We collected 109 situations in which religion was present in the school. The delimitation of the situations allowed us to identify and analyze the individual actions, their objectives, their resources and related logic. Focusing only on resources, we arrive at the following research result: the analysis category related to the resources in the situations is the one with the greatest plurality. In France, the most commonly used resource for teachers is professional habitus, that is, their knowledge of the profession, the discipline taught, class management and knowledge of the context. In Brazil, the main resource is composed of personal dispositions of the teacher. In this text, we will discuss these results.

Usually the instruments of action are those that are available at the moment, i.e. those that are judged by the teachers as the most appropriate to deal with the situation which is often imponderable. Mobilization of these available resources depends on the ability and competence of teachers to use them. In turn, such skills and competencies are acquired from life situations and incorporated dispositions. The specific characteristics of a situation, with its social interactions, resignify the resource used and contribute to subjective transformations of the identity of the actors. Much of the constitution of resources takes place in activity and allows teachers to affirm that their teaching dispositions are acquired in the exercise of their profession.

In the Brazilian case, the inseparability of the identity of teachers (VALENTE, 2018) [4] is also the result of the absence of professional ethics in Brazil, that is, of an ethical reflection on the tensions and dilemmas of the profession that would ideally begin in the training courses of teachers. According to Prairat “Deontology is the place where professional solidarity is made explicit and where the distinction between public (professional) identity and private identity (of the person) is affirmed”. (2009, pp.151-152), [5].

Our research results point to a greater use of professional resources by French teachers than by Brazilians. One explanation would be that the identity of the French teacher is related to his professional socialization in the establishment, with the discipline taught (VAN ZANTEN *et al*., 2002) [6], with republican values and with a civic logic of action. In the case of Brazilian teachers, we perceive a greater tendency for professional socialization to occur from multiple references, being categorized in this study as coming from personal and professional experience. Since their main argument was to preserve individuals right of choosing their own religion, the privileged logic of action was liberal and not domestique, as supposed in the beginning.

The concept of hybrid dispositions of habitus was created to explore a particularity of Brazilian modernity (SETTON, 2002) [7] and facilitates the understanding of the prevalence of the use of personal resources by Brazilian teachers. These dispositions result from hierarchies of multiple references in the life of an individual (SETTON, 2016, p. 96) [8] and result from the socialization effects of different spaces (ALVES, 2015) [9]. Another particularity of Brazilian society is that there is no separation between the domestic and the professional spheres, which promotes conditions of possibility for the construction of hybrid dispositions of habitus (SETTON, 2002) [7].

In the case of a southern country (MARTUCCELLI, 2010) [10], the institutional framework or state strength in Brazil is smaller than in France, leading to a devaluation of the public school, a precariousness of the conditions of professorial work, a reflective fragility of training courses, etc. The state weakness causes individuals to seek references from social ties and not from deontological principles, often using common sense, dialogue, and personal experience as a resource to manage situations in the professional context. Consequently, the absence of a strong state confirms the liberal logic, in which the individual counts only on his/her freedom and with his/her ability to create, produce and interact for his/her survival in society.

With regard to the religious question specifically, the use of resources derived from the personal experience of teachers can be explained from three social facts.

The first of these is related to Brazilian history, which does not pass through a rupture that separates the public sphere (secular) from the private sphere (religious).

That is, even if the decree of separation between religions and state was signed in 1890, religious institutions continued to have an important role in meeting the social needs of state responsibility. Secondly, on education, in the law of guidelines and bases for education [11], the way in which the discipline of Religious Education is presented ("an integral part of the basic formation of the citizen") legitimizes religion and religiosity as a pedagogical tool. Finally, in the social, mediatic or teacher-training spheres, there are no discussions that denature the mixture between public and private space, that approach the theme of secularism (laïcité) or that question the entrance of religion into the school.

Where institutions are strong, as in France, what prevails is a less hybrid socialization, where the weight of the school and the state allow, for example, that everyone knows what secularism (laïcité) means and that each one is their defender, even if by different means. The use of resources derived from the profession itself is also explained by the great working conditions of these teachers.

The debate on the interface between religion and public school in France begins in 1905, when there was a law of separation and implementation of secularity (laïcité).

Among the many documents that are in place today, the "Charte de la laïcité", intended for all schoolchildren, published in 2013 [12], the "Livret de la laïcité" published in 2015 [13], for teachers and the manual or "La laïcité à l'école" for leaders of school institutions, published in 2018 [14]. These materials are guidelines that circumscribe the teaching practice and deontology, even if they are not an explicit resource for teaching practice in the analysed situations.

Teachers, as public French officials, must obey the principle of neutrality and discretion regarding their religious beliefs. The restriction that concerns students arises from the law of March 15, 2004 [15], prohibiting the use of ostensible religious symbols for students. Ostensible symbols are symbols that would attract attention of other students and, in this way, put pressure on the others. The argument used is that the purpose of the republican school would be to distance ideological representations to protect the minor's own existence. In addition, the law instructs teachers to discuss with students before taking corrective action. All these regimented and legitimized norms are, at the same time, obligations and teaching practice resources, which explain why French teachers mobilize professional resources when confronted with a religious situation.

In agreement with Dubet and Martucelli (1996) [16], in which the construction of identity takes place through a double process of socialization and subjectivation, the resources mobilized in the teaching practices of French teachers would have a greater influence of professional socialization, while the resources of Brazilian teachers would have foundations in a subjectivation with multiple references. However, the multiplicity of training routes could be detrimental to the professional socializing process, leading to a precariousness of teaching work, as suggested by Lüdke and Boing (2004) [17].

By itself, the teaching profession consists of fragmented groups, for example, teachers have their trajectories of formation divided by disciplines, by stage of education, by the status of the school (public or private), among others. This disaggregation makes the plurality of resources intrinsic to the profession, although it is an obstacle to the creation of a single and coherent educational deontology. Thus, the resources are chosen according to the situations in order to justify the logic of action, taking into account the unpredictability and plurality implied in the situations.

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Self-Regulation of Pedagogy Students

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Abstract

In process of promoting self-regulated learning, the role of teachers is crucial one. Self-regulation could be described as the ability of an individual to change his own behaviour. Because of this ability it is possible to change our behaviour towards certain requirements. At the same time, self-regulation is understood as a vast ability of man to have a control over their inner state, processes and behaviour. Teachers with well-developed self-regulation skills are better at adapting their learning approach to their own skills and become more effective in the educational process. That is the main reason, why we have decided to focus on the self-regulation process of students of pedagogy studying at universities in the Slovak Republic. As our goal in this article is to look at and investigate the self-regulation abilities of university students, we chosen to use the questionnaire developed at Center for Research on Learning at University of Kansas, which is known as the Self-Regulation Questionnaire. The Self-Regulation Questionnaire is designed to measure a student's proficiency in the four essential components of self-regulation, which are Plan (for what you want to accomplish), Monitor (progress and interference regarding your goal), Control (be able to change by implementing specific strategies when things are not going as planned), Reflect (on what worked and what you can do better next time). As teachers often work in an environment which is tightly controlled and their own self-regulation abilities are often tested, therefore they need to possess strong determination and adequate self-reflection.

Keywords: control, self-regulation, The Self-Regulation Questionnaire, students, teachers

1. Introduction to Theory

Self-regulation is in other words ability to control and manage your-self. It can be described as the capacity to tell your-self what to do and what not to do. Self-regulation is learned from early childhood and it is also one of the main objectives of education. This process consists of guidance, ability of self-control and setting own limits in relation to others. The capability to think and to comprehend is an important element of self-regulation. A certain level of intelligence is required for the process of self-control. It can be understood as a kind of internal struggle with your-self. It is the human psyche that performs oversight of own functions, states and internal processes. Within these stages humans try to gain control over their own ideas, feelings, impulses and performance. By means of self-regulation, person directs own living and own behaviour. That leads towards satisfying his own needs and intentions.

The most important self-regulatory features of the personality include: self-awareness, self-knowledge, conscience, self-esteem and will [1].

For a person to be able to know what kind of person he is, what he knows, what he is capable of doing, how does he define himself and his options. Person must have the knowledge about:

- *own body,*
- *own values and opinions,*
- *memories and experiences,*
- *feelings,*
- *knowledge,*
- *skills and competences,*
- *how the others perceive him,*
- *ideal ideas about him-self and who he is and what he would like to be* [2].

Self-regulation as the ability to control own behaviour and emotions is one of the decisive competencies that manifests itself as specifically human [3].

Intentional self-regulation is an essential aspect of human functioning, which involves the adaptation of own thoughts, attention, emotions and behaviour as a response to environmental demands [4]. The self-regulation strategies also act as protective factors that positively influence a human life. Self-regulation could be also described as a self-care. Regulated behaviour is based on processes that include knowledge and experience. By means of self-regulation, one can change his behaviour to be able to achieve his goal and would not allowed him-self to be controlled by automatic, reflexive and instinctive reactions to stimuli [5].

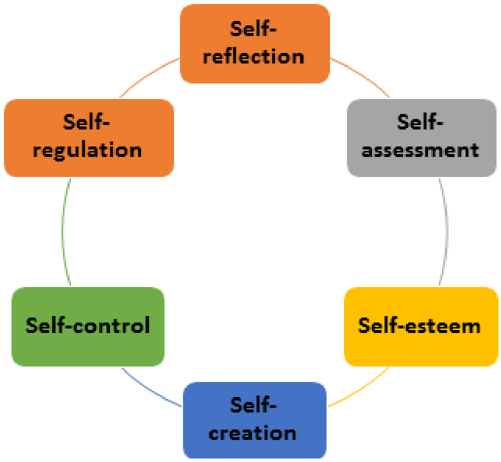
Teacher is the main organizer and implementer of education process. Teacher's personality is understood as a general model of a person's personality, characterized in particular by psychological determination [6]. The process of creating a teacher's personality is very important. The relation between the structure and the dynamics of the personality is understood as the most complicated part in the development of personality. It may also be called as the way to recognize one's personality. The following components are important for the personality of the teacher:

- *psychological resistance,*
- *adaptability of adjustability,*
- *ability to learn new knowledge,*
- *social empathy and communicability.*

The influence and formation of the teacher's personality depends primarily on the innate powers-pedagogical talent, from self-education, self-improvement, to the intensity of the teacher's interest. This process of formation of teacher's personality starts as early as he starts his preparation for the future profession, known as teaching practice. Each teacher is expected to have some degree of creativity. Creativity can be gained from experience, but it can also be the result of self-education. The success of the self-education of a teacher depends on his ability from thinking about own pedagogical work. From his ability to see its positives, its shortcomings and eliminate them. The personality of the teacher enriches the student's experience and shapes his personality [7].

The essence of teacher's educational activity forms student's personality. It is actually a certain sum of teaching knowledge and skills, ways of behaviour and personal qualities. The teacher educates students mainly by his own behaviour. He is a role model for them, an example that students imitate, and they might even try to be like him. Teacher does influence his students in both, in positive as well as negative way. The relation to oneself is specific, as it includes high standards of self-demands, process of own improvement and higher niveau of self-regulation.

Teacher's professionalization is extensively effected by his readiness for his profession. There are six main features that high quality teacher should have [8]:



Graphic 1. Six main features of high quality teacher

And because of above features we are inclined to think that teachers with well-developed self-regulation skills are more suitable for adapting their learning approach to their own skills and are much more capable of becoming more effective in the educational process.

2. Methods and Participants

The survey sample was composed of N=143 students (freshmen at university) studying pedagogy of natural sciences, social sciences, languages, arts and educational subjects at university in the Slovak Republic, Constantine the Philosopher University in Nitra, Faculty of Education.

We have chosen to use the questionnaire developed at Center for Research on Learning at University of Kansas, which is known as the Self-Regulation Questionnaire [9].

The Self-Regulation Questionnaire is designed to measure a student's proficiency in the four essential components of self-regulation, which are:

- **plan** – for what you want to accomplish,
- **monitor** – progress and interference regarding your goal,
- **control** – be able to change by implementing specific strategies when things are not going as planned,
- **reflect** – on what worked and what you can do better next time

Students have completed the questionnaire by self-rating items on a 5-point, Likerttype scale. This scale ranges from 1 (Not very like me) to 5 (Very like me).

The Self-Regulation Formative Questionnaire was developed in 2015 by Research Collaboration. An extensive review of related research resulted in the identification of four components essential for self-regulation. Self-regulation requires students to plan what they want to accomplish, monitor progress, take control and make changes when things don't go as planned, and then reflect on what worked. The questionnaire was tested for reliability using Cronbach's coefficient alpha[2] with 5,543 high school and middle school students during the 2016-2017. The overall self-regulation questionnaire was found to be highly reliable (22 items; α=.896). The plan subscale consisted of 5 items (α=.632), the monitor subscale consisted of 6 items (α=.704), the control subscale consisted of 6 items (α=.744), and the reflect subscale consisted of 5 items (α=.682).

3. Results

As we have already mentioned, the research sample was made by 143 students of academic subjects. The questionnaire consists of 4 self-regulation areas; each area contains 5-6 questions. We share opinion of researchers [9], that these 4 areas in the questionnaire reflect self-regulation not only during the study, but also during professional training and throughout life. As can be seen in Table 1, the average was always greater than 3 which is the middle value for the 5-point Likerttype scale. The highest score was in the area of control. We can argue that the areal of control is the most common among students, that means that they control their roles and goals.

Kurtosis was found -0.57 of Plan, therefore, the values are not distributed close to normal in the file. Skewness is the highest in the field of control, that means that students were close to the average and as it is a negative value, they marked more options that are on the right side of the average. Standard Deviation is an average of 1.03 if we evaluate all areas together.

Table 1. Descriptive statistics for every area of the questionnaire

Area	N	Mean	SD	Kurtosis	Skewness	Sum
Plan	143	3,36	1,09	-0,57	-0,34	480
Monitor	143	3,61	1,07	-0,37	-0,46	516
Control	143	3,72	1,00	-0,23	-0,53	528,5
Reflect	143	3,48	0,97	0,13	-0,37	497

**Note: N = number of participants. SD = Standard Deviation*

Regarding frequency, the most responses, among all the answers were Option 4 – Mostly like me. In Figure 1, we can see all answers frequencies, only in the Plan is the order of the third and fourth answers is different. Otherwise the ranking in the other areas are same, 4-3-5-2-1. Because of that we can assume that all the areas represented in the questionnaire are about the same level. The questionnaire was helpful both for our research and for the students them-selves. When a student has calculated his points, the sum of points is equal to his level of self-regulation. Higher number of points means better Self-regulation.

Fig. 1. Frequency of areas

Despite the fact, that results do not show the situation as alarming, we are still convinced that the self-regulation score should be higher for group that is made of future teachers. The average number of points obtained in the questionnaire was 74.

The self-regulation leads to self-awareness and people with higher self-regulation are capable of controlling their own reactions and manage their own emotions [10].

A higher degree of self-regulation is necessary for the work of the teacher. Self-regulation is essentially based on the theoretical assumption that individuals are important actors in their own development.

4. Conclusions

We came to the conclusion that the self-regulation refers to the proactive application of self-regulatory processes, cognitive behaviours, emotions to obtain goals, learn skills and guide own emotions. [11, 12]. Self-regulated students are metacognitive, behaviourally and motivationally active actors in their own learning process [13].

The self-regulation process could be interpreted as making a plan, monitoring that plan, making changes to be able to stay on track, and reflecting on what has worked and what could be improved the next time [14]. The self-control, confidence, and knowledge gained from self-regulation provide students the perseverance and skill to fruitfully navigate their studies and careers. Implementing self-regulation improvements students' organizational ability and builds healthy work habits. The self-awareness and self-critiques used in self-regulation assist students to stay on track and continue their toward goals, to work well with others and to adapt to new situations.

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Space Representation and Gender Differences: A Flipped Approach to Geography Teaching

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Abstract

According to recent literature, men and women do not process spatial information in the same way (Berthoz, 2009). The origin of these differences is not known, but experimental evidences demonstrate a huge variety of strategies the representation of space according to sex, context, purpose to reach, education, age. Our assumption is that the different behaviors between genders is important in studying geography, in particular in use of maps. Using maps, if concurrent with navigation, implies a transformation from the egocentric perspective to the geocentric perspective, which is one of the aspects in which gender-related behaviors mainly differ.
This peculiar problem is inscribed, in Italy, in a broader framework that sees an educational emergency linked to the study of geography. This emergency arises from the reduction in the number of hours dedicated to the discipline and the distance between the theoretical dimension of human geography and the need for practical activities that make teaching effective.
The Flipped Classroom model provides a complementarity among the logics of problem solving, learning-by-doing, and reflective learning: activity is at the center of didactics, learning is experienced in the first person, matures through the execution of a task and is finally remodeled through a discussion, and a teacher-guided correction. The expert knowledge of the teacher is fully profitable to the extent that he is questioned by the student, involved in solving problems, called to give his point of view in the discussion of a case.
This article proposes some teaching activities, based on the flipped classroom, which were designed and developed keeping in mind gender differences, providing a series of equivalent teaching materials that matched the different cognitive strategies.

Keywords: Spatial information processing, Gender, Flipped Learning

Introduction

DiSalle indicates how the topic of space constitutes a common thread, an uninterrupted debate from Newton to Einstein:

"…when Newton appeals to absolute space, he does not advance any theses about the ontology of space-time. Rather the postulation of absolute space and time is inspired by empirical reasoning about motion. This theme unites Newton with later physicists: At the very least, we can identify a common metaphysical principle uniting general relativity with special relativity and Newton's theory: space-time is an objective geometrical structure that expresses itself in the phenomena of motion." [1]

The philosophical debate on the ontology of space, in extreme synthesis, has been incardinated on two specular positions: an idea of absolute space, according to which space and time exist independently of objects and object relations (or, more radically, based on to which space and time exist), and an idea of relative space, whereby the existence of space and time is linked to objects and relations between objects (or, more radically, for which space and time do not exist at all) (DiSalle, 2006).

The Kantian position, which saw space and time as a priori frameworks, was the object of the subsequent elaborations of Poincaré and Einstein.

During the nineteenth and twentieth century the Kantian conception, both from the philosophical point of view and above all on the objective bases of the new scientific discoveries, was literally demolished.

The recent discoveries in the field of neuroscience have definitively established the indissolubility of the space-mind-body triad.

Neuroscientific investigation does not take space as a category, but frames it from the point of view of brain activity.

"Dans le traitement de l'espace, le problème pour le cerveau, c'est la multiplicité des espaces. Il n y a pas «l'espace », il y a une multiplicité formidable d'espaces.

Deuxièmement, percevoir l'espace n'équivaut pas à percevoir la géométrie, mais à percevoir un mouvement." [2]

The brain, in this perspective, is very far from the idea of a computer of the stimuli coming from the senses, but it represents a "creator of worlds", a "reality emulator".

"Our reality emulator acts primarily as the prerequisite for coordinated, directed motricity; it does so by generating a predictive image of an event to come that causes the creature to react or behave accordingly" [3].

The basis of this discourse is the flipping of the perception-action paradigm.

"We base on our action, and not on representation, our conception of the organism's activity. Perception does not represent the world as it is, but the structure in the Umwelt. [...] There is no perception of the world that does not refer in any way to the acting body" [4].

As for the difference between the genders in space representation, the assumption is that the different behavior between genders is not a variable that intervenes only during the acquisition of the skills being investigated, but that represents a structural difference, and persists into adulthood.

Berthoz summarizes: "there are anatomical and neuroendocrinal bases for gender differences […], but it is now accepted that, whatever the origin (nature or nurture) of these differences, men and women do not process spatial information, for instance, in the same way" [5].

For travel memory, women tend to adopt more egocentric and sequential strategies. Berthoz suggests that this is related to their preference for what can be verbally mediated. In other words, women prefer a verbal description of travel, which is of a sequential nature. This is probably due to the cerebral lateralization process.

Men, on the other hand, prefer more allocentrics strategies. In general, males are statistically more efficient in mental rotation tasks, such as changing perspective by reading a map. Some studies point out that the mental representation of large environments in males contains more "metric" information in men than in women, while females relied more on information about the actual references in the environment during navigation.

On the whole, variation between men and women tends to be smaller than deviations within each sex, but very large differences between the groups do exist in men's high level of visualspatial targeting ability, for one [6].

The evidence that emerges with certainty from diverse studies is, however, that of a huge variety of strategies that differ according to sex, context, purpose to reach, education, age, and profession.

Our assumption is that the different behaviors between genders is important in studying geography, in particular in use of maps. Using maps, if concurrent with navigation, implies a transformation from the egocentric perspective to the geocentric perspective, which is one of the aspects in which gender-related behaviors mainly differ.

This peculiar problem is inscribed, in Italy, in a broader framework that sees an educational emergency linked to the study of geography. This emergency arises from the reduction in the number of hours dedicated to the discipline and the distance between the theoretical dimension.

Our assumption is that Flipped Classroom Model could provide a teaching approach which can fit gender peculiarities in geography learning.

Flipped Learning

The Flipped Lesson is “flipped” because it reverses precisely the usual order of the didactics: traditionally you get the information with a front lesson and then study at home; in the Flipped Lesson, at least in the inevitable simplification that followed the dissemination process, a student studied at home before, and works in class with the teacher at a later time. The accent, in short, has fallen on reversing work time at home/work at school. The meaning we propose here is closer to the methodology of the Episodes of Situated Learning. To be overturned are not primarily the times and the relationship between home and school; The subject of flipping is the didactic actions: what does the teacher do and what the pupils do.

According to the synthetic and effective reconstruction elaborated by Piercesare Rivoltella [7], the idea of a “flipped” methodology is focused in the 90’s by Eric Mazur [8], at Harvard University addresses it to explain the function of the computer in the learning process; in the following years it is being revived and developed in several contributions that now speak of “inverted instruction” and “inverted classroom” [9], “classroom flip” [10] becoming a a slogan (“Flip your classroom!”) and entering common use.

The concept of Flipping Learning today is used to decode one of the possible uses of Blended Instruction, the use of technologies to make available to students the material they need to practice pre-learning before confronting the teacher.

In Flipped Lesson you get the information freely exploring different materials pre-selected by the teacher, and you are confronted later with the teacher. The sequencing of an articulated Flipped Learning Object is scanned in three phases:

- an exploratory moment in which the teacher starts curiosity about the new topic through a stimulus and gives students the opportunity to satisfy this curiosity through free text exploration (text, videos, images, audio, maps, games) pre- selected;
- an operational moment in which the information obtained by the student in the first phase is useful in supporting the production of an artifact through work in small groups;
- a final debriefing time in which the artifact processed at the second moment is subjected to critical review by presentation and sharing.

Approaching Geography through experience (i.e., orienteering practice, map reading) involves a re.thimnking of the restructuring/metacognitive moment management: the nature of the object of the operational stage, indeed, is not an artifact, but a performance.

From artifact to performance: orienteering as teaching strategy

Golden, Levy and Vohra provides a detailed definition of activities and procedures to which is called the athlete who takes part in an orienteering event:

"Orienteering is an outdoor sport that is usually played in heavily forested areas. Located in the forest are a number of "control points" each with an associated score.

Competitors armed with compass and map are required to visit a subset of the control points from the start point (node 1) so as to maximize their total score and return to the end point (node n) within a prescribed amount of time" [11]

Given the type of activity, it is easy to imagine how a scientific approach to orienteering involves a wide variety of fields of knowledge (cartography, geography, medicine, sport sciences, education, psychology, neuroscience) which are sometimes regarded as distant from each other.

National Guidelines for the kindergarten and the first cycle of education, among learning objectives that students should achieve by the third year of secondary school, mention the ability to orient in the natural environment through the reading and decoding of maps.

The selection of the route, in fact, is clearly one of the success factors in orienteering: "There is no doubt that good route selection and proper execution of the five techniques along your route are keys to success in orienteering" [12].

In the practice of orienteering are involved not only the cognitive processes linked to the spatial navigation, but also the "combined task (as well as subtasks) of map reading and navigation" [13].

These tasks are not discrete and separate moments, but represent operations that are managed simultaneously by the brain of the athlete.

The contribution of neuroscience in the investigation of this specific field of study is filling a gap due to the hybrid nature of the research. This gap had already been identified and reported years ago. Robben, in 2004, emphasized how "research into cognitive processes in map reading has been conducted primarily in the fields of psychology and cartography. […] Cognitive studies and spatial ability measures have been conducted for more than 100 years by psychologists and for more than 30 years by cartographers. However, while some studies provide insight into the cognitive processes and strategies associated with specific map-reading tasks, many of these tasks, strategies, and processes have yet to be identified and, possibly more importantly, understood" [13].

Orienteering can represent the ubi consistam of the operational stage in a flipped model to geography, and can allow different performances respecting different gender-based cognitive strategies. The logics of problem solving, learning-by-doing, and reflective learning is complemented and supported in the flipped approach: activity is at the center of didactics, learning is experienced in the first person, matures through the execution of a task and is finally remodeled through a discussion, and a teacher-guided correction. The expert knowledge of the teacher is, in fact, fully profitable to the extent that he is questioned by the student, involved in solving problems, called to give his point of view in the discussion of a case [7].

Conclusion

Orienteering involves directly and primarily cognitive processes that are crucial in the acquisition of the ability to take the perspective of others.

Cognitive processes involved in peculiar orienteering activities (map reading, route selecting, spatial thinking) are involved in the management of intersubjective relationship. In essence, the skills involved in reading maps and in developing strategies for spatial navigation are skills that allow us to see the world from different points of view, abandoning the egocentric perspective, and are therefore involved in educational inclusion-oriented paths.

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Studying Space with Social Networks

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Abstract

The aim of the project is to support the use of technology to encourage the study of science and above all to do research on life in space; it is an opportunity to discover the students' predisposition towards the study of scientific subjects. The project starts from the interest shown by the students in the projects proposed by ASI (Italian Space Agency).
Direct communication through social networks with astronauts, videos published by NASA, the ESA twitter profile, the ***Scientix*** *community website, have supported the participation in competitions for young students of the Aerospace Technology District. The teacher can explain to students how to choose their own sources of information, how to share information and emotions and be creative on the web.*
The training and technological path not only leads to the creation of a new way of storing experiences, but constitutes a cultural heritage available to the student and his/her companions, to be subsequently resumed, revised, modified and eventually improved. The project includes two lines of activity: one oriented to the goal of sensitizing students to the conscious use of tools for educational purposes; a second one oriented to the production and sharing of works realized by the study of experiences focused on space and technology, reported on the websites of the ESA (European Space Agency) and the ASI (Italian Space Agency).
The main phases of the project are basically four: to identify a theme related to life in space, to have an idea and communicate it through posters, web portals, social networks; identify the web tools to create participated activities and stimulate the interest of the students; share the product material; return of the material collected in a narrative and engaging form.
The most modern active teaching techniques are used to stimulate the participants in group work and to understand the problem solving method. The theme chosen, developed by the students and shared on social media is hydroponic vegetation in space. Participant students were aged 14-16, and data was collated through teacher's interviews, classroom observations, students' diaries and concept maps.

Keywords: Space, Science, Social networks, Share

1. Introduction

I became a Scientix Ambassador at the beginning of 2018 and immediately started to develop projects on the study of the STEM disciplines. The aim of this project is to support the use of technology to encourage the study of science and above all to do research on life in space; it is an opportunity to discover the students' predisposition for the study of scientific subjects. The work starts from the interest shown by the students in the projects proposed by ASI (Italian Space Agency).

Direct communication through social networks with astronauts, videos published on the NASA websites, the ESA social profiles, the **Scientix** community website, have encouraged the participation in competitions for young students of the Aerospace Technology District. **Scientix** promotes and supports a Europe-wide collaboration among STEM (science, technology, engineering and maths) teachers, education researchers, policymakers and other STEM education professionals [1].

Scientix was originally born at the initiative of the European Commission and has, since its inception, been coordinated by European Schoolnet, a Brussels-based consortium of thirty ministries of education, which is a driving factor for innovation in teaching and learning and fosters pan-European collaboration of schools and teachers [1]. The project aimed to inform students about research and topics related to the space sciences and to prove to them that space science can be fun and interesting.

Fig. 1. Scientix 3 flyer 2

2. Scope of the project

"Science gives mankind inspiration and aspiration. Space science makes us look outwards from our planet, towards the stars" [2].

My goals were:

- To make science more accessible to students and teachers (through the **Scientix** community);
- Open the minds of the students, getting them used to problem solving;
- Provide a framework for a new pedagogic instruction in the classroom;
- Develop communication skills through scientific discussions;
- Build collaborations between people from different cultural backgrounds and countries;
- Develop a sense of European and global citizenship;
- Support the desire to explore the universe and the rules that regulate it;
- Understand the mechanisms of cause-effect relationships.

The main idea that guided this initiative was to bring the study of space science to the public in general, and in particular to students, through the most used social networks, offering challenges that stimulate intuition and collaboration, and which lead to the "rediscovery" of scientific studies. Explaining science with social networks has involved a major change in the traditional presentation of scientific concepts.

As an ambassador for Scientix, I share teaching strategies with teachers of STEM subjects; a lot of high quality resources and educational opportunities are available online on Scientix and on partner project websites, so very often students only need a device and an Internet connection to access these resources. But of course, they must be made aware of these opportunities. And this is my role as Ambassador Scientix.

3. Methodology

The methodology and the pedagogical approach are based on modern teaching methods, problem, project and learning based on information provided through e-learning platforms. Social media can help students create and manage a large study community; social media make study and communication more efficient for everyone

The phases of the project were:

- *Create a learning environment.*

Designate a hashtag of the course or a name of the study group, start a list of contacts to collaborate and share the materials and invite students, teachers, experts.

The division of the class in heterogeneous working groups stimulated and encouraged the active participation of all the components, as well as tutoring, processing, reasoning and socialization, integrating the learning of each with the sharing of materials, videos, virtual debates through social media.

- *Starting a collaborative learning network.*

Searching for and following the research groups; thousands of students around the world study life in space. Students become followers of researchers, astronauts, teachers who have written books on the subject and ask questions. They save, organize and share learning resources: using collections creation tools like Pinterest, Google Drive, Dropbox to collect study materials.

Use Google Calendar, Hangouts Whatsapp, Skype, Twitter, Facebook, Instagram, to facilitate group study sessions. Look for YouTube videos and playlists for extra learning on the most challenging topics.

Send video notes, questions or reminders to fellow students.

Students are grouped together and have a research to do with the use of social networks. The topics chosen and developed were: the life on I.S.S. (International Space Station), hydroponic vegetation, the tardigrades, the study of orbits.

- *Leading Discussions*

Teacher introduced numerous high quality resources through blogs and social networks. Students are given a topic, decide what problem to examine, and design the procedures to follow. Students are expected to think like an experts. It can also be difficult to implement in typical university settings.

By engaging students in discussion, teacher can help them think about the subject matter in previously unexplored ways, learn to evaluate their own and others perspectives, articulate what they've learned or what needs to be clarified, and even provide motivation to study the topic further [3].

I asked the students some questions, to help them to reflect on what they have learned: What have you learned while developing this activity? Which difficulties did you live?

- *Social networks*

The rise of social media technology has revolutionized the interactive sharing of ideas using online communities, networks and crowdsourcing [4].

I conducted a content analysis of social profiles of scientists who actively discuss about space science. I identified the scientists on the basis of the information listed in the Twitter profiles and the educational sites.

I started by presenting some projects reported on the **Scientix** website as ARCturus (Astronomy Resource Center) or Up There ... How is it? How to live on the International Space Station?

The students used posters, movies or extracts from a reading that was assigned.

Teachers of physics, mathematics, biology and chemistry who have collaborated with me have provided demonstrations , shown videos, slides or examples from dedicated websites (Scientix, ESA, NASA, ASI). Students who wanted to learn more about the most challenging topics, could search for videos and playlists on YouTube for or follow NASA on Instagram. Among the videos of the latest discoveries and historical archives, NASA posts are guaranteed to teach you something new every day. The agency has over 25 million followers.

Twitter is a micro-blogging social media platform for short messages that can have a long-term impact on how scientists create and publish ideas [5].

Social media tools such as Twitter can be incredibly valuable for students. Twitter makes it possible for students to follow the research also on the other side of the world, to directly share their expertise and to get feedback from experts: (@astro_luca, @ ESA, @ASIspazio, @scientix_eu, @ESAEducation, @NASAEarth, @ISS_Research, @Avamposto42, @AstroSamantha, @Telespazio, @astro_JFrancois).

- *Worksheets*

Students study how plants grow "hydroponically" in nutrient enriched fluid. The activity involves the use of *the hydroponic greenhouse*, a technique of cultivation of plants out of the ground and with low environmental impact characterized by reduced water consumption. The research uses this tool to activate innovative laboratory teaching and introduce the scientific method in the classroom.

Students deepened the tardigrades on the NASA website dedicated to the international space station. They conducted further research on orbits.

4. Conclusion

The method used proved to be effective and useful for teaching, sharing and discussing astronomy topics, but above all to increase young people's awareness of the importance of space research. Recent credibility of this theory derives from a study [6] that identifies the factors that lead to success for university students. The project lasted eight weeks, we attended conference with ESA astronaut JeanFrancois Clervoy, we shared videos and interviews with experts on social media. My students appreciated and committed themselves to the project chosen by winning a prize for the experiment on hydroponic vegetation. A visit to the Matera Space Center offered by the DTA (Aerospace Technology District) concluded the activities.

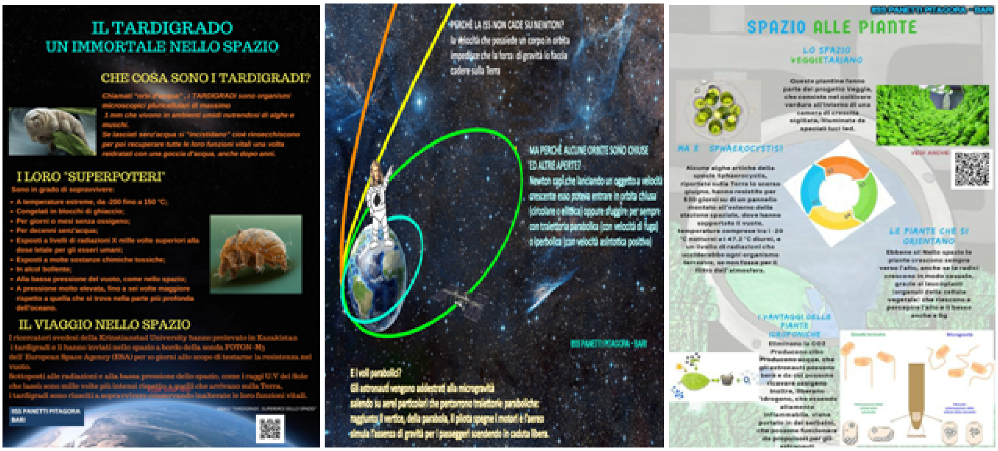

Fig. 2. Worksheets

Fig. 3. Our working group at the C.Colombo space station in Matera (ITALY)

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Using Low-Cost Hardware to Teach Mechatronics in a Project-Based University Course

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Abstract

The syllabus for the mechanical engineering studies at Furtwangen University offers the elective "Mechatronics in practice" for students in semesters 3 to 7. The course goal is to practically apply the previously obtained theoretical knowledge from courses like informatics, CAD and electronics to create a mechatronic system of medium complexity using low-cost hardware. The course is divided into two parts, where the first part consists of a 5-hour lecture introducing the students to Arduino programming with examples on how to control various hardware components and read signals from sensors. Each student group is given a set of motors and sensors that can be used in the introductory lecture and in the project task thereafter. In the second part of the course, the students are asked to define project milestones and allocate the various project tasks to solve the given assignment among the project members. The project progress and the meeting of the self-set milestones is then continuously evaluated by the course examiners during the course progression. The students are free to use the university 3D printers and laser cutter to build the necessary parts for their project. The various group solutions are presented to the other groups in a final event. Course assignments so far included a battle bot, a line-follower robot and a drawing robot. The course experience showed that the various student groups found very diverse solutions to the given tasks with a high quality of execution. The student feedback is collected using a questionnaire. The results of that survey showed a very high satisfaction with the course. Among the various reasons for that was the motivation the students gained through the practical and fun assignments, the possibility to test their solution against the solution of other groups (through e.g. a fight between battle bots or a timed lap for the line-follower robots) and the chance to apply their theoretical knowledge in a practical project. The survey also showed that students invested more time in that course than what is usually required in a course of that scope because they tried to solve the given task as best as possible.

Keywords: Mechatronics education, Robotics, Project-based education, Independent problem solving

1. Introduction

The faculty of mechanical and medical engineering at Furtwangen University offers a study course named "Mechanical and Mechatronics Engineering", which is aimed at providing knowledge in both mechanical engineering through courses such as engineering drawing, design engineering and CAD and mechatronics through courses such as electronics, sensorics and robotics. The study course contains two elective modules in which the students are free to select courses they are interested in. These elective modules are meant to broaden the students' perspective and improve their knowledge in a study area of their interest. Because the majority of mandatory courses are mostly theoretical with written exams rather than semester projects, the students are usually interested in finding electives that provide a more practical learning approach.

A new elective course named "mechatronics in practice" was therefore created to provide for that interest. The course aim was to provide projects that allow the students to practically use their previously obtained theoretical knowledge in informatics, design engineering, CAD and electronics and acquire new skills in order to solve the task. The given tasks should be solved by the groups with as little guidance by the lecturer as possible thus following a problem-based learning approach. Problem-based learning (PBL) is an alternative learning procedure introduced at the McMaster University, Canada in the 1960s. It is frequently applied in education today, because it allows for self-paced learning, a better understanding of the subject at hand, fosters inter-personal skills and teamwork and leads to a higher motivation in solving the task at hand [1, 2].

2. Methods

The course is divided in two parts where the first part consists of a 5-hour lecture that is aimed at providing the students with basic knowledge in microcontroller programming. The students learn how to use Arduino boards to read digital and analogue signals (e.g., buttons or sensors) using appropriate electronic circuits, to control program flow through conditions and loops and to power and control DC motors, servo motors and stepper motors for mechanical movement. The lecture is based on showing various exemplified approaches thus providing the students with sources they can later modify and use in their projects. In addition, each group is given a set of sensors and actuators to allow them to get familiar with the tools they have available to solve the project tasks.

In the second part of the course the students are asked to assemble in groups of four and to define milestones and project responsibilities among the group members.

The groups are asked to meet regularly with the lecturers and present their progress.

The faculty provides the students with various 3D printers and a laser cutting machine along with labs containing soldering irons, electronics and other supplies to build the necessary parts for their projects. The various solutions are presented in a contest at the end of the semester where the groups square off against each other to find which group has solved the task best.

Projects so far included battle bots, line follower robots and drawing robots. With each project the students are given a set of limitations and rules but are unrestricted in their solutions apart from those limitations. The battle bots are limited in weight (500g) and size (20x15cm) and have to be remotely controlled. The drawing robots has to draw a specific set of shapes (rectangle, triangle, oval), while the line follower has to follow a defined path with a set of challenges (interrupted line, narrow curves and start/stop signals) that are indicated by RFID tags. Figure 1 shows the shapes given for the drawing robots and the outlined track for the line follower robot. In the contest, the battle bots compete against each other in 1-on-1 tournaments where a bot wins if the other is disabled or pushed outside the arena. The drawing robots compete for the fastest drawing time and the most exact retracing of the given shapes. The line follower groups also compete for the fastest course completion along with the most exact execution of the given challenges.

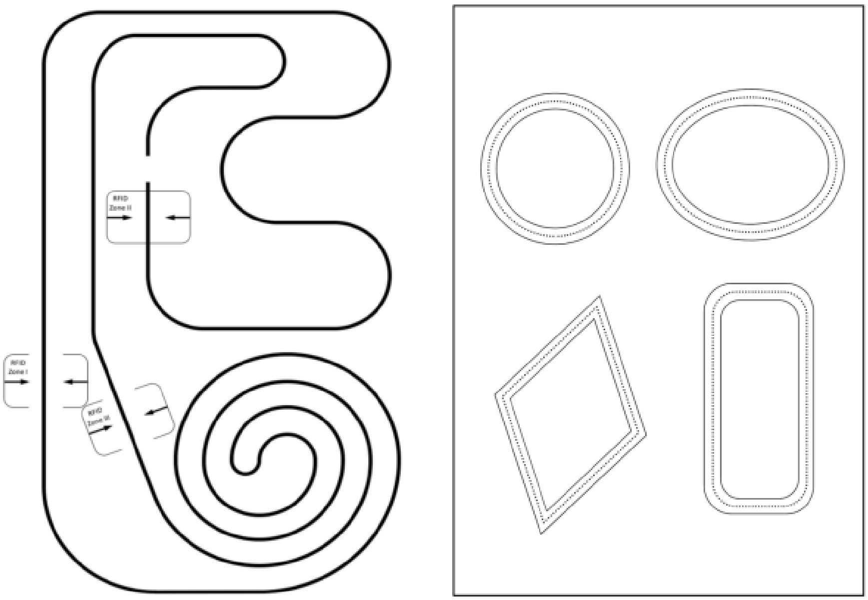

Fig 1. Left: track to be retraced by the line follower robots. RFID zones mark where RFID tags are to be expected. Those RFID tags indicate several challenges: 1 – start/ stop, 2 – interrupted line ahead, 3 – narrow curves ahead. Robots have to react to the tag information independently. Right: Shapes to be drawn by the drawing robots. The drawn lines have to be inside the solid lines.
Student feedback is collected through a questionnaire including yes/no questions, rating questions and free text questions at the end of the semester.

3. Results

3.1 Project results

The course has so far been offered for two semesters with 76 students attending the course. The presented solutions were very diverse and mostly were of high execution quality. One example is the solutions of the groups that chose to build a drawing robot. Here, all groups used two step motors to draw in two dimensions, but with different mechanical designs. One group used timing belts and pulleys to draw the required shapes on a vertical board, one group used a large rotational gear along with a linear actor thus drawing in polar coordinates, another solution attached the step motors to linear gears to draw in x- and y-direction horizontally. Fig. 2 shows the aforementioned solutions.

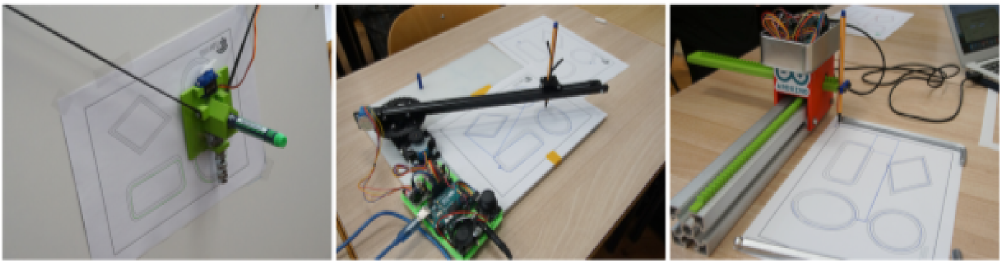

Fig. 2. Different solutions to the drawing robot task. Left: Using timing belts and pulleys to draw on a vertical board. Middle: Using a combination of rotatory and linear movement to draw in polar coordinates. Right: Using two linear gears to draw horizontally.

The battle bot groups also showed a variety of solutions using a mixture of passive (pushing the opponent out of the arena, lowering the chassis to avoid being tipped over) and active (mini saws, water pumps, catapults, spinning wheels, spring loaded pile driver) methods to win. That task especially enabled the students to compare their solutions to other solutions directly, as a poor wiring of the electric components, faulty code or a poor mechanical design lead to an early elimination from the contest.

In addition, it became obvious to the students that simple solutions were more reliable in the contest than highly sophisticated concepts with a higher number of weak points that could lead to failure of the robot.

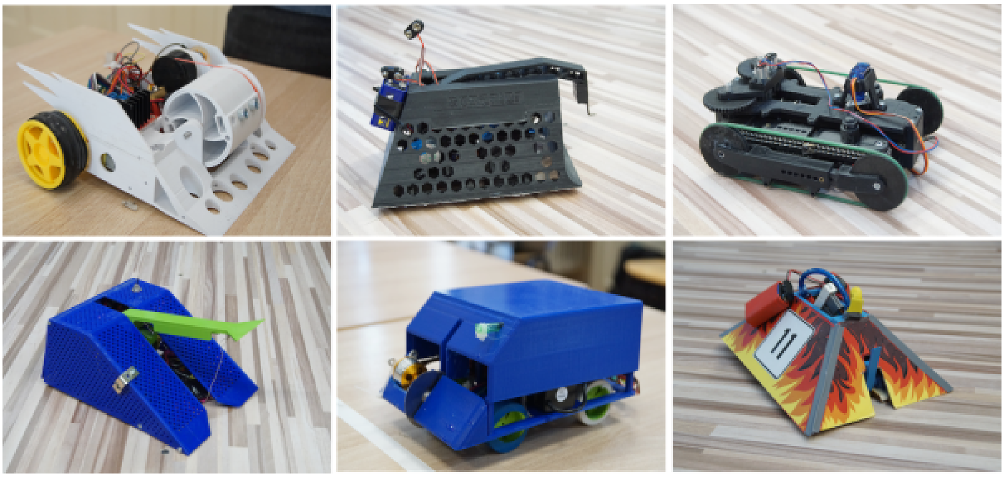

Fig. 3. Various battle bots build by the students. Weapons included spinning wheels (upper left), hooks and a lowerable chassis (upper middle), spring loaded pile driver (upper right), catapults (lower left and lower right) and mini saws and water pumps (lower middle)

Finally, the line follower groups all stated the sensibility of the infrared sensors against scattered light to be the greatest task in their project. Again, different solutions were shown to lead to decent results. Groups used different numbers of sensors to track the outlined course and various approaches to shield the sensors form scattered light such as cardboard shields or mounting the sensors close to the robot chassis in combination with a very low chassis clearance. Additionally, groups used different wheels diameters leading to different line follower speeds and line tracking robustness.

Fig. 4. Various line follower designs. Robots differed in wheel diameter, number of infrared sensors and the placement of the sensors

3.2 Questionnaire results

The questionnaire revealed a very high satisfaction with the course (mean rating of 4.89 on a 1-5 scale). Reasons for the satisfaction with the course were:

- the possibility to put theoretical knowledge gained from the mandatory lectures to practical use
- the minimal limitations thus allowing for highly creative solutions to the given tasks
- the helpful but not stipulating supervision by the lecturers
- the need for autonomous and goal-oriented working by the groups
- the opportunity to compare the individual solutions against solutions by other groups
- the highly motivating projects promoting the students to acquire missing knowledge by themselves

73% of students stated, that they had a high or very high commitment to the task, while 61% stated that they would invest even more time if they would attend the course again. Among the skills the students stated to have improved or acquired through the course were Arduino (83%), teamwork (78%), programming (61%), engineering (56%), rapid prototyping (44%) and CAD (39%).

4. Discussion

The aim of the elective course was to provide students with the possibility to bring their theoretical knowledge to practical use and thereby improve or acquire new skills.

The projects had to be motivating to promote self-acquiring of the necessary skills by the students. The project results showed a high identification of the students with the projects and the questionnaire revealed a high satisfaction with both the given tasks and the course itself. However, there are some drawbacks in the current course design. First, while the single electronic and mechanical components used in the projects are cheap, a high number of components is required to build all robots, thus a semesterly budget for the course has to be appointed by the faculty. Second, at the beginning of the course the students are usually not familiar with 3D printers and laser cutters thus their CAD design might not take into account the design limitations of those production approaches. Therefore, the first attempts at designing the robots and producing the parts are usually trial-and-error leading to a higher work load of both the students and the machines. While the learning by doing approach is part of the problem-based learning, we decided to implement a lecture to teach the design approach in additive manufacturing.

Acknowledgments

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Virtual Reality Explorers

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Abstract

This paper will discuss an active project that is centered around the development and implementation of a teaching tool for the Primary Language Curriculum – English and Irish – in Ireland, through an enhanced learning environment utilising Virtual Reality and Augmented Reality (VR/AR) tools. Other subject areas such as History, Geography, Science and the Arts, will also be investigated over the course of the study. Through the use of a VR/AR tool the pupils benefit from rich opportunities in experiential learning which will be inclusive of all learning styles, needs and abilities. This project and the virtual reality experience it provides will engage and motivate all learners and provide them with the opportunity to engage with the wonders of our world without leaving the classroom. The project uses VR enabled low-cost digital devices for the creation of a virtual, highly engaging collective learning environment for each student in a class, that can be controlled by the teacher. The teacher leads the progress of the students through the environment and can control the pace and level of advancement through the environment to suit the learning requirements of the syllabus and student ability. The system is based around the Google Expeditions software, which is available for use by schools, free of charge. This software is run on low cost, tablet style devices, housed in a low-cost headset 'holder' with all units being tied together through a wifi gateway. All content within the system can be fully vetted and controlled by the teacher at all times from a 'master' tablet. The main advantages of using VR in the classroom are as follows, (1) Active rather than passive experience, (2) Immersive experience means no distractions, (3) Immediate engagement: useful in today's world of limited attention spans, (4) Exploration and hands on approach aids with learning and retention, (5) Helps with understanding complex subjects/theories/ concepts and (6) Suited to all types of learning styles, e.g. visual.

Keywords: Virtual Reality, Immersive Education Technology

1. Introduction

Virtual field trips have become one of the most popular applications of VR technology for learning, and many schools have begun using Google Expeditions [1] to transport students to faraway and even inaccessible parts of the planet. The Google Expedition app is free to download on IOS or Android and teachers can invest in low-cost cardboard headsets that can be attached to a smartphone.

With these simple headsets, students can actively explore anything from the Pyramids in Egypt, the deep sea or to the Solar System. The Expeditions are collections of linked VR and AR content and supporting materials that can be used alongside the existing curriculum, see Fig. 1.

Fig. 1. Google Expeditions RedboxVR 30 User Kit

Through the use of a VR/AR tool the pupils will benefit from rich opportunities in experiential learning which will be inclusive of all learning styles, needs and abilities.

This project and the VR experience it provides will engage and motivate all learners and provide them with the opportunity to engage with the wonders of our world without leaving the classroom.

In Section 2 we will discuss the main learning objectives of the project. This is followed in section 3 by an overview of the observations and challenges. Section 4 will discuss a how we will evaluate the success of the project and lessons learned. The paper is concluded in section 5.

2. VR Project Learning Objectives

This project has four participating primary schools in Co Kerry, Ireland and has the following learning objectives (1) implement the Primary Language Curriculum – oral language, writing and reading. This project will impact positively on the children's learning across all curricular areas as language is the foundation of all subject areas.

This tool will be a vibrant stimulus to ignite their imaginations which will translate into the oral and written form. (2) Increased knowledge and skills development, increased motivation, development of positive attitudes. (3) Broadening the scope of resources available to the teacher, increases the engagement of teacher/pupil, greater sense of achievement for teacher, opportunities to further develop the relationship between teacher and pupil. (4) Development of assessment opportunities for and of learning, KWL, learning styles more easily identified using digital technologies such as VR/AR. (5)

Provision of an innovative tool to engage pupils visually which will in turn lead to greater stimulation and engagement. (6) Collaborative approach to the project, i.e. cluster of schools/third level sharing of good practice between teachers and schools, sharing of expertise, opportunities for Continuous Professional Development (CPD). (7)

Showcasing of positive impact of collaboration between schools. (8) Showcasing of work samples, video and pictorial records of project. (9) Developing a bank of age/class appropriate exemplars of good practice using VR/AR in a wide range of subjects. (10) Improvement in overall standardised results in English and Irish.

3. VR Project Observations and Challenges

The cluster purchased 2 sets of 30 student kits that will be shared amongst the four participating primary schools in the cluster. The kits include 30 student devices plus 30 VR viewer headsets, with a 'master' tablet to provide control of the system to the teacher or group leader and finally a suitably capable wifi router to allow 'casting' of the VR expedition from the tablet to the headsets.

A schedule for sharing of the kits is agreed by the cluster at the start of each school year. The use of this digital tool will allow more experiential based learning. There will be greater scope for the learner to lead his/her learning and opportunities for his/her voice to be heard.

The project will provide great scope for self and peer assessment.

- The impact of the project will be determined from standardised assessment results, interviews with pupils, feedback from all stakeholders including class teachers, SEN teachers, SNAs, principal and parents.

3.1 Project Communications Plan

Monthly meeting of the schools in the cluster in either one of the schools or IT Tralee. A blog will be set up which will be regularly updated by each participating school - it will include details of lessons using VR/AR, teachers' reflections on lessons – what worked well, what I would change the next time etc. Participating teachers will also be in contact via email throughout the duration of the project.

3.2 Initial Digital System Implementation

The following tasks will be undertaken by IMaR and Lero at IT Tralee in preparation for project kick-off in year 1:

- Evaluation of VR class systems available
- Pre-Procurements actions (quotations, negotiations, technical evaluation etc.)
- Assisting lead school in final procurement

- Initial system set-up, evaluation and trouble-shooting
- Initial trials in each school, ensure schools IT system is correctly configured for deployment
- 1 Day training course for primary school teaching staff in each school

3.3 VR Interactive Learning Pilot

Schools will focus on one Progression Continua in the English and Irish curriculum in each of the three years. Other subject areas such as History, Geography, Science, Arts will be fully integrated and lessons will be developed with the aim of reaching the Language milestones.

Year 1 – Oral Language
Year 2 – Writing
Year 3 – Reading

The six step School Self Evaluation Approach will be followed [2] and will focus in the areas identified above in September of each year, gather evidence from standardised test results, teacher observation, pupil questionnaires, parent questionnaires each year, analyse and make judgements as to how we will use the VR/AR tool to develop a set of activities/lessons for the following months to improve the learner experience and learner outcomes in the identified areas in October. An improvement plan and report will be written in October. This plan will be put into action from November to May each year and the impact will be evaluated in June of the three years.

An initial training session at the start of the project in Year 1 will be conducted by IT Tralee as part of the project kick off. IT Tralee, in collaboration with the cluster schools, will determine further training needs for the cluster schools in Year 1.

3.4 Project Outcomes and Deliverables

Year 1 – increase in oral language competencies measured using the Drumcondra English profiles – oral language indicators [3].

- Exemplars in oral language development in all class levels using VR/AR.
- Increased motivation, engagement, attendance by pupils in those classes. CPD by all teachers involved.
- Opportunities for all teachers involved to reflect on and discuss Year 1 experiences, identifying any required modifications for Year 2.

Year 2 – improvement in the writing competencies of pupils measured using the Drumcondra English profiles – writing indicators [3].

- Exemplars in writing development in all class levels using VR/AR.
- Increased motivation, engagement, attendance by pupils in those classes. CPD for all teachers involved.
- Opportunities for all teachers involved to reflect on and discuss Year 2 experiences, identifying any required modifications for Year 3.

Year 3 – improvement in reading competencies measured using Micra-T [4] or Drumcondra Reading Test [3].

- Opportunities for all teachers involved to reflect on and discuss Year 3. A final project report and set of recommendations for other schools interested in using VR will be produced at the end of the project.

- A showcase showing the process of the project to take place in the Tralee Education Centre once each year – videos, blog posts etc.

VR Content Creation

As an additional feature to the program and to increase classroom and student engagement in the project and VR technology, each school will be given the opportunity to create their own VR ‘expedition’ content. Google account holders can use poly.google.com [5] to create their own multi-scene 360º panoramic experiences which can be shared amongst a classroom of students or even as part of an inter-schools collaboration.

4. Evaluation and Lessons Learned

The evaluation process is continuous. The project will be evaluated on a term basis, September to December, January to Easter and Easter to Summer Break. The following parameters will be used to evaluate the performance of the project and affects the introduction of digital technology to the classroom is having:

- Motivation levels of pupils,
- Standard test results,
- Attendance of pupils,
- Parental feedback,
- Pupil feedback,
- Teacher feedback.

The Government of Ireland Department of Education and Skills will be provided with a template for the implementation of a digital technology – VR/AR in a primary school based on thorough assessment, evaluation, data collection, setting of SMART targets to implement the Primary Language Curriculum at all class levels. This will implemented through sharing of best practice. Details of all evaluations and results pertaining to the VR/AR digital technology in the classroom pilot will be made freely available for further evaluation and will be published in suitable education journals.

Action Plan for each year based on the School-Self Evaluation (SSE) Guidelines 6 step approach [2]. The SSE “empowers a school community to identify and affirm good practice, and to identify and take action on areas that merit improvement. School self-evaluation is primarily about schools taking ownership of their own development and improvement.”

1. How well are we doing?
2. How do we know?
3. How can we find out more?
4. What are our strengths?
5. What are our areas for improvement?
6. How can we improve?

A final project report and set of recommendations for other schools interested in using VR will be produced at the end of the project and will be presented internationally as an extended journal article and conference presentation.

5. Conclusions

This paper has described an innovative project around primary school learning using VR technology and an investigation into the potential method for the introduction of immersive learning into the primary school classroom. This paper also presented an overview and observations of the project thus far and the benefits were outlined.

The evaluation of the use of such technology in the primary classroom, generating knowledge of its effects on curriculum delivery to the whole Irish education sector will benefit not just Irish education system but education worldwide.

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Water Education in the Context of Environmental Education. The Views of Private School Teachers

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Abstract

In order to create capable citizens, able to continue and develop culture, environmental education plays an essential role in shaping values, attitudes and education that promote and secure a sustainable future. At the same time, environmental education is based on the promotion of the citizens' responsible behavior towards nature, and on the effective treatment of environmental problems. This paper focuses on critical thinking and holistic problem-solving skills that enable learners to make decisions and act collectively. In the present work, we have created and present innovative teaching approaches to water as the most valuable natural resource of the planet Earth. The ultimate purpose of this project is to realize the necessity, conservation and protection of water resources. An effort is being made to change the environmental behavior of learners through multidisciplinary methods and activities. The holistic approach of the subject includes the necessary theory as well as innovative teaching approaches (teaching forms, conceptual maps and exercises in a playful form). The research population comprises secondary school teachers, specifically from a private high school and lyceum (Aristotle College of Thessaloniki). The quantitative research was performed using questionnaires following the Likert 1 - 5 scale. The data were processed with the SPSS 21.0 statistical program using descriptive statistical analysis techniques, and Cronbach's alpha was tested. The results of this paper have shown that school can be transformed into a space of creative expression and imagination development, with the contribution of experiential activities. Through the innovative teaching approaches, teachers have shown an increased level of satisfaction pupils participate more actively in the classroom processes and show an increased degree of interaction and awareness about environmental issues.

Keywords: Water Management, Concept Map, Lesson plan, Environmental education

1. Introduction

The purpose of this research project was to create an integrated teaching and educational framework for the teacher, as well as the application of alternative methods of approaching the knowledge for the students. The detailed description of the entire teaching approach, with the lesson plans, the conceptual charts, and the necessary methods (brainstorming and project), is the available ready-to-use material.

The material is a valuable tool for any teacher in order to teach the water chemistry, as well as its implications (water management) in secondary education.

The cross-thematic and interdisciplinary approach to water knowledge contributes positively to the educational process as it provides students with the opportunity to develop pro-environmental behaviors, to become interested, to acquire awareness and to become alert to a vital environmental issue of the present time. Specifically, Kollmuss & Agyeman [1] define pro-environmental behavior as the kind of behavior that consciously seeks to minimise the negative impact of an individual's actions on the natural and man-made world. Environmental issues are not just about nature, and are not limited to the relationship between man and nature. In this way, the kind of E.E. which is finally promoted can be defined as "environmental management and control training" (Huckle, 1998).

2. Material and Methods

The conceptual map was developed by Novak and Gowin [3], and is a powerful tool for teaching and learning, as well as the active participation of learners in the learning process. The notion of the C.M. is based on the theory and the findings of meaningful learning [4]. At the same time, the findings of cognitive psychology for the constructive approach to knowledge [5] recognize the conceptual maps as a useful tool so that the learner can combine, associate, assimilate and classify the new knowledge with pre-existing knowledge. The conceptual maps are charts that represent organized knowledge, consisting of concepts and their interrelations in a particular learning object [3].

The process of creating a C.M. is called conceptual mapping. Conceptual mapping is a way of graphically representing knowledge, ideas, concept structures and the mental processes of the students [3]. According to the same researchers, the contribution of conceptual mapping as a cognitive tool is due to the fact that learning is to link new ideas or concepts with already-acquired knowledge in a non-arbitrary way [3].

Conceptual mapping is a technique and a mediating cognitive tool that represents graphically the concepts and their interrelationships in a hierarchical structure, thus reinforcing a critical approach to the content of teaching. It takes into consideration the structure and the representation of knowledge, setting the more general, important and vague concepts at the top of the map, while the more specific and less general concepts are placed at the lower levels [6]. The C.M. is widely used as an assessment technique during the diagnostic or initial assessment, when the teacher uses the C.M. as an exploratory tool for the identification and representation of prior knowledge [7].

The choice of dealing with water, and more specifically with water management, with the contribution of a concept map of Figure 1, stems from the need to emphasize the factors affecting the water reservoirs, as well as the holistic water management at a global level.

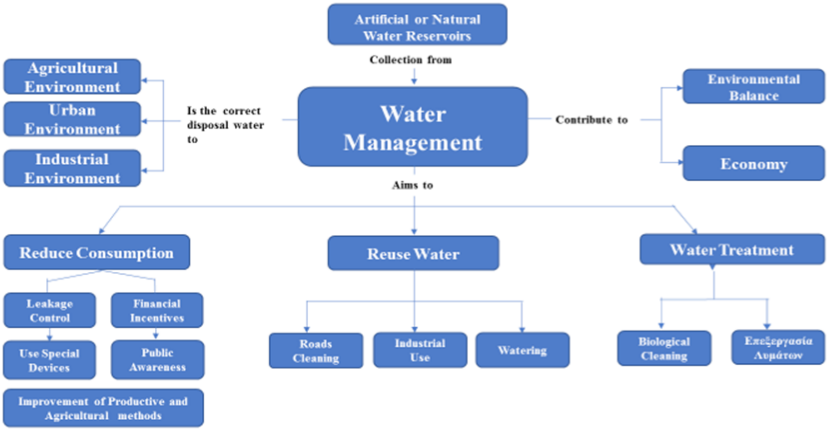

Fig. 1. Concept map for water management teaching

The definition of “lesson plan” is a fully structured and effective teaching proposal, in all its parts, that creates an integrated framework in which the teaching will take place. The teacher plans the presentation of a specific module in such a way as to approach the particular subject, taking into account the needs of the learners [8]. The course design is a rational design cycle that includes: a) building learning objectives, b) selecting content, strategies, methods, resources, source materials, activities organization, as well as teaching behaviors, c) implementation, and d) evaluation of the results.

At the stage of educational intervention, the educational environmental program gets planned and implemented. The program’s objectives determine the selection of the appropriate educational methods and teaching techniques, taking into account the trainees’ characteristics, the available space and time, as well as the available infrastructure. In the following illustrations you can see the intstructional design document applied to the water management module (Fig. 2-3).

Module	Water Management
Module Concepts (Keywords)	• Water management • Water collection • Reuse of water • Reduce water consumption • Water treatment
Teaching Goals	• Define water management • Present the methods of water collection • Describe the methods of reuse the water • Apply methods to reduce water consumption in everyday life • Suggest ways to reduce water consumption in the school environment • Combine water treatment methods with the reuse possibilities

Teaching Method - Course description with corresponding technique and means at each step.

Teaching method: Method of concept attainment

	Course	Teaching Technique	Educational equipment
1	**Preparation of a teaching framework** Recall relevant knowledge from students. Lesson Objectives Notification.	Questions and Answers Dialogue	PC Projective Software Power Point Transparencies
2	**Students deals with main question:** What do you know about water management?	Brainstorming	PC Projective Software Power Point Transparencies
3	**Application – Concept map construction** An application form is distributed to the students in which a conceptual map should be created according to the ideas listed in the table.The teacher splits the students into 4 teams and gives them 5 to 7 minutes to create the concept map, followed by a two minutes presentation of each group's conceptual map.Finally, there is a 5 to 7 minutes team discussion in which everyone can give an opinion so as to create a complete and comprehensive conceptual map for water management.	Concept map construction	PC Projective Software Power Point Transparencies
4	**Evaluation** An evaluation testing form is distributed to the students asking them to complete and expand the concept map. Emphasis is placed on the correlation between water treatment and the reuse of water.	Evaluation testing form	PC Projective Software PowerPoint Transparencies
5	**Feedback** Review of the key points from the team presentations and the answers to the questions in the evaluation testing form.	Lecture	PC Projective Software PowerPoint Transparencies
6	An individual homework activity is assigned to the students (homework assignment) in which they should create a concept map about water management in the school.	Assignment form for homework	PC Projective Software PowerPoint Transparencies

Evaluation: Description of the evaluation techniques applied.
Students are given an evaluation testing form asking them to answer multiple choice questions and fill the concept map regarding the above-mentioned theory.

Fig. 2. The first page of lesson plan

Skills development through the description of specific activities
Cognitive
Through the recall of previous knowledge, questions and answers, new data, the commenton the figures, the students will get to know the concept of water management. Also, they will clarify the differences among the reduction of consumption, the water reuse and water treatment. They will also learn about the practical ways in which they themselves can contribute to the reduction of the water consumption. In addition, they will be informed about the relationship between water reuse and water treatment.
Affective
Through the dialogue and the presentation of ideas, students will getaware about the importance of water for the people and the environment. The trainees will discover the correlations regarding proper water management and will be actively mobilized to apply simple practices of water consumption reduction in their everyday lives.
Social
Group participation develops the students' socialization, the effective co-operation and the respect for their colleagues. The discussion and the brainstorming of ideas motivate the learner to become interested and actively participate in the educational process.
Metacognitive
Through the questionnaires, the trainees will understand the concepts taught and more specifically the correlations between them. They will find out that their own actions can affect the overall water management.

Fig. 3. The second page of lesson plan

3. Results and Discussion

A questionnaire with 11 questions was set up and administered to secondary school teachers, specifically from a private high school and lyceum (Aristotle College of Thessaloniki). The collection of primary material, using the questionnaire method, took place in the period from September 2018 to November 2018. Closed-type questions were selected in order to make it faster to complete and process its data.

All questions were scaled questions with a 5-point rating. The scale chosen for this research was the Likert [9-11]. Also, particular attention was given to clarity. The questions were brief and explicit. Negative questions were avoided as they can lead to misunderstanding, in that the negative word may be overlooked and the respondent gives an answer that is contrary to his/her true opinion [9-11]. The questionnaires (both groups) were tested for their reliability. The results obtained are illustrated in Fig. 4, 5.

Environmental Programs	1	Current human water management is effective.
	2	I get informed from environmental programs for rational water management.
Reliability Index Cronbach's Alpha 0.789	3	Developmental plans should take into consideration the quantitative and qualitative conservation of water.
	4	Proper water management should take measures for saving and reusing water.
	5	I am aware about extreme weather conditions management strategies (floods, water scarcity)

Fig. 4. Verifying the reliability of questions environmental programs

Educational material	6	The water management training material helped you: to understand the definitions of “sustainable development” and “sustainability”.
	7	The educational material for water management helped you: to use water in a rational way.
	8	Based on the water management training material, you consider: Managing interventions in the supply and demand of water are necessary.
Reliability Index Cronbach’s Alpha 0,814	9	Based on the water management training material, you estimate that: If water management is applied universally, there will be a progressive improvement in water quality.
	10	Educational material for water management helped you to understand the need for a holistic approach to managing water resources.
	11	Water training materials helped you: To take personal action on water management in your everyday life.

Fig. 5. Verifying the reliability of educational material

4. Conclusions

The conclusions drawn through the learning process, the interaction of teachers and students, and the results of the research, indicate that although environmental programs have been integrated into the school activities, teachers rarely implement them. Experiential activities allow the school to become a space of creative expression and imagination development. Also, students’ interactions significantly increased, and a meaningful and constructive dialogue emerged. Teachers and students expressed the desire to continue this way of teaching. Their metacognitive abilities improved, as during the stage of the documentation of their views they had to express and to justify their conclusions verbally. The learning asset offered was developed interdisciplinarily thanks to the desired holistic approach to knowledge.

According to the above-mentioned research carried out in the limited context of an educational institution, it can be seen that the EE offers many opportunities to change children’s behaviors and attitudes towards modern environmental issues. This is evidenced by the plethora of pedagogical approaches offered by EE depending on the motivation of the pupils, their cognitive, learning and emotional stage, the materials and resources available to each school and, above all, the interest and the resourcefulness of the teacher.

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Why Do Students Focus and Enjoy Carring out Tasks? Developing Procedural Scientific Knowledge of Preservice Primary School Teachers

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Abstract

When students are deeply focusing on a school task and enjoying it (experiencing flow), their willingness to perform similar tasks and the quality of the work done are higher. The objective of this study is to analyse the factors that favor the appearance of flow in tasks designed to develop procedural scientific knowledge in Preservice Primary School Teachers (PPST). For this purpose, preservice teachers were video-recorded while they were working in groups to solve volume and capacity measurement tasks. Collected data were analysed following an observation template which considers both, student's actions and the guidance of the teacher. Based on Flow Theory and Self-Determination Theory six main factors were analysed: feedback, clarity of the goal, the level of challenge and skills, perceived competence, autonomy and the relationship established with their work group and the teacher. The results of this analysis suggest that immediate and formative feedback and having positive relationship between the members of the group are essential factors to flow. Both factors make PPST participants to perceive that their contributions helped the group to accomplish the task, which increase their perception of the competence and that their skills match the challenge of the task. As soon as they feel both greater competence and challenges and skills balanced, students used to participated more often, which helped to increase concentration and enjoyment (flow).

Keywords: Procedural scientific knowledge, experiences flow, preservice training

1. Framework

Educational research has become an essential element for the improvement of educational quality. In recent years, Science Education research has focused on what knowledge is necessary to respond to situations in which science and technology are present (OECDa, 2016).

Traditionally, greater importance has been given to the knowledge of scientific content, that is, knowledge of facts, phenomena, concepts, theories and ideas related to science (Kind & Osborne, 2017; OECDb, 2016). However, several investigations show the existence of others (Howe, Tolmie, Duchak-Tanner, & Rattray, 2000; Montoro, Gil, & Moreno, 2017; OECDb, 2016), such as epistemic and procedural knowledge. Epistemic knowledge refers to the understanding of certain constructs related to science, as well as the characteristics that allow to build knowledge. In other words, epistemic knowledge favors the understanding of such relevant elements as questions, hypotheses, models, etc. Procedural knowledge refers to the necessary knowledge to carry out the practices on which science is based and allow us to verify scientific ideas (Montoro *et al*., 2017). Examples of this are: *distinguishing between dependent and independent variables, noting control variables, knowing the types of measures, errors and methods to minimize the error, identifying patterns within the data, etc*. (OECDb, 2016, p.23).

If we want everybody to be scientific competent, the three aforementioned kind of knowledge must be present in compulsory education. Another must for this concern is that Preservice Primary School Teachers (PPST) have to acquire scientific competence. According to the 2012 PISA Report (Ministry of Education, Culture and Sport, 2013), motivation and interest are considered to be the learning engine.

However, the reality is that the rate of people who intend to dedicate themselves to areas related to science is getting smaller and many PPST are not interested on science topics. Considering factors causing motivation and interest would be appropriate in order to deal with this situation.

According to Self-Determination Theory, an individual might carry out an activity for pleasure or curiosity (intrinsic motivation), for getting a reward or avoid a punishment (extrinsic motivation) or not to be motivated at all (amotivation). It maintains that human behavior is driven by three basic needs: autonomy, competence and relatedness.

People make efforts to feel that they are the source of the actions they perform; they achieve the goals set in an effective way and to belong to a group (Deci and Ryan, 1985).

Flow Theory arose with the aim of explaining how people feel doing intrinsically motivated activities and what make the experience so rewarding. In these situations, people are so focused on their activity that they isolate themselves from what is happening around them and lose track of time (Cskiszentmihalyi, 2014). This experience, called *flow*, led to people to repeat the activity several times in order to feel the same again. Montoro and Gil (In press) affirm that the main factors used in previous literature to explain the appearance of flow are the necessity of setting clear goals, providing immediate and productive feedback and proposing challenges balanced with individual perceived skills. The interest and utility of the tasks were also taking in account in their research.

2. Metodology

The objective of this research is to analyze the aspects that facilitate flow experiences in PPST performing tasks that promote procedural knowledge, using both self-determination and flow theories.

In order to work out a first approach to this problem, three tasks used in a PPST training course of teaching and learning measurement were selected because of their capacity of promoting procedural knowledge. Task 1 asks to order different bottles according to their capacity (Fig. 1), task 2 asks them to order two stones and an empty shaving foam bottle according to their volume (Fig.e 2) and task 3 asks them to measure the capacity of their handful, their drink and their lungs (Fig.e 3).

Fig. 1. Group 1 solving capacity comparison task

Fig. 2. Group 4 carrying out volume comparison task

Fig. 3. Group 8 performing capacity measurement task

Several voluntary PPST were video-recorded working in groups of 4 or 5 students to solve these tasks. Groups 1 to 3 solved task 1, group 4 to 6 solved task 2 and groups 7 to 9 solved task 3. Observation template and atlas.ti software were used to analyze the videos.

Following the structure of Pazos, Micari and Light (2010) ´s template, two large areas were considered: one to analyze the actions of the lecturer and another for PPST. This template was adapted to include key factors of both Flow and Self-Determination Theories: feedback, clarity of the goal, the level of challenge and skills, perceived competence, autonomy and the relationship established with their work group and the teacher.

3. Discussion or results or conclusions

The most relevant results will be shown taking into account the space we have available. More than 80% of students who performed task 1 experienced flow (concentration and enjoyment), roughly a 70% of student who solved task 2 flew and just a 40% of student carrying out task 3 enjoyed it. Therefore, the question would be what have been the reasons why some have experienced flow and others have not.

One of the main characteristics of the three tasks is that all students understand what they were asked for and knew some knowledge which allowed them to start thinking about a way of solving them. They felt they could be successful. Both, having clear goals and feel the challenge is matched with perceived skills, are conditions for feeling flow.

However, big differences were found between their confidence with capacity and volume magnitudes. All students affirmed that the order of the bottles and the measure of the capacity of their handful and their drink (body measurements) were correct, although it could have been done it in a more accurate way. In contrast, half of the students were not sure about the suitability of their process in the volume comparison and just one of the three groups who made volume measurement task.

That is, they needed the teacher´s approval to know if they succeed, since their previous knowledge is not enough to get feedback about their performance.

Since they were working in groups and shared the same vocabulary, peers provide positive feedback, discussing the best process to success or correcting mistakes.

For example, in G4 a participant noted that their partners were doing the procedure to compare the volume wrong because they had immersed just a part of the shaving foam bottle in water. As soon as she told them, they agreed they were wrong and changed the procedure. The same happened in group 8, when students suggested measuring the capacity of the lungs by weigh the balloon or by the time they need to blow the air of their lungs in the balloon. However, in groups 7 and 9, the teacher had to make them to realize they were wrong, for example, by suggesting weighing an empty balloon or asking them about the units of capacity measurement.

Likewise, when feedback indicated that performance was not adequate on several occasions or team members did not support or helped each other, the perception of competence decreased, so they did not express their ideas or did not insist on performing the procedure suggested. That happened in groups 7 and 9 while measuring the capacity of the lungs. However, the members of group 8 listened and evaluated the ideas of their peers' without trying to impose their own view and understanding the perspective of the rest. For example, two of the members of the group affirmed that they need to know the volume of water before immersing the balloon, even though the rest of the group told that it is enough to fill the whole container and measure just the water displaced, which is faster. One of the members of the group, instead of imposing his idea, proposed to do both processes in order to realize that both were correct. Once the fastest method was carried out, the rest of the team agreed there was not necessary to do the alternative process.

In summary, the feedback provided to the students and a positive relationship between the different team members, where they feel that they contribute ideas to the group, favored an increase in their self-confidence. This increase causes a balance between the challenges presented by the tasks and the skills of the individual and an increase in students' participation, which helps boosting concentration and enjoyment.

In contrast, when peers did not trusted on their mates' ideas or when the teacher made them to realize their processes were wrong more than twice, the perceived skills decreased and became unbalanced with the challenge. To know more about the difficulties and mistakes made by students, see Montoro, Gil and Moreno (2017).

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Enhancing Student’s Motivation

Analysis of the Influence of Learning State before University Admission to College Dropout Using Hierarchical Bayesian Model

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Abstract

In this research, we express the probability of college students dropping out using a hierarchical Bayesian model and derive to what extent the variables before admission influence college dropout. In Japan, about 5% of students entered university, but they drop out without graduation. Many studies have shown that the proportion of dropout students varies from university to university and correlates with university scale and deviation value. Many researches have been made to forecast dropouts in advance, but studies have not been made to express how the dropout probability dynamically changes depending on the situation before admission. It is assumed that the change in the dropout probability varies according to the variables before enrollment (number of absences at high school, type of high school etc.). Variables used in the model consist of pre-admission variables and post-admission variables, and the post-admission variables are the number of units per semester and GPA. We created a hierarchical Bayesian model using pre-admission variables and post-admission variables to derive the drop-out probability for that term. It was found that the probability of dropping out depends on the variables before entering the school, especially the type of high school and the number of absences. The probability of withdrawal is increased because the type of high school is communication system and the number of days absent at high school is large. Furthermore, we found that the change in the probability of dropout for each term differs for each variable before enrollment.

Keywords: Hierarchical Bayesian Model, Logistic Regression, Dropout

1. Introduction

The dropout rate in universities in Japan has been rising since the 1990s and is becoming a serious problem [1]. Tellingly, the student dropout rate has become a major point of interest in the annual survey conducted by the Yomiuri Shimbun and is increasingly used in university evaluations [2]. Overall, 8% of Japanese students drop out of college, with a lower rate at the national and public universities and a higher rate at private universities. Since the rate of graduation in Japan is higher than other OECD countries, there is not much to discuss dropouts in Japan. Especially at Kaetsu University where the author belongs, it shows a high dropout rate of 34.7% in the survey of 2014.

In this research, we express the probability of college students dropping out using a hierarchical Bayesian model and derive to what extent the variables before admission influence college dropout.To predict dropping out, you can do a regression using the results of the semester and the unit number. However, the score and the number of credits will change depending on the state before enrollment. In this research, we group state before enrollment and create a dropout prediction model with the group difference taken into account using hierarchical Bayesian model. After that, by examining the results of the dropout prediction model with the group difference taken into consideration and the results of the nonadditional model, we examine how much the group difference before entering the classroom is heard.

2. Related Works

Research on predicting student dropouts and establishing the underlying causes is widely conducted. It has been shown that there are a number of variables affecting the decision to dropout, including gender, teacher-student ratios, deviation values, university size, economic factors and variables related to dropping so far.

Tajiri analyses the relationship between educational history and dropping out at a business university and derives a set of micro variables for leaving students [3].

He found a low probability of female students dropping out within four years, but found that the probability is reversed beyond the four-year period. He also identified factors such as academic ability tests, grades, and number of credits being taken as significant micro variables related to dropout.

According to Kondo [4], a dropout prediction can be made at the beginning of the third year by using prior data (sex, undergraduate, entrance examination class, attendance rate, etc.). He compares various methods for making dropout predictions, including a logistic regression model, a support vector machine, and the random forest algorithm. In the U.S., where retention rate (school enrolment rate) is often used rather than dropout rate, Bingham *et al.*, [5] used a logistic regression model to show that enrolment rate differs according to the parents' educational background and ethnicity.

3. Methods

3.1 Data

The data in this study is from students who entered K University in Tokyo, Japan, from 2012 to 2014. The university is a college that teaches the social sciences.

Transfer students and graduate students are excluded from this data. There are 657 students with no missing data, of which the number of dropouts is 194 people.

It is known that dropping out has a correlation with the results at the first and second semester in the university. For example, in the study of Kondo [4], at the end of the 5th week of the 1st spring semester, it is estimated that about 40% of students who drop out by the beginning of the third year can be predicted.

In the graph 1 below, it is a box plot chart showing the GPA of the 1st spring semester of a dropout student and a regular student. The median value of GPA of students who dropped out is 2.36, and the median value of GPA of regular students is 1.43. As can be seen from this figure, there is a clear difference between the dropout student and the other students after entering the university.

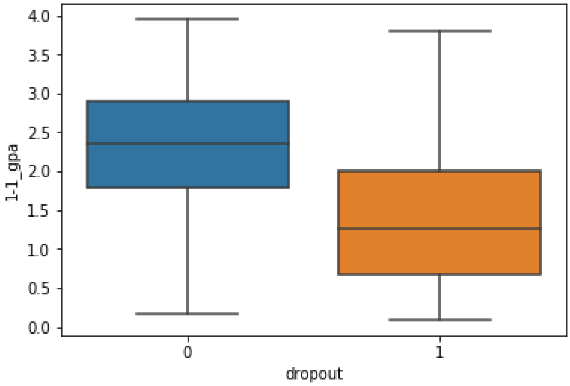

Fig. 1. GPA of 1st semester between dropout student or not

Next, it checks whether the number of absence days at high school which is a pre-admission variable has a relation with GPA which is a variable after admission.

Fig. 2 below is a box plot showing the relationship between absence days at high school and GPA of 1st semester. The X axis is a discretized number of absent days at high school. On the X axis 1 represents absent days from high school days 0 to 9, 2 from 10 to 19 days, 3 from 20 to 29 days, and 4 represents over 30 days. The Y axis is GPA of 1st semester. The median value of each is 2.25, 2.11, 1.82, 1.58.

From this we can see that the variables after enrollment are influenced from the pre-admission variables.

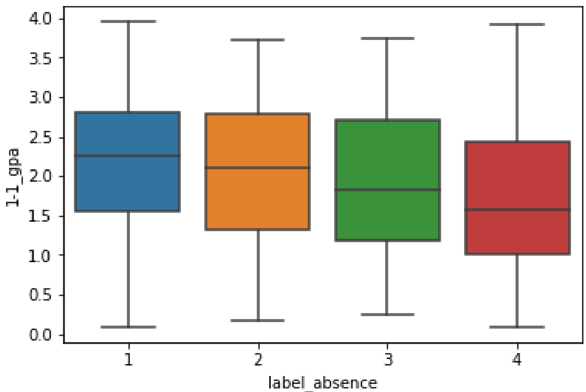

Fig. 2. GPA of 1st semester and high school absent days

3.2 Variables

Among the data, the variables to be used this time are the following five.

1. Fulltime Highschool or not: a student in fulltime high school or not (0, 1)
2. Number of Absence in high school (1, 2, 3, 4)
3. 1-1 GPA: GPA in the 1st semester (numerical, lower=0, upper=4)
4. 1-1 credits (numerical, lower=0, upper=24)
5. dropout (A student who dropout of the college or not): (0,1)

In this study, we use 1. high school type and 2. high school absent days as pre-admission variables. High school type represents whether it is full-time high school or not, high school absent days are discretized into 4 and used. 1 in high school absence days represents absent days from 0 to 9, 2 is from 10 to 19, 3 is from 20 to 29, and 4 is over 30 days. As the variable after enrollment, use 3.1st semester's GPA and 4.1st semester unit number. However, since the variables 3 and 4 after enrollment are highly correlated (corr=0.81), only the GPA of 3 is used as a variable after admission. The relationship between the GPA of the variable 3 after admission and the unit number of the post-admission variable 4 is represented by the following scatter diagram, Fig. 3.

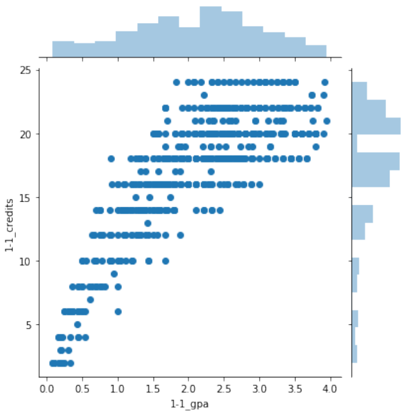

Fig. 3. scatter diagram of GPA & Credits

3.3 Model

Using pre-admission variables and post-admission variables, we can verify how much we can predict dropping out. For verification, the following three models are defined. In addition, logistic regression models are used for each model.

Model 1: using only post-admission variables

$$Y[n] \sim Bernoulli(\frac{1}{1+exp(-(a_1 GPA[n]+b_1))}$$

n=1, 2, ..., N. N represents the number of students and n represents the index of the student. Y represents dropout/not. a - 1 is a GPA variable, and b is an intercept

Model 2: using post-admission variables for each group of pre-admission variables

$$Y[n] \sim Bernoulli(\frac{1}{1+exp(-(a_1[LAbsence[n]]GPA[n]+b_1[LAbsence[n]]))}$$

n=1, 2, ..., N. A 1 and b for logit function change for each absence group. N represents the number of students and n represents the index of the student. Y represents dropout/not.

Model 3: using groups of pre-admission variables and post-admission variables, Bayesian hierarchical Model

$$Y[n] \sim Bernoulli(\frac{1}{1+exp(-(a[LAbsence[n]]GPA[n]+b[LAbsence[n]]))}$$

$$a[k] = a_{all} + a_{group}[k]$$
$$b[k] = b_{all} + b_{group}[k]$$
$$a_{group}[k] \sim Normal(0, \sigma_a)$$
$$b_{group}[k] \sim Normal(0, \sigma_b)$$

In model 3, a [k] of each group is divided into terms expressing a common overall average in all Absence groups and terms expressing each group difference. a_all and b_all are average values of the entire group, a_group, b_group are variables representing each group difference. Each group difference is assumed to follow the average 0 and standard deviation σ. k is 4 representing the number of absent groups in high school.

These three models were modeled by Stan and Bayesian estimation was performed using PyStan and MCMC (Markov Chain Monte Carlo methods). For model 1 and model 2, Iteration was used 2000 times, warmup was 500 times, chain number was 4.

For model 3, Iteration was used 7000 times, warmup was 1000 times, chain number was 4.

4. Results

The estimation result of the parameter of model 1 is as follows. The average value of a1 is -1.32, the average value of b is 1.63, and both of Rhat are 1.1 or less, and even if you look at the graph, it converges.

	mean	se_mean	sd	2.5%	25%	50%	75%	97.5%	n_eff	Rhat
a1	-1.32	3.1e-3	0.12	-1.55	-1.4	-1.32	-1.24	-1.09	1484	1.0
b	1.63	6.0e-3	0.23	1.18	1.47	1.62	1.78	2.08	1474	1.0
lp__	-324.2	0.02	0.98	-326.7	-324.5	-323.9	-323.5	-323.3	1768	1.0

The estimation result of the parameters of Model 2 is as follows. The slope and intercept for each group converged because Rhat is less than 1.1.

	mean	se_mean	sd	2.5%	25%	50%	75%	97.5%	n_eff	Rhat
a[1]	-1.27	2.4e-3	0.16	-1.58	-1.37	-1.26	-1.16	-0.97	4178	1.0
a[2]	-1.67	6.2e-3	0.38	-2.47	-1.92	-1.66	-1.4	-0.98	3805	1.0
a[3]	-0.81	6.0e-3	0.38	-1.62	-1.05	-0.8	-0.54	-0.1	4132	1.0
a[4]	-1.67	6.5e-3	0.42	-2.54	-1.93	-1.64	-1.38	-0.93	4138	1.0
b[1]	1.35	4.6e-3	0.3	0.77	1.14	1.34	1.55	1.96	4347	1.0
b[2]	2.14	0.01	0.69	0.85	1.66	2.12	2.59	3.56	3953	1.0
b[3]	1.9	0.01	0.86	0.3	1.31	1.85	2.44	3.75	4002	1.0
b[4]	2.59	0.01	0.71	1.3	2.11	2.55	3.05	4.04	4192	1.0
lp__	-317.7	0.04	2.05	-322.6	-318.9	-317.4	-316.2	-314.8	2131	1.0

The estimation result of the parameters of Model 3 is as follows. The slope and intercept for each group converged because Rhat is less than 1.1.

	mean	se_mean	sd	2.5%	25%	50%	75%	97.5%	n_eff	Rhat
a0	-1.27	0.01	0.4	-2.01	-1.43	-1.26	-1.1	-0.52	1252	1.0
b0	1.84	0.01	0.68	0.74	1.49	1.78	2.11	3.22	2868	1.0
al[1]	-0.06	0.01	0.4	-0.82	-0.24	-0.05	0.09	0.7	1174	1.0
al[2]	-0.16	0.01	0.42	-1.05	-0.32	-0.1	0.03	0.5	1279	1.0
al[3]	0.3	0.01	0.44	-0.35	0.05	0.26	0.47	1.2	1391	1.0
al[4]	-0.06	0.01	0.42	-0.97	-0.21	-0.03	0.11	0.63	1239	1.0
bl[1]	-0.37	0.01	0.69	-1.82	-0.64	-0.26	-4.6e-3	0.67	2677	1.0
bl[2]	-0.08	0.01	0.7	-1.5	-0.33	-0.03	0.18	1.21	3495	1.0
bl[3]	0.25	0.01	0.76	-1.09	-0.06	0.13	0.56	1.87	3287	1.0
bl[4]	0.18	0.01	0.69	-1.06	-0.07	0.1	0.43	1.6	3509	1.0
s_a	0.52	0.02	0.66	0.03	0.2	0.34	0.6	2.1	1572	1.0
s_b	0.85	0.03	1.18	0.02	0.28	0.57	1.02	3.46	2193	1.0
a[1]	-1.32	1.7e-3	0.14	-1.61	-1.42	-1.33	-1.23	-1.05	6784	1.0
a[2]	-1.43	0.02	0.26	-2.0	-1.58	-1.41	-1.25	-1.0	210	1.01
a[3]	-0.96	0.01	0.3	-1.52	-1.18	-0.96	-0.74	-0.42	481	1.0
a[4]	-1.33	0.02	0.28	-1.96	-1.49	-1.32	-1.14	-0.89	198	1.01
b[1]	1.47	2.2e-3	0.28	0.92	1.29	1.48	1.65	2.02	15941	1.0
b[2]	1.76	8.6e-3	0.45	0.94	1.47	1.72	2.02	2.75	2755	1.0
b[3]	2.09	0.03	0.62	1.05	1.62	2.01	2.49	3.43	613	1.0
b[4]	2.01	0.02	0.48	1.25	1.66	1.97	2.3	3.08	401	1.01
lp__	-315.1	0.29	4.06	-323.4	-317.7	-315.0	-312.4	-307.2	197	1.01

5. Discussion

By comparing models 1, 2 and 3, it became possible to express common items and differences for each pre - admission variable group. The average of common coefficients was -1.27, the intercept was 1.84, and we could derive the parameter difference for each pre-entrance variable group. For example, look at the case of a student whose GPA is 1, the probability of dropout in model 1 is 0.576, and in case of model 2 it varies from 0.519 to 0.74 according to the number of absences before enrollment. Furthermore, in the case of Model 3, it can be represented as high precision of the system in the form of common variables and group differences.

Acknowledgment

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Costs and Benefits to Implement STEM Programs in Schools: The Stimey Project

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Abstract

This paper describes the costs and benefits derived from the implementation of the European Commission Research Programme-Horizon 2020 Project, STIMEY (Science Technology Innovation Mathematics Engineering for the Young), for primary and secondary schools throughout Europe. STEM education provides invaluable benefits to the society when it makes students better problem solvers, innovators, inventors, self-reliant, logical thinkers, technologically literate, increasing their interest and motivation at school [1, 2 and 3]. Some experiences have evidenced that STEM education has to be linked with creative accessible affordable educational materials, available to elementary and secondary schools in a continuous fashion. For example, in the specific case of experiences using robotics, some of the problems come from the lack of teacher's time and training, organization, easy of access to age-suitable academic materials, the lack of ready-to-use tools for lesson and material preparation and the lack of affordable robotic platforms. Moreover, in spite of the slowly growing numbers of robotic platforms and kits on the market, the lack of a range of affordable robotic platforms persists. If we want to reach the whole pre-university students and schools, such materials must truly be inexpensive, as they must be acquired in significant numbers and be replaced regularly due to natural wear-and-tear of hands-on education materials [4].

To motivate the implementation of STEM Education in schools, thus resolving the above disadvantages is exactly what STIMEY will do while bring science and society together in Europe, and consequently increase the continent's international competitiveness. Its socially motivational platform for emotional and educational engagement will combine: social media components and entrepreneurial tools (the present), robotic artefacts (the future) and radio (the past) based on its well-researched pedagogical framework. STIMEY will not only engage and increase the youth's interest in STEM education and careers, but provides the gateway to a viable business investment that shapes the future generation. With all of these possible benefits of STEM education, it is important to ascertain how school headmaster/teachers can effectively include STEM programs in their teaching.

Keywords: STEM, Schools, Robots, K-12 education

1. Introduction

STEM education has become an essential tool for countries to improve their international competitiveness. This type of education makes students not only better problem solvers, innovators, inventors, logical thinkers and technologically literate, but also self-reliant, increasing their interest and motivation at school. That means STEM education have a non-negligible impact on the society [1, 2 and 3] and, because of this, educational authorities have been promoted it as a way to improve the quality of the studies programs in primary and secondary schools.

Assuming this concern, in recent years a whole industry has been developed to supply the materials and tools that are needed to implement STEM education in a society in continuous technological advance. As we will see afterwards, the Global Education Industry (GEI) is considered as an industry sector in expansion. This industry are designing and supplying e-books, software, courseware, learning devices, learning platforms, or dedicated IT solutions to schools. All of them are elements that make it easier for teachers to develop STEM strategies with their students. However, it is known that not all schools have developed the same capacity to adapt to these resources and implement a successful STEM education.

The lack of elements such as teacher's time and training, ready-to-use tools for lesson or affordable platforms is causing many schools to find barriers to promote this type of education in their classrooms. In order to guarantee that the benefits of implementing a STEM education are higher than the costs that have to be faced by schools, an integrated tool must be supplied by the industry. By integrated tool, we understand that which includes age-suitable and gender sensitive academic materials, training for teachers, communication platform with contents in continuous updating, access to robots, etc. In this line, the STIMEY project (Science Technology Innovation Mathematics Engineering for the Young), an European Commission Research Programme – Horizon 2020 Project, endeavours to become that tool for primary and secondary schools throughout Europe.

The rest of the paper is organized as follows. Firstly, we analyze the industry related to the STEM education to determine if it is an active and growing market which offers products to satisfy its needs. Next section will describe the costs and benefits that schools have to face when decide to implement STEM programs. We argue that the costs generally exceed the benefits and this is the reason why the STEM education is not enough widespread. The fourth section describes our proposal for an inexpensive and integrated STEM tool, the STIMEY project. The main conclusions and the references are placed in the last sections.

2. The global education industry and its future perspectives

For the Organization for Economic Co-operation and Development's (OECD) [5], those companies selling educational resources and services of a technological nature to schools, including e-books, software, courseware, learning devices, learning platforms, or dedicated IT solutions, represent the Global Education Industry (GEI).

The GEI field includes a broad range of actors, the more relevant are: chains of private schools; big education corporations and conglomerates providing a broad range of publishing, IT/software and educational services; consultancy firms; philanthropic foundations and advocacy networks. Moreover, we may also find regulators (national and international organizations), public providers, workers (and their organizations), private capital and clients (students and families) [8].

Regarding this industry, Merrill Lynch-Bank of America calculated in 2014 that the value of the education sector, in an international level, is $4.3 trillion (USD) [6].

Moreover, the market size of the for-profit education sector is expected to grow by 17 percent in the last five years of this decade [7]. Given these expectations, the GEI can be considered as an industry in expansion, acquiring its strength and dynamism by the penetration of business actors in new market niches such as on-line education, tutoring or supplemental/'shadow education,' edu-marketing, consultancy services for governments and schools, testing preparation services [8]. Traditionally, there have been more market opportunities in those sub-sectors and educational levels, such as pre-kindergarten and post-secondary education, where the state is not so present.

Nonetheless, in the last decade, a significant penetration of primary and secondary education levels could be observed by the for-profit sector as well. In fact, this development has been apparent all over the world [8], because the internationalization of this industry lets its actors increase their influence in educational politics, including their capacity to settle education policy agendas and frame education regulation at different scales [9].

However, the implementation of STEM strategies in schools is very heterogeneous up until now. This may be due to the fact that the costs faced by the teaching staff of schools are very diverse, not limited to economic costs, which discourage the implementation of these projects. Knowing in depth not only the benefits but also the costs associated with STEM education will facilitate the development of a tool that can reduce costs globally and make its implementation more attractive.

3. Benefits and costs of STEM education

As it was illustrated above, the educational industry development is guaranteed, because many economic actors are operating in this market and their influence in educational politics and families is growing in recent years. As the intention of providing a proposal which could satisfy the needs of schools, it is of great importance to take into account the two sides of STEM education, benefits and costs. It is an obligation to consider the time and effort invested, mainly by teachers in this emerging industry.

3.1 Benefits

STEM education should contribute to a STEM-literate society, with a general workforce with 21st-century competencies, and an advanced research and development workforce focused on innovation [10]. All of these improvements are crucial for a country's competitiveness in the global marketplace. In doing so, STEM qualifications prepare people for a broad range of occupations, including management. In the OECD's Programme for International Student Assessment (PISA), which compares student achievement in mathematics and science at age 15, the nations/systems with the largest group of students at the top three proficiency levels are also the systems with the smallest proportion of under-performers in PISA. Interestingly, these nations that are also exceptionally strong in research and development, are rapidly growing their scientific output and have all experienced two decades of exceptional economic performance. This situation shows a strong relationship among science, universal learning, and economic dynamism and prosperity, being a single interdependent system [11].

Then, driven by genuine or perceived current and future shortages in the STEM workforce, many education systems and policy makers around the globe are preoccupied with advancing competencies in STEM domains. The idea is to make students better problem solvers, innovators, inventors, self-reliant, logical thinkers, technologically literate, increasing their interest and motivation at school [1, 2 and 3].

But, what does it really mean STEM education in K-12 settings? Following, for instance, the National Research Council [12], it fosters interdisciplinary knowledge and skills that are relevant to life and prepare students for a knowledge-based economy.

STEM education includes the knowledge, skills and beliefs that are collaboratively constructed at the intersection of more than one STEM subject area. In this line, a flexible curriculum enables teachers to teach STEM subjects in their natural contexts, being this curriculum the result of an integration of all the STEM subjects.

3.2 Costs

However, it is clear that the implementation of this integrated STEM curriculum requires a strong effort for schools, in general, and for teachers, in particular. The main costs arise from teacher training and specific materials and tools that are needed.

Regarding the first type of costs, STEM education demands knowledge, skills, and teachers acknowledgement. Reducing the gap between current teaching practices in schools and the actual skills needed for STEM education is contingent based upon the expertise of STEM teachers to successfully work with an integrated teaching model [13]. In this model, teachers have the additional responsibility of guiding their students in at least one other STEM subject, which necessitates both an investment in professional development of in-service teachers, and a reorganization of the teacher education programs at universities [14]. In the case of teaching with robotics, teachers are best prepared to innovate when working from a solid foundation prepared by robotics educators [4].

In relation to the resources that are needed, some experiences have evidence that STEM education has to be linked with creative accessible affordable educational materials, available to elementary and secondary schools in a continuous fashion.

Moreover, given the current shortage of student interest in STEM topics, increasing attention has been paid to developing innovative tools for improved teaching of STEM, including through robotics [4]. For example, in the specific case of experiences using robotics, some of the problems come from the lack of three resources: age-suitable academic materials, ready-to-use tools for lesson and material preparation and affordable robotic platforms. Moreover, in spite of the slowly growing numbers of robotic platforms and kits on the market, the lack of a range of affordable robotic platforms persists. If the desire is to cover the whole pre-university students and schools, such materials must be inexpensive, as they must be acquired in significant numbers and be replaced regularly due to natural wear-and-tear of hands-on education materials [4].

The above costs make it so difficult for some schools to provide a STEM program in a permanent way. An integrated tool, which provides teacher training and support as well as motivating materials for students with the support of a communication platform, as do STIMEY project, would be an effective way to reduce the costs in order to reach the whole benefits of STEM education.

4. STIMEY Project: A proposal to make STEM education attractive to schools

STIMEY proposes an Educational Environment (EE) with multi-level components, designed and developed on the base of a well-researched pedagogical framework and gender sensitive guidelines, which aims to bring science and society together in Europe while making STEM education more attractive to young people from age 10 to 18 years old. Under STIMEY EE universities, schools, teachers, students, parents, business and media partners come together to complete a circle in which STEM becomes a part of the daily life of youths through an educational portal that also prepares them for future careers.

STIMEY socially motivational platform for emotional and educational engagement combines social media components (the present), robotic artefacts (the future), and radio (the past) to educate, engage and increase the youth's interest in STEM education and careers. The platform, with individual e-portfolios, is designed to tap into young people's curiosity and motivations from an early age while taking into account the specific needs of girls and boys, to not only be attracted to, but also stay with STEM in a social collaborative environment with serious games and entrepreneurial tools that promote healthy competition among peers.

STIMEY EE will provide teachers with well-researched gender sensitive modern low cost tools to deliver STEM education in an attractive and engaging manner. For example: The STIMEY Socially Assistive Robotic Artefacts that are designed and developed with the sole purpose to motivate students between 10 and 18 years old, are not only inexpensive, but are also easily upgraded with low maintenance; Radio STIMEY is a 24 hour broadcasting STEM Radio that takes 'The STEM Conversation' to the next level. The Youth STEM Community, STEM Business Organizations, etc. will use Radio STIMEY as a public forum to voice their views.

5. Conclusions

The aim of this article is to highlight the importance of providing useful and inexpensive STEM-orientated tools for schools to reach all pre-university students.

We have described the most important barriers that schools must face when they try to implement STEM education. In addition, we have shown the positive aspects of this type of education, which are a growing, profitable global industry and a great impact in society wealth. The international STIMEY team has focused on the above-mentioned costs to design and propose an integrated tool, which helps schools to avoid most of these costs. STIMEY socially motivational platform is a revolutionary tool because combines social media components, robotic artefacts, and radio to educate, engage and increase the youth's interest in STEM education and careers.

The usefulness and efficiency of this tool will depend on the number of users (schools, parents, students, teachers, among others) that will join STIMEY community. Follow us on www.stimey.eu.

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Using Eye Tracking Technology in Design – Possibilities and Limitations

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Abstract

As part of the design education at Offenburg University, the teaching in technical documentation is continuously optimised. In this study, numerous mechanical engineering students, ages 19 to 29, are observed using the eye tracking technology and a video camera while performing various design exercises. The aim of the study is to enhance the students' ability to read, understand and analyse complex engineering drawings. In one experiment, the students are asked to perform the "cube perspective test" after Stumpf and Fay to assess their ability for mental rotation as part of spatial visualization ability. Furthermore, the students are asked to prepare and give micro presentations on a topic related to their studies. Students have a maximum of 100 s time for these presentations. Thus, they can practise presenting important information in a short amount of time, show their rhetorical skills and demonstrate their acquisition of basic knowledge. During the presentation, the eye movement of a few selected students is recorded to analyse their information acquisition. In a further test, the students' eye movements are analysed while reading an engineering drawing that consists of multiple views. All the spatial connections have to be included based on the different component views. Including these and their acquired knowledge, the students are asked to identify the correct representation of a component view. Furthermore the subjects are describing the function of an assembly, a parallel gripper and then they are to mentally disassemble the assembly to replace a damaged cylindrical pin. Simultaneously, they are filmed using a video camera to see which terms the students use for the individual technical terms. The evaluation of the eye movements shows that the increasing digitalisation of society and the use of electronic devices in everyday life lead to fast and only selective perceptual behaviour and that students feel insecure when dealing with technical drawings. The analysis of the videos shows a mostly non-technical and inaccurate manner of expression and a poor use of technical terms. The transferability of the achieved results to other technical tasks is part of further investigations.

Keywords: Engineering education in the age of digitalization, design education, technical drawings, spatial imagination, presentation skills, eye tracking

1. Introduction and motivation

The results of the mechanical engineering students at the Offenburg University in presenting, reading and understanding technical presentations are decreasing all the time.

Today's products are becoming increasingly complex. At the same time, as a result of globalization, interfaces within the overall development process are increasing more and more. Complex presentations of product data are produced in the form of freehand sketches, technical drawings, CAD and FEM models. In addition the holding of presentations, in which complicated circumstances must be summarized in short time, belongs nowadays to the everyday life of engineers.

As part of the design training at the Offenburg University, teaching in the subjects Technical Documentation and CAx Techniques is continuously optimized. In order to make this process efficient and targeted, empirical laboratory tests are carried out on the key skills of presentation, spatial perception, reading and comprehension of technical drawings [1].

2. Goal setting

The aim of this work is to use various empirical methods to find out why students in technical courses increasingly show weaknesses in the practical key competences mentioned above and to derive from this how these deficits can be reduced and how existing abilities and skills in teaching can be supported.

3. Investigation of the spatial visualization ability

148 mechanical engineering students from the first, second and sixth semesters were tested. The students were subjected to Stumpf's and Fay's [2] tube figure tests to assess their mental rotation competence as a component of the ability to visualize three-dimensional figures. For each task there are two illustrations showing a transparent cube with a twisted tube in it from two different perspectives, see Fig. 1.

The students had to decide from which perspective the second illustration was taken. Almost half of all test persons were classified as average in the easier part A and far below average in the more difficult part B [3]. The interviews with the probands showed that those who used a combination of visualisation and logical reasoning to find a solution achieved better results. The students showed impatience and lack of concentration in finding solutions for the much heavier figures in part B. Consequently, only about two thirds of all tasks were handled at all and about 50% of them were faulty [3].

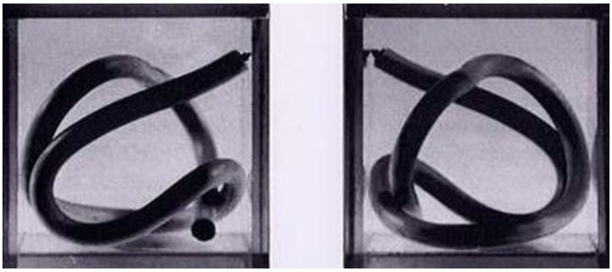

Fig. 1. Example of a tube figure pair according to [2], left: the front view of the transparent cube with twisted tubes inside, right: the same tube figure shown from another perspective

4. Eye-tracking during micro presentations

A micro presentation is a session with a maximum duration of 100 s, in which the results of the investigation of a technically oriented task are presented and held in a clear manner in front of an audience [4]. The students from the main study course should divide their micro presentations consisting of a single slide into four quadrants Q1 (task area), Q2 (FEM result), Q3 (technical diagram), and Q4 (text summary).

These quadrants are provided with so-called Areas of Interest (AOIs) for detailed recording of the results.

At 24%, the average length of stay of all test persons in Q1 is significantly shorter than it would have been necessary for the complete interpretation of the task. The total time in Q4 of 27% is significantly longer than desired. This is an indication that the ability to recognize the essential results of an investigation has not yet been developed. The students use less than half of the available time to deal with the actual result (Q2=21%, Q3=28%, Q2+Q3=49%). This tendency towards “fast, fast”, which prevents a careful and precise investigation of a task, is not only observed among students today. Fig. 2 shows examples of the heat maps of an expert (left) and an above-average student (right). The picture shows that the subject dealt with all four quadrants and the time division was exemplary. This brought him very close to the expert’s target.

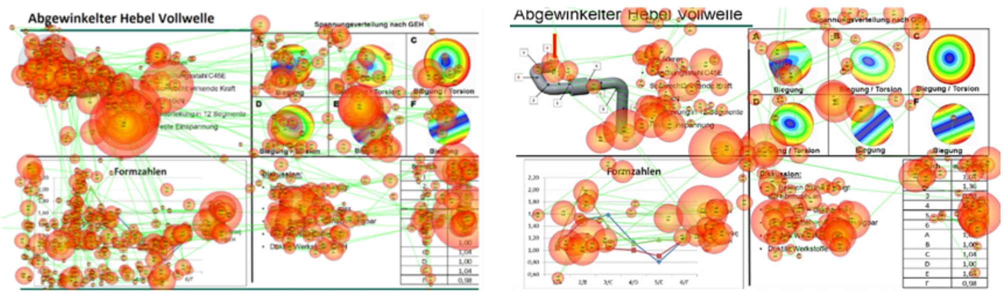

Fig. 2. Heatmaps Q1-Q4 of the expert (left) and of an above-average test person (right), (Source: own presentation)

5. Eye-tracking when viewing technical diagrams

Technical diagrams are a form of representation that is not sufficiently appreciated in scientific studies. The evaluation of the eye-tracking analysis for viewing the technical diagram (Q3) resulted in the following average time shares of the test subjects: 48 % for the curves, 31 % for the legend, 11 % for the title, 6 % for the x-axis and 4 % for the y-axis. Fig. 3 shows a section of Fig. 2 where Q3 is enlarged. Here the expert's higher appreciation of the diagram is clearly visible.

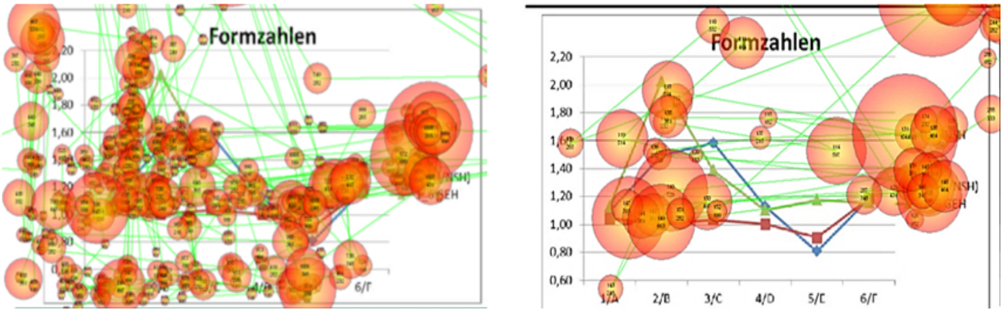

Fig. 3. Heatmaps Q3 of the expert (left) and of an above-average test person (right) (Source: own presentation)

6. Eye-tracking for reading and understanding technical drawings

For this experiment, the students were observed finding solutions for a typical task in the field of "Technical Drawing". The investigation focuses on a component that is not very complex (Fig. 4). The subjects receive the front and top view of these workpiece. They must decide which of the four side views presented the correct one is.

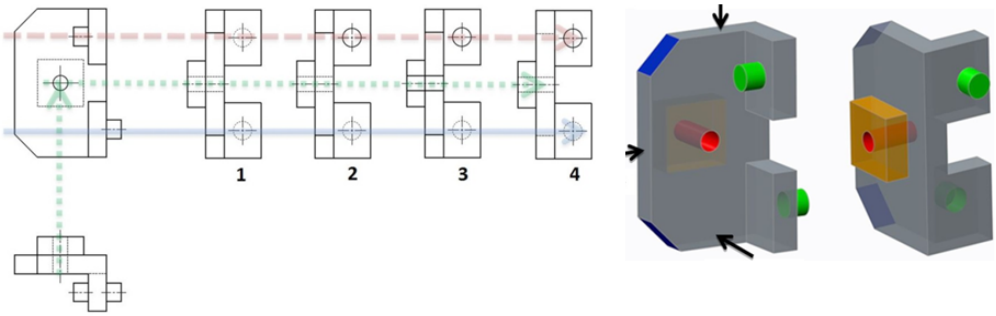

Fig. 4. Possible procedure and representation of front view and top view of the component as well as the four side views from the left for selection (Source: own presentation)

Although the rules for finding a solution are extremely simple (visible edges are marked with a solid line, invisible edges with a dashed line), only 47% of the test persons indicated the correct solution.

The evaluation of the eye-tracking data shows that only one third of the students takes time for a detailed examination of the front view and top view. A further third begins too quickly to find a solution. The last third did not recognize the decision criteria for finding a solution. This is indicated by the high number of fixations and/or many saccades.

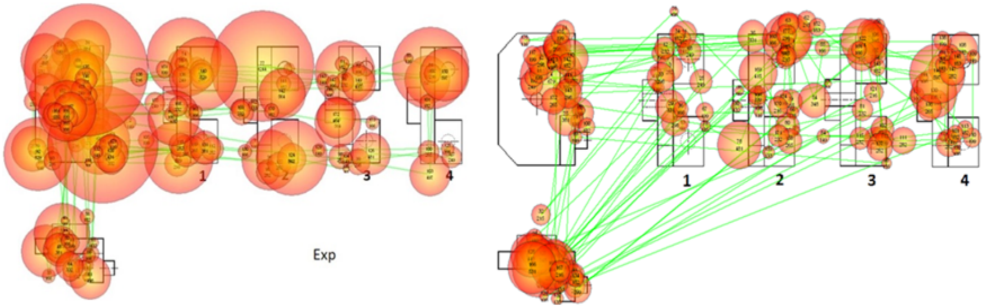

Fig. 5. Heatmaps of the expert (left) and a test person (right) viewing a technical drawing (Source: own presentation)

Fig. 5 shows examples of the heat maps of the expert (left) and a test person (right).

The saccades of the proband seem confused and imprudent. The large number of saccades indicates an existing uncertainty. The person did not take sufficient time to examine the cylindrical sections in side view. The top view was examined in detail, which was not desired.

7. Eye-tracking during the analysis of an assembly drawing

In a further investigation, the students were observed using eye-tracking technology and a video camera in the analysis of a component drawing. The present drawing consisted of different views and sections. In the first task part, they were to use these to describe the function of a parallel gripper (Fig. 6). In the second part, they were to name the disassembly steps. It was to be assumed that a certain, worn component would have to be replaced (task of a final examination of the vocational schools in Baden Württemberg).

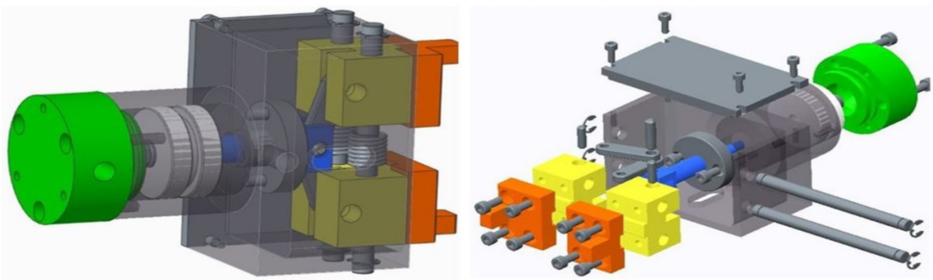

Fig. 6. CAD model of the parallel gripper (Source: own presentation)

The results of the video recording should be related to the heat maps in order to identify possible connections between what is seen and what is spoken. In addition, the number of technical nouns and verbs used by the probands should be investigated.

According to the authors, the function of the mechanical assembly can be explained verbally using fifteen different technical nouns and six different technical verbs in a time of 150 s and the disassembly of the components can be described using nine technical terms and five technical verbs in a time of 120 s [5].

This experiment is the continuation of the 100 s micro presentations. The students were asked to explain to another person what they had learned during the solution of a previous design task. The fact that the test subjects were not only recorded using the eye-tracking method, but also with a video camera, made it possible to analyse the connection between eye movement and "loud thinking". The working hypothesis that the eye movements follow the thinking process was strongly supported.

The results of the previous design task had shown that almost all test persons were able to solve it. The deficit was not in the understanding. However, many students showed a lack of ability to present their own understanding to a third person in a structured and comprehensible way. Likewise, most of the probands hardly used any technical terms. The video recordings show an average use of five technical nouns and three technical verbs per solution. This applies to both the functional and disassembly descriptions. Often the item numbers were mentioned instead of a correct technical term. Instead of a correct technical term, a colloquial term was repeatedly used.

Furthermore, the following findings from the previous tests were confirmed:

- The available time is far from being exhausted (functional description: approx. 66 s, description of disassembly: approx. 77 s).
- The lack of structure in the spoken sentences was reflected in restless and «confused» eye paths.

Fig. 7 (left) shows an example of the heat map of a test person in the functional description. Many short fixations and saccades indicate a lack of specialist knowledge.

This is confirmed by the video recording, which shows the use of only one technical noun and one technical verb.

Fig. 7 (right) shows an example of the heat map of another test person in the disassembly description. It shows long fixations in the AOIs, especially on the front view. The person takes a lot of time to look at the views in detail. The video recording shows a structured approach and the use of many technical terms.

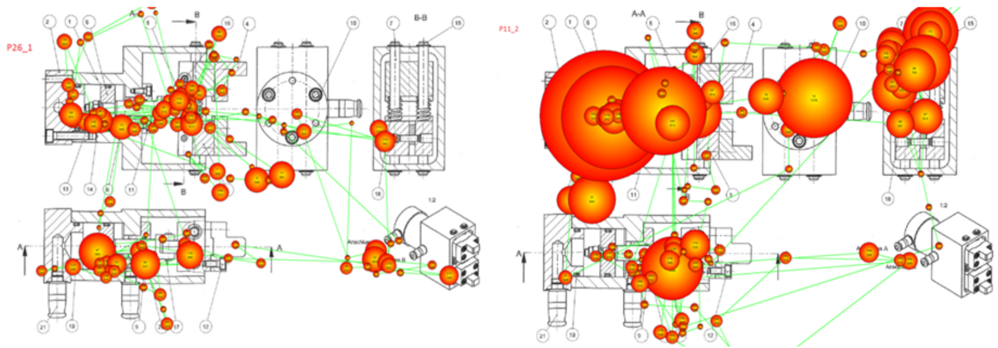

Fig. 7. Heatmaps of the assembly drawing of two test persons: Functional description (left), Disassembly description (right), (Source: Own illustration)

8. Conclusions

From the empirical investigations presented here, conclusions were drawn about the visual approach of students in the analysis, interpretation and presentation of technical representations in pictorial and textual form. The following basic statements can be made:

The ability of students to independently acquire knowledge from technical representations is insufficient. Deficits were observed in the ability to concentrate and abstract, in logical thinking and reasoning, and in the ability to structure.

Furthermore, students seldom make full use of the time available to them to cope with theoretical tasks and often deal inadequately with a task. They clearly underestimate the importance of correct technical expression using technical terms, as well as the use of illustrations, especially technical diagrams.

In contrast, good skills and persistence in solving practical tasks have been demonstrated.

From the authors' point of view, therefore, two teaching tasks are to be solved with priority:

Through a strong practical orientation with interesting projects and the use of IT tools, which are intuitively used correctly by most students, motivation and "inventiveness" are to be awakened and promoted and early experiences of success are to be created, in order to cause "stamina" for the training of the necessary key competencies.

The encouragement of practical and personal competences must be constantly driven forward and their teaching must take place in a balanced manner parallel to the technical and methodological competences.

The transferability of the achieved results to other technical tasks is part of further investigations.

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Extra Curricola Activities

Intellectual Property Problems on Photographic Information Analysis in University Environment

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Abstract

A necessary condition for career development in educational institutions is the creation of a connection between education, research and practice. A successful step in this direction is made by the University of Library Studies and Information Technologies (ULSIT) in Sofia, Bulgaria, where the PhD Program "Organization and Management of Information Processes" has been developed in the professional field "Public Communications and Information Sciences". University education in Intellectual Property is of crucial importance in various fields of knowledge. Intellectual property research, especially copyright and related rights, is often aimed at the creation or use of commercial products such as audiovisual and performing productions. In particular, it is rarely mentioned copyright on photographic images, because in this area we have huge technological advances that can hardly be presented in any R & D-friendly frameworks. Current conditions and circumstances are such that now almost every person, holding a photographing device, produces a photographic image that can be protected. Photography is an art and business, hobby and profession. When it is created as a result of the creative activity of professionals and possesses artistic character, it becomes an object of copyright protection. In the framework of the above-mentioned PhD program "Organization and Management of Information Processes" in ULSIT, intensive research in the field of the intellectual property on photographic information is made. This is a problem that is globally explored but at the same time it is of particular importance for the modern information society, which often handles, advertises and illustrates its business achievements or the daily routine of its individuals through photographic images. The report summarizes some of the most important and innovative results from researches on intellectual property, copyright and related rights, and in particular copyright on photographic images. Specific proposals for future research and their actual application in public practice have been formulated.

Keywords: copyright, intellectual property, R & D, photographic information

1. Introduction

Research on intellectual property (IP), in particular copyright and related rights, is aimed at the so-called creative industries related to audiovisual and stage productions.

New technologies also create new perspectives and challenges for science, so research in this area is of utmost importance to both business and their creators.

The technological advancement of photography in the 1970s and the mass production and use of digital photography at the beginning of the 21st century changed the attitude towards the end product called a photograph because of its specific digital format. Regardless of the photographic image creator's status – professional or amateur, any photographic image that is a result of the author's creative activity and has an **artistic character** (aesthetic, spatial, compositional, stylistic sense of a work of photography) could be an object of copyright [2, 8].

The purpose of this report is to highlight examples of IP research in copyright and related rights at photographic information, and research has been carried out in various electronic resources such as WorldCat, the National Information and Documentation Center Bulgaria (NIDC), COBISS Platform – Co-operative Online Bibliographic System and Services and Scientific Research Fund at the Ministry of Education and Science of Bulgaria. Research in this area helps to raise the awareness of the whole society on legal issues relating to copyright products.

2. Intellectual Property Training in University Information Environment in Bulgaria

The importance of IP in the modern world goes far beyond the protection of the creations of the mind, as it affects all aspects of economic and cultural life. That is why the question arises, which is of utmost importance for the intellectual property literacy of the society, namely IP education in a university information environment [1, 9, 10]. The theoretical and practical IP training leads to the acquisition of professional knowledge, skills and experience to work with different products, which is a prerequisite for the innovation of the society and the increase of the information literacy [6]. Active participants in the information process are: The World Intellectual Property Organization, the European Patent Organization, the Office of the European Intellectual Property Union.

In Bulgaria, **IP education** is offered in bachelor and master programs at the University of National and World Economy, the National Academy of Theater and Film Arts, the University of Library Studies and Information Technologies and the New Bulgarian University. After completing a master's degree, students can continue their education in the educational and scientific degree "doctor".

In addition to formal education in a university environment, the focus is also on informal learning and certification of knowledge, through the creation of an appropriate educational structure and environment in/outside educational institutions [6]. Non-formal learning is of interest to the scientific and students' community, exemplary of which are different educational structures and institutes, the organization of scientific seminars and the realization of project and research activities.

3. Research in the IP field on photographic information – examples from international practice

Internationally, studies related to the "copyright on photographic images" are published in information sources such as:

- Encyclopedia Britannica containing a section related to Copyright LAW.
- Copyright and photographs: an international survey by Ysolde Gendreau, Axel Nordemann, Rainer Oesch
- Photographer's legal guide by Carolyn E. Wright
- Photo 1: An Introduction to the Art of Photography by Katie Stern
- Copyright Workflow for Photographers: Protecting, Managing, and Sharing Digital Images by Christopher S. Reed

- Photographer's Survival Manual: A Legal Guide for Artists in the Digital Age (Lark Photography Book), by Edward C. Greenberg and Jack Reznicki
- Photographers at Work: Essential Business and Production Skills for Photographers in Editorial, Design, and Advertising by Martin Evening.

For the purpose of the report, the **WorldCat** database is also used, resulting in the following examples of world-wide research in the field of photographic copyright:

- Rights and Reproductions? Commercial Photography and Copyright Law in the United States, 1884-1909 By Katherine Brooks Mintie [3];
- Legal aspects of visual resources archive management: effect of the 1976 Copyright Act and U.S. admission to the Berne Convention (1988) on scholastic collections of photographic materials - by John Stuart Koehler;
- Copyright and photography: digital dilemmas by Michelle L Mitchell;
- The appropriation of photographic images in works of art: legal and aesthetic issues inherent in the conflict between modernism and postmodernism, by Louise Harmon;
- Art, photography, copyright: a history of photographic copyright 1850-1911 by Elena Sophia Christina Cooper;
- A delicate copyright issue: photographing public art by Ae Lee Sin;
- Copyright law and the freedom of panorama: the right to commercialize photographs of protected works: a dissertation submitted to the Victoria University of Wellington in fulfilment of the requirements for the degree of Master of Laws.

These examples testify that the intellectual aspects of photography are a topical and significant problem internationally. In Bulgaria, the copyright on photographic information is a subject that is partially addressed in separate articles and publications.

4. Investigations related to the IP aspects of photographic information – the experience of ULSIT

IP can be seen as an element of information literacy in the university information environment because, in order to successfully develop students at university and in life, they must learn to use efficiently and effectively the wide variety of information and communication technologies to search, find, organize, analyze and evaluate the information they need. This requires them to assemble the entire set of basic skills for research, technological skills, critical thinking and evaluation. [6]

In Bulgaria, the Scientific Research Fund supports financially projects and activities to promote and develop research.

To give examples of research activities in Bulgaria, the NCID database is available at https://cris.nacid.bg/. As a result of a study, the following conclusions can be drawn – since 1998, studies have been carried out on various industrial and IP sites, some of which are dedicated to the creative industries.

An example of the experience of ULSIT in the context of the studied subject is a scientific study on "Organization and IP Management of Photographic Information".

The subject of the scientific research is interdisciplinary and covers current issues in the field of visual arts, law, formal and non-formal education, pedagogy, sociology and others, considered in the context of the contemporary information society. A theoretical material about current trends and business models for the organization and management of copyrights on photographic information has been accumulated, analyzing the legal protection of the three main levels: international law, European Union law and national legal framework.

Another example of good practice in research at ULSIT are two projects funded by the Scientific Research Fund and implemented by ULSIT:

1) “Creation and development of educational and scientific facilities for documentary and applied photography as part of the training of students in the professional field 3.5 – Public communications and information sciences” (2019-2021) – Within this project, a team of young scientists, postdoctoral students, PhD students and a student from ULSIT will create a scientific and educational base for documentary and applied photography, designed for ULSIT students trained in the professional field of “Public Communications and Information Sciences”. During the experimental training, students will be familiarized with the features of visual literacy and intellectual aspects in photography, resulting in future research on the role and importance of photo-based IT training.

2) “Application of the mixed reality in the training and promotion of the cultural heritage for the purposes of the in the university information environment” (2019-2021) – The project is part of a competition to fund fundamental research and societal challengesq funded by the National Science Fund (NSF). The methodology of the project is focused on the problems related to the application of the mixed reality in the training and promotion of cultural heritage (CH) in Bulgaria. Within the project through photographic means specialists of ULSIT and South-West University will create a real 3D model of the specific object of CH (ancient city Skaptopara). The team of the project is composed of established scientists, young scientists and PhD students, some of whom are intellectual property specialists.

Conclusion

In order to change the attitude of society towards the improper use of intellectual products, it is necessary to carry out scientific studies and experimental trainings tailored to the technologies and innovations of the present. The examples of IP research in photographic information cited in the report testify to the encouragement and motivation of the educational institution (like ULSIT) and NSF to carry out similar research in the future.

Aknowledgements

This research would not have been possible without the financial assistance of the following projects: “Application of the mixed reality in the training and promotion of the cultural heritage for the purposes of the in the university information environment” financed by National Science Fund of the Ministry of Education and Science of the republic of Bulgaria with Contract № KP – 06 – OPR 05/14 from 17.12.2018, led by Prof. DSc Irena Peteva and “Creation and development of educational and scientific facilities for documentary and applied photography as part of the training of students in the professional field 3.5 “Public communications and information sciences” with Contract № KP – 06 – M30/3, led by Assist. Prof. Kamelia Planska-Simeonova, Phd.

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Short Courses: Sharing Knowledge with Students, from Students

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Abstract

The undergraduate years are crucial for students to broaden their horizons and learn about new research areas. However, most of the times the training opportunities that students could resort to to complement their academic education are not specifically designed for them, for being too advanced, significantly expensive or ocurring during the week, overlapping with academic commitments. With this in mind, the Centre for Ecology, Evolution and Environmental Changes (cE3c), based at the Faculty of Sciences of the University of Lisbon, Portugal, joined efforts with the Association of Biology Students of the Faculty to create an offer of brief training opportunities aimed at undergraduate Biology students: the Short Courses. During the academic year 2017/2018, thirteen Short Courses were organized (corresponding to 215 vacancies), spanning areas as diverse as ecology, taxonomy, programming and science communication, and putting in direct contact researchers, PhD and Post-Doctoral students from cE3c – as trainers – with undergraduate students – as participants. Furthermore, to meet the students' needs the courses had the duration of 1-2 days, were scheduled for public holidays and weekends, and the inscription cost was kept at a minimum possible to ensure just logistic needs and the payment of the trainers' work. In this first edition, the Short Courses registered a global occupancy rate of 83%, with several courses sold out. As expected, the majority (70%) of participants were undergraduate Biology students from the Faculty, but the Short Courses also welcomed master and doctoral students, and participants from other faculties across the country. The evaluation surveys reveal that all participants rated the initiative as either "Very Good" (maximum) or "Good", with very positive appreciations about the organization and the pertinence of the courses to their academic education. Trainers also praised the initiative, emphasizing its importance for communicating their work and inspiring a new generation for their research area. Evaluation results and suggestions will be used for improving future editions of the Short Courses.

Keywords: Science education; Science Communication; Undergraduate education; Soft skills;

1. Our motivation

The undergraduate years are crucial for students to broaden their horizons. It is also an important period for students to acquire skills that will be important in their near professional or academic career, such as programming skills, laboratory techniques and soft skills. Frequently these skills are not explored in depth during the bachelor's degree, as time must be allocated to the heavy curriculum of each discipline.

In the academic year 2017/2018, the Faculty of Sciences of the University of Lisbon (FCUL) had 3202 undergraduate students, of which 732 attended the Bachelor Programme in Biology – the one with the largest number of students in the Faculty [1].

In collaboration with its research units, the Faculty offers several brief training opportunities – however, these are mostly aimed at Master and postgraduate students, being too advanced for undergraduates or significantly expensive. Frequently these training opportunities also take place during the week, overlapping with academic commitments.

2. The project: Short *Courses*

To meet the students' needs, the Centre for Ecology, Evolution and Environmental Changes – cE3c, based at FCUL (Portugal), joined efforts with FCUL's Association of Biology Students to create the *Short Courses*: an offer of brief training opportunities – with the duration of 1-2 days – aimed at undergraduate Biology students.

The courses were scheduled for public holidays and weekends, and as far as possible from periods of the academic year identified by the Association of Biology Students as periods of greater academic work, to ensure that students could participate. The inscription cost was kept at a minimum possible, just enough to ensure the payment of the trainers' work and logistic expenses.

We aimed to have preferentially PhD students and PostDoctoral researchers as trainers – for some of th trainers it was their first teaching experience. The fact most trainers had been undergraduate students themselves not long ago also allowed them to identify more easily the students' difficulties.

In July 2017 we launched a call among cE3c PhD students for the submission of *Short Courses*' proposals. In the previous academic year, the Association of Biology Students had also undertaken a survey to identify areas in which undergraduate students were more interested in complementary activities. With that in mind, we also sent invitations to cE3c PostDoctoral researchers and Professors in key areas.

The *Short Courses* were launched in September 2017, through social media (our main communication channel) and posters affixed at the Faculty. Students interested in enrolling were asked to complete a pre-inscription form, also indicating their academic area and level. As this initiative was preferably aimed at undergraduate and Master Biology students of the Faculty, students from other scientific areas and institutions would start by being placed in a waiting list. After the inscription deadline for each course, these students would also be admitted whenever there were vacancies available.

The courses spanned diverse scientific areas, from Ecology to Taxonomy, from Programming to Scientific Writing and Science Communication. Whenever appropriate, the training would take place not only in the classroom, but also involving field trips and laboratory classes (Fig. 1).

At the end of each course, we asked participants to fill out a brief survey to collect participants' assessment of the scientific content of the course, logistical aspects, and suggestions on what should be improved in future editions. Trainers were also asked to fill out a brief online survey, focused on their evaluation of logistical aspects, in understanding if they would be interested in proposing again a *Short Course*, and in understanding how they perceived the impact (if any) of their involvement in this initiative in communicating their research.

Fig. 1. The Short Courses spanned diverse scientific areas and took place in different environments – not only in the classroom, but also involving field trips and laboratory classes whenever appropriate.

4. Results

Thirteen *Short Courses* were organized in the academic year 2017/2018, corresponding to 215 vacancies [2]. In total, 180 students enrolled in the courses, which corresponded to an occupancy rate of 83%, with six courses sold out. The main audience corresponded to undergraduate students (70%), as expected, among which the majority (58,7%) was attending the third and last year of their bachelor's degree (Fig. 2). Remarkably, the courses also attracted more advanced students: 22,2% of the inscribed participants were Master students, while 2,8% were PhD students (Fig. 2).

The dissemination of this initiative through social media allowed us to reach a wider audience than initially expected: some inscriptions came from students of other institutions, not only in Lisbon but also, in some cases, from other parts of the country as well.

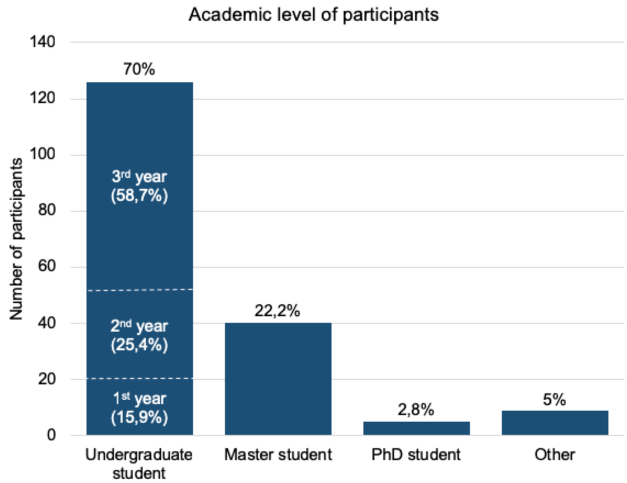

Fig. 2. Academic level of the participants inscribed in the Short Courses, according to the data gathered in the pre-registration form

4.1 Evaluation by the participants

The participants' surveys were organized in three sections: evaluation of training, evaluation of logistics and overall opinion. Each section corresponded to a five-point scale rating question.

The participants' overall opinion about this initiative is very positive: 89,8% of the participants affirmed that the course they attended corresponded to their expectations "Completely" or "A lot"; this result increases to 90,6% when asked if they considered the course important to their academic background (Fig. 3 a).

The participants' satisfaction rating concerning the trainers and scientific content of the courses was also very positive: for all the categories – such as the courses' utility, relevance and appropriateness, and overall performance of the trainers – the overall majority of the participants rated as either "Good" or "Very Good" (the maximum).

Only three participants rated three categories with "Reasonable" (Fig. 3 b).

While also corresponding to a very positive evaluation, the participants' satisfaction rating concerning logistic aspects did not gather the same overall consensus. The quality of the coffee-breaks was the most disputed question: 5,3% evaluations as "Terrible" and "Bad", while 15,3% classified the coffee-breaks as "Reasonable" (Fig. 3c). As we monitored these results from course to course, by talking informally with some participants we understood that the more critical evaluations were due to the fact that the coffee-breaks were little diversified, an aspect which was improved in later courses.

4.2 Evaluation by the trainers

The *Short Courses* involved 19 trainers, of which 11 were PhD students or Master's degree holders, 7 were PostDocs and 1 was Assistant Professor. After each course the trainers were asked to jointly fill out an online evaluation survey, so that one response was collected per course. The first author of this paper, co-organizer of this initiative, was simultaneously the trainer of three courses – as such, her responses were not considered to the survey so as not to influence results. Also, when a course had more than one edition trainers were also asked to fill out the survey only once.

The trainers' evaluation survey was structured in two sections: evaluation of logistics – a five-point scale rating question –, and opinion and suggestions (open-ended questions). In total, n=8 answers were collected.

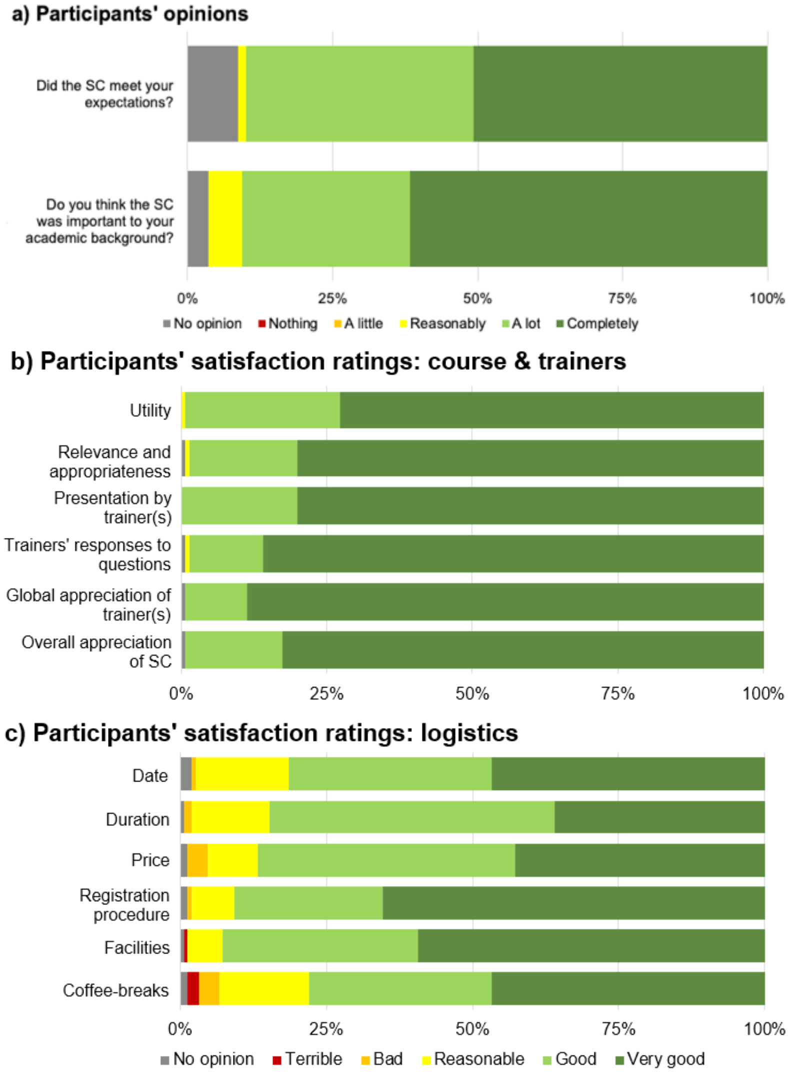

Fig. 3. Results of the participants' evaluation surveys, considering a) their overall opinion (n=138 as these questions were inserted after the first course), and the participants' satisfaction ratings concerning b) course and trainers, and c) logistics (n=150).

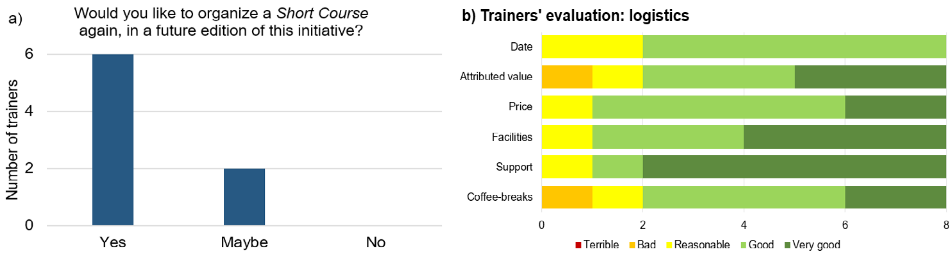

Fig. 4. Results of the trainers' evaluation surveys (n=8), considering a) whether they would like to organize a Short Course again in the future, and b) their evaluation of logistics

Concerning their motivation to propose a *Short Course*, trainers mostly highlighted their interest in gaining experience as trainers (for several of them it was their first teaching experience) and in giving visibility to their research area. Six of the eight answers were positive about organizing a *Short Course* again in a future edition (Fig 4a), and emphasized that organizing a course was important for them from the perspective of communicating their research, as highlighted by these excerpts: "Yes, as some of these students end up working with us during their Master's theses", "It was important, because it allowed me to disseminate the results I had the opportunity to collect as a researcher", "Yes, by the involvement of young students who could constitute the new generation of taxonomists".

Concerning the trainers' evaluation of logistics, all categories received at least six (out of eight) votes as either "Good" or "Very Good" (Fig 4b). Only the coffee-breaks, and the value attributed to the trainers' work, received one answer each as "Bad" – concerning the latter, this is related to the fact that the payment to each trainer could not be too high in order to keep the inscription cost accessible to students.

5. Discussion and Conclusions

The high number of inscriptions by our target audience and the positive evaluations by both participants and trainers allow us to affirm that the first edition of the *Short Courses* was very successful – an outcome that encourages us to organize this initiative again in the near future. In following editions, we will work towards broadening the scientific areas covered by the courses, following suggestions presented by the participants, and simplify the inscription process and the trainers' payment.

We also aim to involve more PhD students and PostDocs as trainers: to strengthen their role as mentors of undergraduate students and also to reinforce what is, to several of them, their first teaching experience, through which they can also gain new perspectives on their research.

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Spectroscopy in a Suitcase: A Model for Implementing and Coordinating a National Chemistry Education and Public Engagement Programme in Ireland

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Abstract

The Irish senior secondary school (Leaving Cert) chemistry curriculum requires students to learn about spectroscopic techniques such as Infra-Red (IR) and Ultra-Violet (UV) spectroscopy. However, most teachers find this section one of the most difficult to teach since schools don't normally have access to the required equipment due to its prohibitively high cost. As a result, the instrumentation question on the annual Leaving Cert Chemistry exam was reported to be the least attempted question across the entire paper. [1] In addition to this, only about a third of Leaving Cert chemistry students who sit the exam continue on to pursue a chemistry related course at an Irish Higher Education Institution. [2] Unlike biology which enjoys widespread school coverage, not all Irish schools teach chemistry or physics to senior secondary level and the schools who do offer these subjects can regularly change depending on demand. [3] Collectively this situation presents a unique challenge for school-based interventions involving chemistry or physics in Ireland. The Spectroscopy in a Suitcase programme is run through six Higher Education Institutions chosen for their expertise in chemistry and geographic location to maintain a high standard and widespread national coverage respectively. Using portable spectrometers and context based learning (CBL) techniques, workshops are run by a team of trained higher level students usually in school labs during school time as a short-duration intervention activity. The benefits of the "scientist in the classroom" model to postgraduate students, secondary students, teachers and the partner Higher Education Institutions are numerous. [4] Recently, the programme has expanded to provide public engagement events and teacher enrichment workshops in addition to the already successful student workshops which have now been running for over four years in Ireland. Feedback and evaluations received to date have been overwhelmingly positive and the programme has provided workshops in half of all Irish secondary schools nationwide as well as running dozens of public engagement and teacher enrichment events.

Keywords: Public Engagement, Science Communication, Spectroscopy, Chemistry Education, Outreach, Context-Based Learning

1. Introduction

Spectroscopy in a Suitcase (SIAS) started as a pilot in 2007 across four regions in England as part of the Royal Society of Chemistry (RSC) “Chemistry for our Future” project. [5] Using a kit of professional spectroscopy equipment two models were initially developed; one where teachers were trained to use the equipment so they could borrow it for their classroom and the other based on the familiar Scientist in the Classroom model with postgraduate students trained to use the kit and deliver workshops in schools. [5] In 2014 the RSC Ireland team brought the Scientist in the Classroom model of SIAS to the Republic of Ireland after running successful pilot workshops in a number of Irish schools. Workshop content and the specific kit equipment (IR and UV Spectrometers) were adapted for the Leaving Cert Chemistry curriculum and three hosts were initially chosen from a number of applications in the two largest urban centres; Cork and Dublin.

The Irish programme was expanded further in 2015, 2016 and 2017 with support from three successful Science Foundation Ireland (SFI) grant applications. The SFI funding provided more kits, a greater range of school visits and new host institutions to expand the programme nationally. Together these expansions have now ensured that all Irish secondary schools are within reach of the programme. [6] To date about a hundred postgraduate students and a dozen undergraduate students have visited nearly half of all Irish secondary schools from six host institutions in the Republic of Ireland. Feedback from Irish teachers has been overwhelming positive and SIAS is now integral to the postgraduate training programme at most of the host institutions.

2. Chemistry in Irish Schools

The current Irish senior secondary school chemistry curriculum, as part of the Leaving Cert, was first introduced in 2000 and is currently being revised. [7] Assessment of the current Leaving Cert Chemistry course is by way of a terminal examination only. Mandatory practical experiments are undertaken by students throughout the two year course and these are currently assessed in written form as part of the terminal exam. Instrumentation is the term normally used for spectrometers or other analytical devices described on the course. The Higher-Level course (taken by 86% of chemistry students) [2] requires students to learn the principles of Mass Spectrometry, Atomic Absorption Spectroscopy, Chromatography (TLC, GC and HPLC), Infra-Red (IR) and Ultra-Violet (UV) Spectroscopy. However, from experience, to date the only instruments or relevant techniques on the syllabus that are available for students to use in Irish schools are colorimeters, pH meters and TLC.

Students are required to know that IR is a ‘fingerprinting’ technique involving the absorption of infra-red radiation and UV is a quantitative technique involving the absorption of ultraviolet light. The current syllabus specifically states that students do not need to interpret spectra. [8] This is in stark contrast to the UK chemistry curriculum where students are required to interpret spectra [9] and therefore when SIAS was expanded to Ireland, the workshop material needed to be adapted to make it relevant.

Fig. 1. Left the IR spectrometer with ATR attachment and right the UV-vis spectrometer, both of which are used for SIAS workshops in the Republic of Ireland

Each SIAS kit comprises of an IR and UV Spectrometer as well as all the required glassware, worksheets and stock solutions to run the workshop. Students are split into equal groups to accurately measure out serial dilutions of a known stock solution usually with pipettes and volumetric flasks. During the workshop the identity of an unknown sample is identified with the IR spectrometer. A straight-line graph is also produced using absorbances obtained from the UV Spectrometer against the known concentrations. The concentration of the unknown sample is then identified using the calibration graph as per the Beer-Lambert law.

A story is weaved around these methods to give students context and real-world examples of what the instruments are used for. Determining an unknown concentration based on a calibration graph of known concentrations is already on the course as a mandatory experiment using colorimetry. Therefore, the students can identify the workshop as being relevant to their studies with respect to the course. Also, because SIAS workshops are linked to the syllabus, teachers have embraced the programme in Irish schools and are consistently willing to give up scheduled classes to allow ambassadors to run SIAS during school time.

3. Regionally Specific Expansion

In recent years the miniaturisation and increased portability of professional IR and UV spectrometers have allowed these instruments to become more widely available.

However, their costs are still prohibitively high for secondary schools to purchase their own instruments. Therefore, the SIAS programme gives Higher Level Institutions a platform for visiting schools via the Scientist in a Classroom model [4], which provides a much-needed service for chemistry students and maximises the use of each kit by visiting multiple schools with the same spectrometers.

Fig. 2. Left: location of all six SIAS Higher Level host Institutions with two each in Cork and Dublin, and right: schools in the Republic of Ireland that have received a SIAS workshop to date

Over time the number of SIAS kits available to Irish hosts has increased from two up to six with successful grant applications. Host institutions generally visit schools on a regional basis as determined by their location, with some overlap between hosts from time to time. Initially some kits were shared between partner host institutions, but the costs and logistics involved in moving the kits between the hosts meant this needed to be changed in favour of each host having their own kit. With one kit per host, it has increased the flexibility of the host ambassadors to match their timetables with local school timetables which has resulted in a greater number of school visits.

Although some SIAS workshops are run in labs on a host institutions' campus, the vast majority are run in school labs during school time which reduces the workload, logistics and requirements for schools to participant. This has hugely contributed towards the continuous expansion of the programme with increased demand from schools year on year.

4. Public Engagement

In addition to the school based, curriculum specific workshops, the Irish SIAS programme also provides public engagement opportunities. Public engagement with the SIAS kits has varied from interactive demonstrations to shortened workshops designed specifically for each event. Public events that are generally themed around science such as the BT Young Scientist and the Kerry Science Festival involve ambassadors providing demonstrations using the IR spectrometer with various over the counter pharmaceuticals. However, SIAS demonstrations have also been very well received at non-science themed events such as the annual Irish National Ploughing Championships which is one of the largest outdoor events in Europe and is based around food and agriculture among other activities. For this event the IR spectrometer was used to demonstrate the difference between petroleum based road diesel, agricultural diesel and biodiesel. The response was hugely positive with hundreds of the public engaging with the activity and asking questions about the chemistry behind the various fuels.

The SIAS programme in Ireland has also successfully engaged with younger audiences at computer and technology based aimed at primary students. The IR spectrometer was used in these cases for a quick demonstration involving the sorting of similar looking plastics. Various similarly coloured plastics made from different polymers were differentiated using the IR spectrometry into recyclable material and non-recyclable. This was very well received by the students and teachers since it tied chemistry into the Green Schools programme already run in schools.

5. Conclusion

For the Spectroscopy in a Suitcase Ireland programme 40% of teachers whose students received a workshop responded to the post workshop survey. 100% of the respondents stated they would recommend the service to colleagues and 88% attributed their score to positive student outcomes and increasing their confidence in teaching analytical chemistry. When asked, 94% of teachers thought the workshop significantly increased their student's understanding of spectroscopy and 97% said that it significantly increased their students' knowledge of its real-world applications and their chemistry career options.

6. Acknowledgements

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The Chemistry of Remembering: Integration of a Learning Video into an Inquiry-Based Chemistry Unit Based on the Topic of Alzheimer's Disease

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Abstract

During the 21st century mankind will be facing new challenges, including demographic change and the resulting risk of widespread diseases such as Alzheimer's and their socio-economic costs. The German Alzheimer's Association e.V. states that currently 1.7 million people are affected by dementia in Germany, most of them with Alzheimer's disease, with rising tendencies [1]. Correspondingly, fundamental chemical research focuses its research questions on the elucidation of such diseases, so that therapeutic options can be used to accelerate the sustainable relief of society.
To sensitize and prepare future generations for such current research topics, they should be integrated into chemistry education for a contemporary and future-oriented teaching [2]. As recent studies showed, such lessons should include topics such as "chemistry & medicine" as well as "current topics in chemistry" in order to effectively arouse students' interest [3].
Based on Alzheimer's disease, the presented teaching unit examines how remembering works from a chemical point of view. By means of an inquiry-based method and with the aid of a learning video, processes at biomembranes on a molecular level as well as the regulation of ion channels are explained (e.g. diffusion, chemical gradients, etc.). Since acetylcholine, as a neurotransmitter, is relevant both for the process of remembering as well as for research on Alzheimer's disease, its synthesis and degradation is shown. As a result, the substance group of esters is emphasized and serious effects of the misregulation of the synthesis and degradation explained. Finally, references are made to current research on Alzheimer's disease so that students can put their newly acquired knowledge about important basic chemical concepts directly into an application-oriented context. Additionally, the students will work on a supportive worksheet focusing on the ester group, allowing the learning concept to be used either as an elaboration or as a repetition.

Keywords: Chemistry & Medicine, Alzheimer´s Disease, Teaching Unit, Ester

1. Introduction

In recent years, scientific-educational research has dealt intensively with the role of the natural sciences in formal and non-formal educational contexts. Thus, large-scale studies such as 'The Relevance of Science Education' (ROSE) and 'Programs for International Student Assessment' (PISA) already focus on the mutual relationship between science teaching and students' interest in science [2, 4]. Accordingly, the research consensus can be derived that science education should be reoriented.

Furthermore, Schiepe-Tiska *et al*., (2015) suggest that, in addition to an increase in knowledge and competence, a motivational orientation and an improved self-image of the pupils must be promoted in order to meet challenges of the 21st century (*e.g.*, demographic change) [4]. In addition, Merzyn (2008) points out that chemistry teaching should be oriented primarily towards the basic structures of the scientific disciplines.

Focal points such as areas of application or interdisciplinary research questions are only given minor consideration. But exactly these contents are of special interest for the students [5]. Complementarily, a pilot study was used to substantiate the fact that pupils show a particular interest in the subject areas "Chemistry & Medicine" and "Current Topics in Chemistry" [3].

As a result, Alzheimer's disease was selected as a topic for the presented teaching unit. While on the one hand, this disease lies within the students' fields of interest, on the other hand it reveals specific areas of application as well as medical research questions with respect to chemistry.

2. Scientific Principles

In 2018, 50 million people worldwide were affected by Alzheimer's disease and it is predicted that 152 million people will be affected in 2050 [6]. It's apparent, how demographic change is being exacerbated by such widespread diseases and is creating additional demand for both treatment and care.

According to current knowledge, the neurotransmitter acetylcholine plays an important role for learning processes and remembering. Acetylcholine is synthesized from acetyl coenzyme A and choline (see Fig. 1), which is a transesterification.

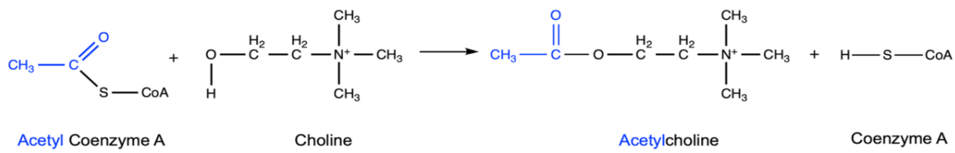

Fig. 1. Synthesis of acetylcholine from acetyl coenzyme A and choline

The acetyl coenzyme A present in the body belongs to the group of thioesters.

Due to the high potential for the transfer of acetyl groups, *i.e.*, the transfer of the acetyl group is exergonic, the reaction to the ester can take place in the body without, for example, having to carry out an acid catalyzed esterification [7]. The acid catalyzed ester formation is often discussed in chemistry class, which enables a direct comparison between the two forms of synthesis. Whether the substance group of thioesters should be discussed here can optionally be decided on the basis of the curricular specifications.

Additionally, not only acetylcholine as such should be considered here, but also its release in the body in order to be able to understand a possible dysfunction in Alzheimer's disease. The release of acetylcholine into the synaptic cleft of neurons occurs through the fusion of intracellular vesicles. As soon as the vesicle fuses with the membrane, acetylcholine molecules are released into the synaptic cleft. After the neurotransmitters interact with the postsynaptic receptors, the information is passed on to the following cell. If a reduced number of neurotransmitters is released during the process (*e.g.*, because of died off nerve cells), remembering becomes more difficult since the concentration of acetylcholine molecules in the synaptic cleft is no longer sufficient to stimulate the postsynaptic receptors. However, a number of therapy options exist which prevent the breakdown of the released acetylcholine of still active nerve cells. Acetylcholinesterase, for example, can be inhibited which leads to an increase in acetylcholine within the extracellular space. This increase in molecules can, in turn, enhance the stimulation of subsequent cells and regenerate the memory process. [8]

3. The Teaching Concept "The Chemistry of Remembering"

The teaching concepts primary questions are: "How does remembering actually work? And what happens at the molecular level when Alzheimer's patients can't remember?". Based on these questions, the above-mentioned scientific principles will be taken up within the concept in a didactically reduced form. In order to establish a link to the students' everyday life experiences, a general introduction to the disease and its symptoms should precede the scientific principles. Additionally, an emotional connection to the topic should be established in which students can talk about their own experiences with regards to relatives or acquaintances. Once the significance of the topic has been worked out, both chemical and biological basic knowledge should be repeated and acquired. Since the topic is of interdisciplinary nature, the learning prerequisites can be very diverse.

In order to do justice to this heterogeneity, a learning video with subchapters was created, in which the basic knowledge regarding membranes as well as transport routes and stimulus transmission is presented (see 3.1). This enables individualized learning and each student can extract the information he or she needs to acquire a basic understanding of the topic. A supplementary worksheet is used to support the consolidation and the transfer of newly acquired knowledge (see 3.2).

The teaching concept will be implemented by alternating between digital as well as analogue media:

1. Development of research questions: "How does remembering work? And what happens on the molecular level when Alzheimer's patients can't remember?
2. Acquisition or activation of knowledge regarding basic chemical concepts of substance transport through biomembranes (required material: learning video and worksheet, see 3.1 and 3.2) Central points are:
    a. Basic chemical concepts such as diffusion or electrochemical gradients, which regulate the transport of substances.
    b. Influence of the concentration on diffusion processes.
3. Learning about the synthesis and degradation of acetylcholine related to Alzheimer's disease (required material: Learning video and worksheet, see 3.1

and 3.2). Central points are:
c. Functional groups of the hydroxy-, ester- and acetyl groups.
d. Ester formation and the underlying reaction mechanism.
e. Possible dysfunction in Alzheimer's disease.

4. Discussion of the social relevance of membrane- and Alzheimer's research, pro- and counterarguments, concluding statement (required material: worksheet, see 3.2)

3.1 Structure and Content of the Video

The inquiry-based learning video begins with the central question: "How does remembering work?". Along with a video sequence from everyday life the question should arouse the students' interest, since the process of remembering affects each individual on a daily basis. The students are guided through the video based on different topics (see Fig. 2). This structure is intended to illustrate that several processes build on each other. The structure is also supposed to serve as an orientation for the students to realize what they have already achieved and where they still need to go in order to achieve the overall learning objective.

Remembering	•How does remembering work? •Why do we forget things?
Neurons & chemical synapses	•What are synapses and how are they structured? •How are the signals transmitted at the synapses of neurons in the brain?
Substance transport through ion channels	•How are ion channels structured? •Why do the channels at the presynaptic membrane open? •How does the ion transport through the channels work?
Vesicular transport	•How does the transport of neurotransmitters from the pre- to the postsynapse work? •How does a vesicle fuse with the cell membrane?
Neurotransmitters	•Which neurotransmitter influences the process of remembering? •How does acetylcholine affect cognitive processes?
Research & pharmacology	•What role does acetylcholine play in research and pharmacology?

Fig. 2. The learning video possesses a superordinate learning structure (left), which is used to clarify more specific questions (right).

Based on the video the following topics need to be discussed:

- Biochemical principles of substance transport through membranes related to human memory (see Fig. 3, left).
- Principles of synaptic transfer, substance transport through ion channels and vesicular transport (see Fig. 3, right).
- Relevance of basic chemical concepts for the (mis)regulation of biological

processes.
- Interdisciplinary nature of the natural sciences.
- Current research on Alzheimer's disease.

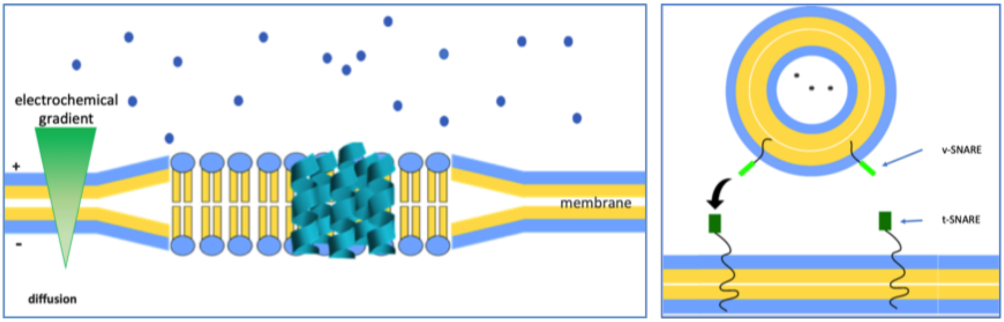

Fig. 3. Screenshots taken from the learning video. Left: Schematic of the biomembrane and the electrochemical gradient. Right: Vesical and SNARE-Proteins necessary for the fusion with biomembranes

Overall, it should be noted that the transport via vesicle is described in more detail, since the process is of particular importance for the understanding of Alzheimer's disease.

3.2 Worksheet

The supplementary worksheet contains various key aspects in order to do the complexity of the topic justice. The following aspects are addressed by the worksheet:

- Basic chemical concepts regulating biological processes (such as substance transport).
- Influence of the concentration on diffusion processes.
- Functional groups of hydroxyl-, ester- and acetyl groups.
- Ester formation and the underlying reaction mechanism.
- Thioesters (optional).
- Possible dysfunction in Alzheimer's disease.
- Social relevance of membrane- and Alzheimer research

4. Implementation into Chemistry Lessons

The occurrence of Alzheimer's disease can't yet be fully explained, which means that the focus in chemistry class is on simplified basic chemical processes (see above). Based on the mentioned chemical principles, the concept is suitable for an upper secondary class and can be used as a supplementary interdisciplinary lesson.

The following contexts may allow the embedding of the unit:

- Esters as well as thioesters
  - Synthesis and degradation of acetylcholine
- Biocatalysis
- Simple diffusion, passive and active transport
  - Voltage dependend ion channels
- Electrochemical gradients

5. Conclusion and Outlook

The aim of this unit is to educate students about Alzheimer's disease by linking it to current research and important basic chemical concepts. This will help them to develop a better understanding of the disease and those affected and ultimately prepare them for possible challenges lying ahead. By means of an inquiry-based method, the process of remembering as well as not remembering should be understood by the students. In order to be able to support the learning process, both a learning video and a supplementary worksheet were created.

The teaching concept presented here will be tested with students in the near future. During the evaluation, a particular focus will be placed on the interest in the topic. In addition, it should be investigated whether the learning objectives have been achieved.

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The Impact of Conducting Youth Scientific Research Camps within the Academic Institute

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Abstract

Inspiring the next generation of scientists is one of the challenges that the scientific community is required to address. At the time of graduation, teenagers who have already proved themselves at school, are about to choose their academic path. While they may have profound confidence in their academic skills, many of them lack knowledge regarding science and research outside school. In this paper we will discuss the relevance and impact of integrating motivated and excellent science oriented youth, into the core of the academia, the scientific research and the additive value of a boarding-school atmosphere. For over 50 years high achieving high school students and graduates are integrated into research groups at the Weizmann Institute of Science. Hence, students ages 16-19 conduct a research project under the supervision and mentoring of scientists (graduate students, postdoctoral fellows, staff scientists or principle investigators). Participating students become members of the research groups for a period of two to four weeks. Research projects may be related to either experimental science or theoretical one and may combine multiple methodologies and disciplines. They are engaged in the various aspects of scientific research from designing their projects, through planning experiments or models, via analyzing data, drawing conclusions and publishing the outcomes. Thus, students submit a scientific mini paper and present their projects in short talks at the final program's conference. The intensive scientific demand is supported by social and cultural activities led by the counselors, strengthening the bonds within the peer group and providing a comfort zone for growth. What is the impact of such programs on participants? Alumni of these programs describe it as a life changing experience. They report that they became familiar with the various aspects of the scientific life and research, including overcoming challenges, demonstrating determination, creativity and comprehending that research is a long process necessitating perseverance and collaboration. All these enabled them to make well-established decisions regarding their future academic career. They gained friends for life, peers with similar interests and passions, and became a young community for personal and professional network sharing global responsibility.

Keywords: science, camps, research, academia, youth, excellence

Introduction

In the early sixties, the Weizmann Institute of Science established a summer science camp for excelling youth. The rational was to enable a direct interface between science-oriented youth and scientists, thus not only enhance their motivation to become scientists themselves but to adopt the scientific approach as a standard for life style. By ways of actively participating in cutting-edge research, side by side with the scientists in their labs, the program shapes the students conceptions regarding science research and future academic career. Moreover, this intensive and collective experience leads to the formation of an interdisciplinary science community for professional and personal relationships.

The summer science camp for Israeli youth was initiated in 1964 and was followed by an international camp in 1969, with approximately 6000 graduates until today. In this paper we will refer to them as “the program”. Over the years, the program continuously develops and progresses thus maintaining relevance and providing participants with a unique and additive value. Alumni refer to the unforgettable summer as a marking point that attributed to their future choices and taken path, leading many of them to high positions in academia and industry worldwide.

The Program

The program is geared towards talented, highly-motivated students who have demonstrated their self-ambition to gain deeper scientific knowledge above and beyond what is taught at school. Participating students are engaged in the on-going laboratory work at the Weizmann Institute, and are assigned to a specific research project that lasts between two to four weeks. Optimal matching to projects relays on various criteria including academic background, previous experience, interest and skills. An important aspect of the scientific maturation is the ability to communicate and share research ideas, challenges and outcomes, with the scientific community, by publishing manuscripts, giving talks and experiencing critical review. Similarly, students practice scientific writing by summarizing the research in a report according to the criteria of academic papers. The final seminar day which is equivalent to an academic conference, provides the opportunity to orally present and share their projects with their peers.

Communication between students and mentors is established prior to their arrival.

This fosters both personal acquaintance as well as laying the grounds for collaboration, where both parties discuss the required professional material.

Subsequently, mentors provide students with relevant papers and related references. Despite previous high academic performances, most students lack the skills of reading scientific manuscripts. Therefore, we offer an on line course designed for this audience and purpose hence, providing a box of tools. These early steps are integral part of the program and are essential for smooth integration and a successful experience.

While the scientific projects are the core, the program is designated to be a mixture of scientific and cultural enrichment. Hence, participants are exposed to various scientific subjects outside their specific fields of interest, by meetings with senior scientists from diverse disciplines and discussing state of the art research. With the notion that scientific research becomes more multidisciplinary and collaborative, the projects are conducted in groups of 2-3 students, thus promoting teamwork. Students are constantly engaged in discussions regarding social, environmental, ethical and moral issue, which stimulate mutual and global awareness. The social and cultural activities held throughout the program further strengthen the bonding and belonging of participants.

Long-term impact

The unique experience enriches these prospective scientists, providing a nourishing environment for growth and a life-long impact. Alumni of recent and early years emphasize the substantial outcomes with respect to the program's goals and rational.

Quotes:

To create a significant personal impact: "The summer of 1983 was life-changing for me." "Sometimes it is hard to foresee the importance of a month-long summer school, but now it is clear how crucial it was to give me a perspective of the academic realm."

To enable well-established academic career decisions: "The program not only enhanced my passion for science, but solidified my resolve that I wanted to perform scientific research as a profession and one day have my own lab."

"My experience contributed to my decision to pursue neuroscience research in college and ultimately to my career in clinical psychiatry and psychoanalysis."

To adopt the scientific approach as a standard for life style: "While I no longer do research, the creative and multidisciplinary thinking fostered by my time in the program remains an important part of me."

To promote scientific communication and collaboration skills: "As we conducted research and presented it to our peers, our expectations of ourselves and of each other were high. Yet the research process was always collaborative and never competitive, both among us and the scientists".

To form a peer group and establish a community: "Building a community of Alumni in has become an effort that is close to my heart. I am committed to helping others reconnect based on a shared love of science and our time at the Weizmann Institute."

"In the last 13 years, I have crossed paths with many fellow participants in college, graduate school, and, more recently, in international conferences."

To enhance global awareness and responsibilities: "Through the program, I became more aware of science's potential to make an impact on the world and draw people together around a single cause. The program shaped my goals not only wishing to become a scientist but also in terms of becoming a 'global citizen' "

Discussion

In this paper we described the impact of integrating motivated and excellent science oriented youth into the core of the academia, the scientific research and the additive value of a resident camp atmosphere. In light of the vast changes in social interactions, learning mechanisms and concepts as well as technological progress, how does the program retains its relevance for over 50 years? In a world with endless opportunities, perhaps it is more relevant than ever. Thus, we are constantly required to evaluate, modify and optimize the program to the needs of the changing world.

Technological development enables new avenues which can be applied for communication and learning. Hence, with the intention of both putting the grounds for reading and writing scientific papers as well as initializing the group communication, we developed an online course. This pre-program interaction minimizes the unfamiliar zone both academically and socially. Scientific research is becoming more multidisciplinary and brings together scientists from various fields and disciplines.

This is extensively manifested throughout the program, begging in the pre-program online course via the research assignments to the supporting academic and cultural activities. The strength and effectiveness of the program resides in the synergistic effect of the various components. These include but not restricted to the multidisciplinary approach, intensiveness of the program, integration into research groups, application of techno-pedagogical concepts and academic requirements. The fine-tuning of every such aspect, lays the foundations of the community that provides the support system of the group and nourishes the social and professional relationships that continues through the course of life. Hence, our educational paradigm presented in this paper enables the impact that pushes the boundaries of personal, social and academic growth.

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Health Education

Children's Perceptions on Cancer: Digital Storytelling as Means of Education

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Abstract

The model of Health-Promoting School has received increasing recognition in Portugal, and oncology prevention has been a recurring theme in several actions that involve the interaction between several actors that go beyond the school community. This study was developed in order to implement an awareness raising action, using programmatic contents of the school curriculum and adapting it to innovative multimedia resources. We achieved the profiling of 625 students between the ages of 9 and 13. The results show that the overwhelming majority of children (98.2%) have heard about cancer, but in one of the schools the percentage of students who consider cancer a contagious disease reaches 12.6%. Risk factors for the development of this type of disease are correctly identified by most of the students (72.9%). Still, nearly 40% of them have the perception that cancer can be originated from a flu. After a multimedia session, of the 625 students participating in this experiment, more than 80% were able to correctly identify risk factors associated with cancer, treatments and positive strategies for living with patients. Of the 21 teachers involved, 18 considered highly relevant the adequacy of new multimedia resources and digital storytelling for the dissemination of health education contents.

Keywords: Cancer; Education; Multimedia; Storytelling

1. Introduction

Pointed out as the second leading cause of death in developed countries, cancer incidence has been rising from year to year. [1] However, and according to the World Health Organization (WHO), "about 40% of all cancers can be prevented and others can be detected at an early stage of development, treated and cured." [2] This perspective gives priority to the implementation of health education actions capable of working healthier lifestyles in the long term. School seems to be particularly important in it, given its unique characteristics to construct behavioural directions at crucial ages. [3] The concept of "Health-Promoting School" has been cited a good example of the shifting focus from the behaviour of individuals to the development of health "settings" [4], as promoted by the Ottava Charter. [5] But School represents more than an intervention place regarding prevention [6].

Medical treatments has increased the number of children who survive cancer [7] and they tend to spend less time outside of the hospital setting [8] Returning to school after hospitalization has been demonstrated as an important step to improve their diminished physical, psychosocial, and academic functioning. [9] On the other hand, there are some difficulties that arise when a child with cancer returns to school. [10]

The lack of knowledge from teachers about the disease [11] and the social rejection from the other students appear as significant determinants to the reintegration of surviving children. [12]

2. Methods

This study was developed based on the implementation of a cancer awareness activity in four different schools, from the same city in Portugal. Each 90 minutes session was organized by cancer and communication researchers to achieve three different goals: 1. To understand the perceptions about cancer of students from the 5^{th} and the 6^{th} grades; 2. To increase the knowledge about cancer with a multimedia tool; 3. To assess its pertinence for teachers and students.

2.1 Students' perceptions about cancer

A cancer knowledge assessment questionnaire was applied. The instrument was composed of four sets of questions: 1. Socio-demographic; 2. Parental qualifications; 3. Knowledge about cancer. 4. Contact with people with cancer. The questionnaires were completed in the presence of the researchers who conducted the awareness activities, and the confidentiality of the responses was guaranteed. Data was analyzed and statistical associations were calculated through Chi-Square and Cramer's V tests.

2.2 Multimedia tool

After the questionnaires been applied, an educational tool in Portuguese was presented and a 40 minutes discussion was encoureged.

A short animation movie called "My Brother is a Superhero" was developed based on three strategies: explanation of scientific concepts based on the implemented curricula; identification of the most common miscoceptions about cancer; integration of the content in a creative story told by a cancer survivor.

The narrative of this story was developed in different steps: 1. John, a very curious kid discovers his brother has leukemia; 2. The main character reveals he wants to know more about this disease, and his parents helped him talking with his brother's doctor; 3. The doctor explains the biological origin of the disease, based on the knowledge children in 5th and 6th grades have about the cell, the unity of the human body; 4. Celular proliferation, different types of tratment and side effects are explained; 5. After the treatments, the recovering brother reveals that he is afraid to go back to school because doens't know how he will be received by his colleagues. 6. John help him by talking with his brother's classmates, and describes his brother as a superhero who killed malignant cells with powerful weapons (Image 1).

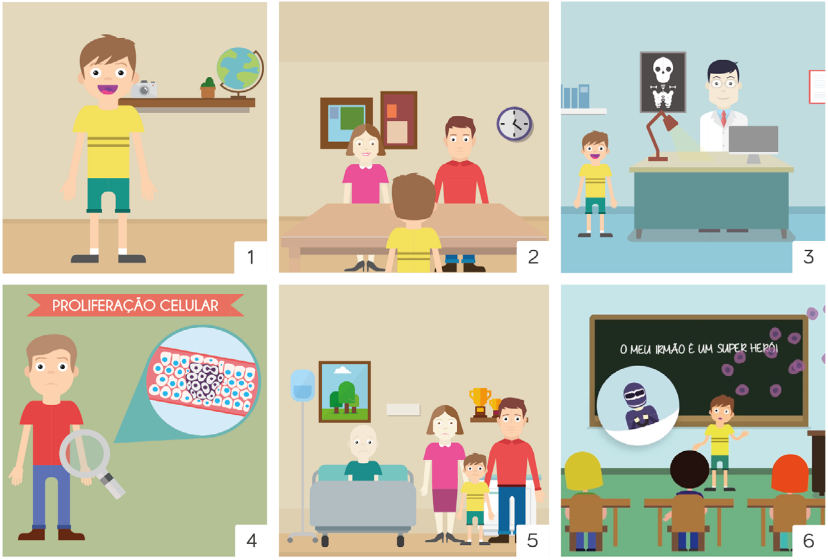


Image 1. Six frames of "My Brother is a Superhero", the short animation movie developed for the awareness sessions

2.3 Evaluation of the awareness activity

After the discussion, the class was divided in groups, and a quiz game with 10 questions about the movie was promoted. The teachers who accompanied the classes were given a questionnaire with three groups of questions: 1. Socio-demographic data; 2. Previous contact with students with cancer; 3. Relevance of the current activity.

3. Results

3.1 Students' perceptions about cancer

Students from the four schools, now identified as School 1, School 2, School 3 and School 4, answered the same questionnaire, with a total of 625 participants, being 49.8% female and 50.2% male. About 48.3% of the students invited to the awareness sessions were 11 years old, 37.3% were 10 years old and only 12.3% were 12 years old. The four schools have a distinct number of students: School 4 presents the largest amount (n=315), with the remaining three schools having similar smaller numbers, around 100 each. The age distribution of the sample is, however, quite homogeneous within the four schools.

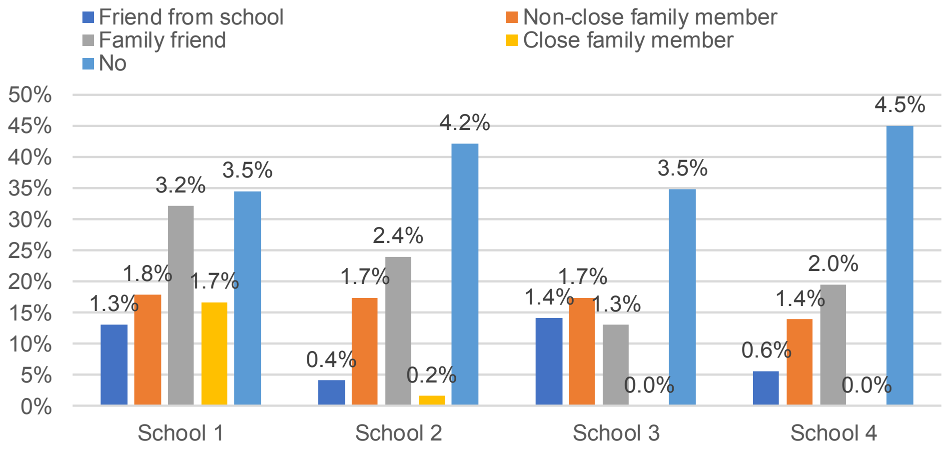
	School 1	School 2	School 3	School 4	Total per variable
Students	**84**	**127**	**99**	**315**	**625**
Gender					
Female	37 (44,6%)	52 (41,3%)	55 (55,6%)	165 (52,7%)	309 (49,8%)
Male	46 (55,4%)	74 (58,7%)	44 (44,4%)	148 (47,3%)	312 (50,2%)
Age					
10 y.o.	32 (38,1%)	42 (33,1%)	31 (31,3%)	128 (40,6%)	233 (37,3%)
11 y.o.	35 (41,7%)	61 (48,0%)	53 (53,5%)	153 (48,6%)	302 (48,3%)
12 y.o.	13 (15,5%)	23 (18,1%)	15 (15,2%)	26 (8,3%)	77 (12,3%)
Grade					
5th grade	42 (50,0%)	57 (44,9%)	47 (47,5%)	167 (53,0%)	313 (50,1%)
6th grade	42 (50,0%)	70 (55,1%)	52 (52,5%)	148 (47,0%)	312 (49,9%)

Table 1. Distribution of the participating students of each school by gender, age and schooling

Parents from school 4 has the best average regarding their level of education, with the best percentages of mothers and fathers that went to College. In contrast, Schools 2 and 3 share the strongest percentage of parents with less than High School.

Of the 625 students, 98.2% had previously heard about cancer, and 48.6% reported knowing someone with the disease. Most of the students from School 3 who answered affirmatively stated they know a non-immediate family member with cancer.

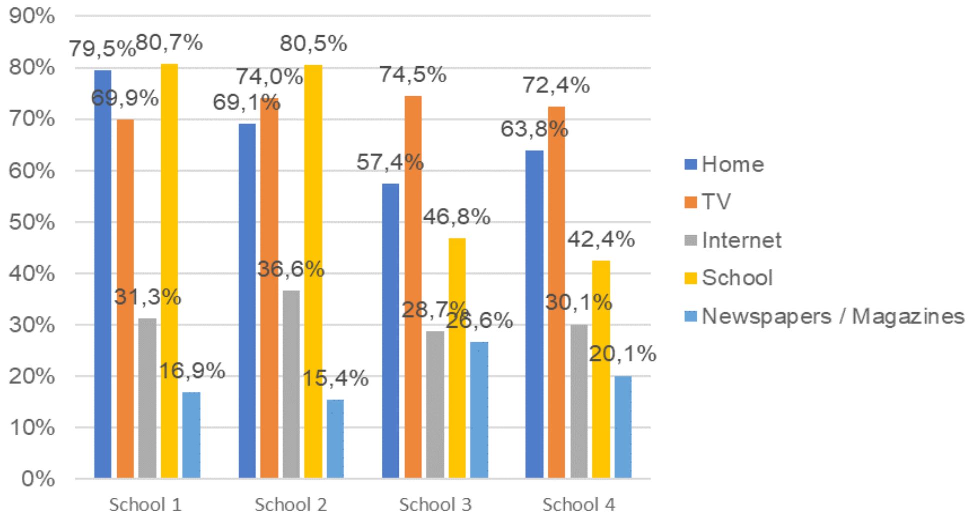
In the other schools, most of the students have family friends who have or had the disease (Graph 1).



Graph 1. Previous contact of the students with people with cancer

Most of the students from School 1 and School 2 heard about cancer at school, 80.7% and 80.5%, respectively. On the other hand, School 3 and School 4 have more students hearing about this topic through TV (Graph 2).

Approximately 72.9% of the participants were also able to correctly select behavioural risk situations. The values obtained by the four schools demonstrate small variations, with a stable number of correct answers.



Graph 2. Cancer information resources reported by the participants from each school

On average, more than 90% of students in all four schools identify cancer as non-contagious, but 218 students answered thinks cancer can be caused by a flu. School 3 and School 4 presented higher percentages of affirmative answers (42.2% and 38.5%). Of the 625 students, 68.3% indicated they did not know the name of any cancer treatment.

Three pairs of variables presented significant levels of association: (1) more females heard about cancer at home than males (p=0.001); (2) older students tended to hear more about cancer in school (p=0.002); and (3) students whose father had a higher level of education heard more about cancer through television (p=0.008).

Having a friend from school (p=0.014), a relative (p=0.001), a friend of the family (p=0.000) or a direct family member (p=0.017) with cancer boosted the percentage of students that heard about cancer in their homes.

3.2 Evaluation of the awareness activity

A total of 124 groups debated 10 questions. From those, 101 groups, about 81.6% of the students, could answer correctly to all the questions. Twenty-one teachers, 15 female and 6 male, accompanied the students. Working in different areas, the majority (42.9%) were between the ages of 46 and 55 years old. Four teachers reported they have already dealt with an oncological disease situation with their students or with close relatives of students. Most of the teachers (around 85.7%) recognize the relevance of addressing this issue in the 5th and 6th grades with multimedia resources.

The remaining (14.3%), while recognizing the importance of the topic, justify it should be discussed only in situations where a child has cancer or lives with someone close to him who is sick.

4. Conclusions

The awareness action has been shown to be useful in increasing students' knowledge about cancer. Its effectiveness should be measured in the long term, studying the level of individual knowledge of teachers and students and the adoption of school strategies to host cancer surviving students.

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Comparative Study on the Sources of Information Contributing to the Cancer's Representations on a Public of Pupils and Students

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Abstract

Throughout a large study on cancer's representations among pupils from Year 6 to the second year of master [1], we got an interest at the different sources of information on this young public. To do so, we asked the pupils where they first heard about cancer. Cancer is absent of the French curriculum until science specialised year 12, although it is, among any diseases, the most present in the pupils' mind. This paradoxal situation thus legitimates to question the different sources that structure the representations of this young public.
In a previous work [2], we presented the sources of information of the youngest pupils of our study (year 6 and year 9 pupils), and we compared both levels. In this study, we present the data corresponding to older students (year 12 and Master students) and we propose a general comparison overall the four levels.
Our results show that the family and media spheres stay the two main sources of information on cancer, at every level. Even if information sources seem to be more diverse for older students, television stays largely the predominant medium.
Peers, the scholar sphere and the medical sphere seem to remain of secondary importance.
It is so intriguing that, considering the K, V, P model of Clément P.[3], young adults seem to have constructed their representations of cancer mostly thanks to their interactions within the family and thanks to television. This consideration might partly explain why pupils/students and finally many adults keep a very dark, more or less mythological representation of the disease, which remains far enough from its actual nature.

Keywords: communication, children, school, knowledge, illness

1. Introduction

Representation is an act of thought related to an object. Through communication, a person is likely to partially convey its own representation of an object [1, 2].

Numerous studies got interested in cancer's representations on the general public, who had globally been confronted to cancer, in a more or less direct way [5]. These studies give us an outlook at a given moment of the way cancer is perceived in our society.

The originality of our approach is based on the choice made to study different scholar publics and to be more precise, our main objective is to identify the different sources of information acting as the starting point of the structuration and/or evolution of the pupils' representations on cancer.

As we selected 4 different levels, from primary school to higher education, we had the opportunity to, first, identify the different sources of information that can supply the representations on cancer of such a public and secondly, to locate the variations of their influence over time. With this approach, we also wished to question ourselves on the role of the scholar sphere on the development of cancer's representations.

The sources of information of year 6 and year 9 pupils were already presented and a comparison between both levels was discussed last year in [1]. Here we complete the picture with year 12 and master student's sources of information and we propose a general comparison between the four levels.

2. Methodology

The different sources of information contributing to the cancer's representations were identified through the answers given to the question "How did you hear about cancer?". The previous question, rather open, allows the pupils to use their own vocabulary and does not orientate their answers.

2.1 Data collection

The sample questioned is composed of 277 pupils, from four different levels: 38 pupils from year 6, 96 pupils from year 9, 83 pupils from year 12 with a specialisation in sciences and 38 students from a Biology Master.

2.2 Analysis of the results

A first set of results is presented thanks to conceptual cards. For each level studied, a conceptual card gives us the different sources of information recounted (gathered in spheres) and their percentages calculated from the number of times the pupils or students cited them.

A second set of results, presented as a diagram, will allow us to follow the eventual evolutions through time of those same sources of information.

3. Results and discussion

3.1 The students' sources of information on cancer

3.1.1 The sources of information in Year 12

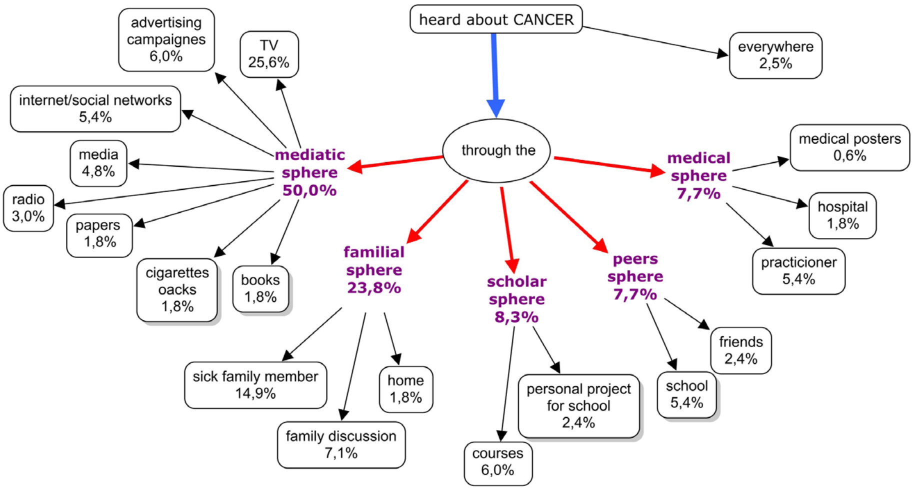

Fig. 1. The sources of information and the percentages collected from the answers given by students in Year 12 with a specialization in sciences (n=83)

As it was the case for younger pupils, in Year 12 with a specialisation in sciences, the two main sources of information are still family and media. The two spheres gather more than 70% of the information collected by this public.

In the media sphere, TV remains the main source of information and the message conveyed by the packets of cigarettes is still present in those young spirits and is associated to cancer.

The scholar sphere appears in the answers given by Year 12 pupils though its impact seems marginal as the percentage is rather low (8,3%). However, 2,4% of the answers relate to the group works put into place at that age and allow us to note that, though the topic is totally free, pupils often chose to tackle the problematic of cancer.

Finally, the element “Never heard of cancer” disappeared compared with the two earlier levels and indicates that all the pupils have now heard about cancer.

3.1.2 The sources of information in a Biology Master

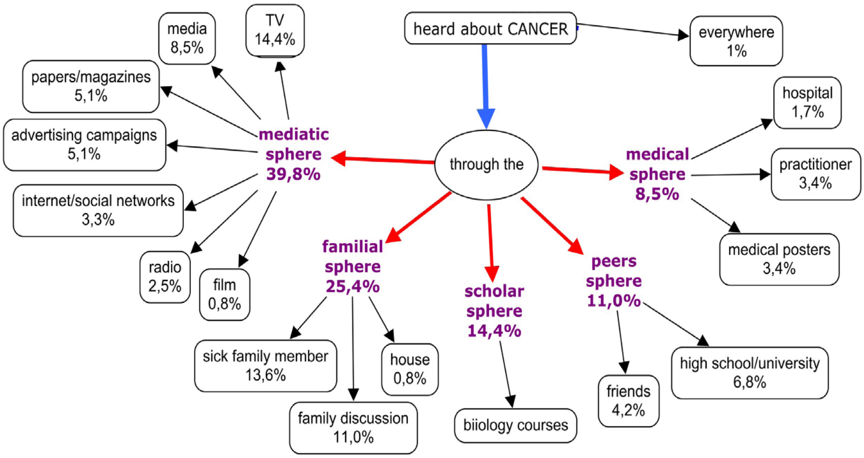

Fig. 2. The sources of information and the percentages collected from the answers given by pupils in a Biology Master (n=38)

At the Master level, the two main sources of information are the same as before: family and media, though they are less cited by this public of young adults (65,2%).

In the media sphere, TV still remains the main source of information (14,4%) with an impact that decreases though. This decrease is to be moderated as there are 8,5% of the answers under the term "media" that could be an association to television in the students' minds. It is surprising that internet and social network represents only 3,3% of the answers.

The source of information "Packets of cigarettes" disappeared which may indicate that this information is no longer present in this young public's everyday life. We may wonder why and risk some hypothesis that, as for instance, this public is no longer linked to packets of cigarettes or they do not dare telling us because they are feeling embarrassed.

However, the scholar sphere is much more cited with 14,4% of the answers. It seems that the information read or heard during a lesson grows in importance in the elaboration of cancer on this public. Of course this importance of the scholar sphere might be specific, since these students are specialised in biology, the result is expected to be different for other specialised students.

3.2 Variation of the importance of the sources of information depending on the level of studies

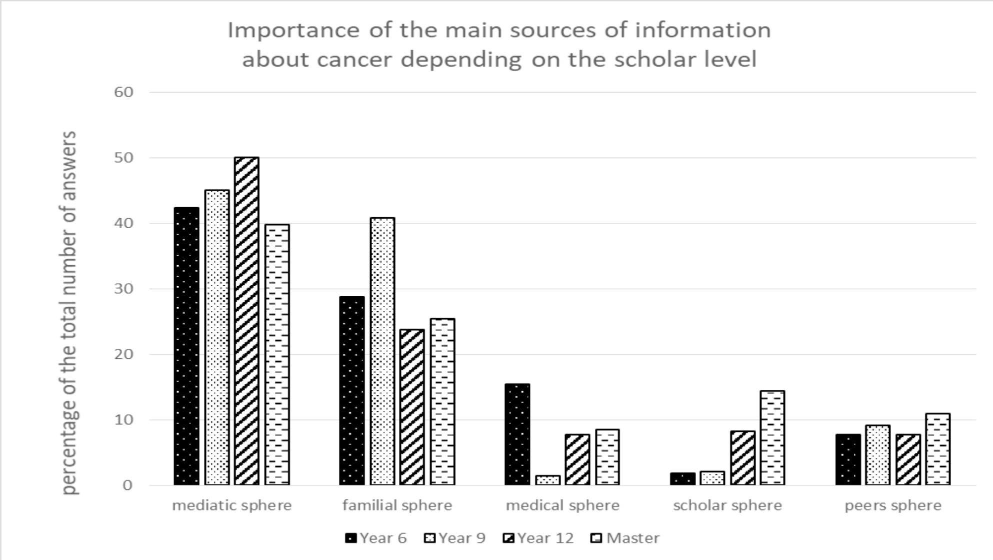

Fig. 3. Variations of the importance of the sources of information depending on the scholar level

The familial sphere seems to be a space where cancer is largely evoked, especially for young pupils. Despite a supposed existing taboo, it appears to be an important source of information for the representations on cancer. According to our results, the influence of the family seems to be more important at the year 9 level, than at any other level. Maybe because this serious topic is less often evoked with younger children, then older teenagers might be more distant in their relationship inside the family and privilege other sources of information.

The media sphere remains the most cited source of information at any level. One could expect this result because the importance of media in general (TV and Internet in particular) is well known amongst young people under 25.

In this sphere, TV remains the most important source of information, even if its influence seems to diminish for master students.

The apparent weak influence of internet and social network among the sources of information of the older students (3,3%) might be surprising. Indeed, one could expect that in 2015, this young generation take mainly its information from these modern media. This result is probably the illustration that pupils and young adults are mostly informed about cancer in a passive way. Using internet and social network implicate generally a direct search of keywords. And we can imagine that young people usually don’t do any active research of information about cancer.

The peers sphere is one of the secondarily important sources of information on cancer, at every age, maybe because there is a certain discomfort to tackle this difficult and painful topic. It is also possible that fear could be one of the reasons as, still nowadays, the representation of cancer as a contagious disease is persistent [1, 3, 4, 6].

The scholar sphere only appeared as a source of information on cancer in Year 12 (around 16 years old). As formerly said, this source of information was mostly cited among students in a Biology master and it is not surprising to see that this source was cited by pupils in Year 12 specialised in science and students from a biology master.

Indeed, this thematic is to be seen in Biology as stated in the programs elaborated by the Department for Education. But what about pupils with other options (literature, economics or technology) who never tackle this thematic as it is not included in their programs. We may thus think that the scholar influence is tiny once you include every young French pupil from 10 to 21.

4. Conclusion

Our results showed that as from Year 6, cancer is a very present topic in a pupil's life [1] and that it is rather rare that they have not heard of it. The topic is often tackled in the familial sphere, largely heard in the media and discussed between peers. We can thus suggest that from a very young age, 9-10 years old, the representations on cancer in our kids' minds start developing (or are already developed) with information coming mostly from family, media and to a less extent, discussions or opinions issued by peers.

These joint influences still persist through time and do not vary much until adulthood, even though we noted a diminution of the impact of peers from 21-22 years old.

The references to scholar and medical spheres appeared late: from 12-13 years old for the medical sphere and 15-16 years old for the scholar sphere [4].

Former studies showed that cancer was strongly perceived by the scholar public with an extreme dangerousness factor. Pupils and students cited cancer as the most serious disease and the deadliest, way before AIDS [1]. In that, the scholar public share a same sensibility with the rest of the population [2, 3, 6].

Even though medicine has made a lot of progress in the recovery from numerous cancers, the notion of death is still associated to this disease in the representations of the studied public.

The scholar sphere is practically absent from the sources of information that structure these representations, yet the representations remain the product of a triptych involving values/opinions, social experience but also knowledge [5]. It would thus be interesting to understand how these media and familial sources of information structure these representations and how the scholar sphere could be more implicated.

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Health Education and the Future of Natural Resources: Food Safety, Food Waste and the Culture of Sustainability

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Abstract

Food safety, food security and its counterpart, food waste, are among the priorities set by the new UN Sustainability Development Goals (SDG) and the 2030 Agenda. The SDG 12, in particular, focuses on ensuring "sustainable consumption and production patterns". The implications of this challenge are multi-layered: economic, social, political and, above all, cultural. Vocational education on such topics, addressed to students from two upper secondary schools, was the main goal of a three-year project implemented by Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise between 2016 and 2018. It was carried out in the framework of the National School Reform entered into force in 2015, as a contribution to implement the overall lifelong learning policies set by the EU 2020 Strategy, the Copenhagen Process and the Lisbon Strategy on Vocational Education and Training. Educational activities were dedicated to specific, interrelated themes, such as the "One Health" approach, food safety, environmental sustainability, the experimental method, and the techniques to disseminate scientific knowledge to peers through digital tools, with a focus on social media. Class activities, visits to laboratories, creation of digital communication tools under the supervision of scientific experts, testing of e-cloud instruments and practical qualitative and quantitative research exercises were the main methodological and conceptual tools utilised so far. Questionnaires and daily diaries were filled by the project beneficiaries and their families. Indeed, during the third year, the health education project was centred on food waste and food safety, as an attempt to sum up the previous experiences, but also as a way to introduce the beneficiaries into a real research environment. The students were involved in an ongoing research project on the balanced distribution of food through the application of a method for waste reduction and sustainable social solidarity. They were asked to measure their household waste. Training methods based on adult learning principles were applied to upper secondary school students, increasing their responsibility, self-confidence, and the value of peer-to-peer education and learning. The success of this initiative encourages the authors to further explore this approach and to increase connections between high school students and the working environment of a research institution.

Keywords: Health education, sustainability, food safety, food waste, circular economy, scientific communication

1. Introduction

In 2015, Istituto Zooprofilattico Sperimentale dell'Abruzzo e Molise "G. Caporale" (IZSAM) started a three-year vocational education project in collaboration with upper secondary schools of Teramo province (Italy). The project was consistent with the 2015 national school reform (so called "*Buona Scuola*", L. 107/2015) and coherent with the involved schools' priorities and the IZSAM mandate (3). The main conceptual landscape was provided by the new UN Sustainability Development Goals (SDGs) and the 2030 Agenda, along with the EU 2020 Agenda. Given the multi-layered implications of the challenges raised by the above-mentioned documents, and the young age of the beneficiaries, the project activities addressed any economic, social, political and, above all, cultural legacy of such themes.

IZSAM is a public health body belonging to the Italian national health system, whose mission is to provide scientific and technical support to the national and regional governments in veterinary public health, promoting the "One Health" integrated approach. The three-year vocational education project was composed of two different, yet interrelated, modules, which were titled: "Digital natives at work: digital communication for scientific dissemination and the safeguard of animal, human and environmental health" (2015-2016) and its follow up, "The future flows in our hands: scientific dissemination for the safeguard of animal, human and environmental health" (2016-2018).

The activities, devoted to 15-18-year students, were mainly based at the International Centre for Veterinary Training and Information (CIFIV) of IZSAM, whose training services are certified as conform to the ISO 9001:2015 norm. Hands-on work experiences and visits were carried out at the IZSAM laboratories of Diagnostic Microbiology, Virology, Serology, Food Hygiene and Biotechnologies. Furthermore, part of the activities was carried out in the school premises, also engaging schoolteachers.

The three-year project pursued the following general objectives:

- to approach the main veterinary scientific issues related to health protection;
- to experience modern communication strategies by using specific narrative techniques (i.e., storytelling) supported by audio-visual media;
- to use social networks and applications to disseminate scientific information;
- to be acquainted with a professional scientific environment;
- to practice students' attitudes, skills and abilities;
- to assess their educational and professional life plan;
- to apply the method of scientific research by testing qualitative and quantitative research tools in real environments;
- to get culturally aware of the multi-layered implications linked to the concept of "sustainability";
- to grow up as "reflective" global citizens by developing a "critical" mind set (*forma mentis*) towards the surrounding social landscape.

Indirect beneficiaries were the peer-group, families, and citizens who were informed on the project themes, either at home or via social media and other communication products.

The *One health* approach, food safety, effective use of natural resources, biodiversity conservation and environmental sustainability were among the technical issues addressed. The design and development of research activities, and the dissemination of scientific knowledge through digital tools were particularly cared, thus producing valuable outputs. The exploitation of social media to disseminate scientific knowledge and the use of the storytelling technique were explored successfully.

This paper highlights the themes chosen and the methods adopted during the third year of the project, when students were asked to test digital cloud instruments to share data and outputs. Above all, they were introduced to a real research environment through the research project D.E.MET.R.A. ("*Distribuzione Equilibrata delle risorse alimentari attraverso un METodo per la Riduzione degli sprechi e la solidarietà sociale sostenibile*"), on the balanced distribution of food through the application of a method for waste reduction and sustainable social solidarity. The project is funded by the Italian Ministry of Health in the framework of the "Ricerca Corrente" programme.

In the project framework, the students were trained on how to use and test qualitative and quantitative research tools such as questionnaires and weekly diaries for the detection of food consumption and eating habits and the measurement of food waste in their households.

2. Materials and methods

Blended training activities were implemented adopting an interdisciplinary approach to the transversal theme of "sustainability", dealt from an ecological to an anthropological perspective.

The project involved, in total, 166 students coming from 3 upper secondary schools of the Teramo province. The core group of beneficiaries remained the same during the whole duration of the programme. This continuity improved the educational and methodological approach adopted and chosen in order to sustain the students' transversal competence acquisition as foreseen in the National Qualification Framework (http://www.cedefop.europa.eu/files/8608_en.pdf) implementing the European Qualification Framework (http://www.cedefop.europa.eu/files/5566_en.pdf).

Class lectures, guided visits to IZSAM laboratories, student's alphabetisation to social networks and e-cloud tools, development of communication outcomes for the peer-to-peer dissemination of scientific information, were carried out to achieve the project goals.

Intermediate individual evaluations (at the end of each year) were performed to monitor competence achievements. A final certification was issued at the conclusion of the whole project by the school.

Table 1 describes the transdisciplinary and transversal competences and their related descriptors.

Table 1. Transdisciplinary and transversal competences and descriptors

Knowledge	**Skills**	**Responsibility and autonomy**
Critical awareness of specific knowledge, autonomous problem solving; sense of responsibility towards others	Social interaction, availability to collaborate with the group of peers and adults, team working	Self-management ability in the framework of a working context; autonomous decision making
e.g., development of newsletters and blogs focused on the technical topics	*e.g., by using Google Drive as a tool for sharing didactic materials and edit draft documents elaborated by the groups of students with Google Docs*	*e.g, to be able to fill in autonomously questionnaires and diaries linked to the D.E.ME. TR.A. research project*

3. Results

The overall achievement of the three-year project was the transmission to the participating students of multi-layered, transversal competences based on acquired new knowledge and soft-skills, all related to the scientific domains in which IZSAM is active.

The main project outputs are:

- one public Facebook profile, administered by the IZSAM project team;
- two blogs, developed in Wordpress: “The digital science” and “Science is life”;
- two logos (Figures 1 and 2);
- three newsletters (Figure 3);
- one video titled “Alimentarsi bene per vivere meglio”;
- forty-six questionnaires related to household food consumption habits
- forty-three weekly diaries on food waste.

Fig. 1. “The digital science” logo

Fig. 2. “Science is life” logo

Fig. 3. Newsletter "Alimentazione e sport: cosa mangiare?"

The questionnaires and the diaries were carried out in the framework of DEMETRA.

The students were introduced to the research instruments, and then asked to use them at home for interviewing household members who regularly take care of administering food in the house, from purchasing to keeping to cooking, and for keeping track of any kind of food – fresh or not – that, over seven continuous days, was destined to garbage. The diaries were, in fact, used to measure the amount of food wasted in the students' households; they were also asked to keep note of the reasons for throwing away the wasted food.

The added value of this initiative is related to the active role played by the students in a "real" research project, with the support of the Institute veterinarians, veterinary epidemiologists, and biologists. In fact, they were able to use qualitative and quantitative tools with a scientific approach, adopting impartiality, accuracy, and fairness principles in data collection.

4. Conclusions

This experience was appreciated by the students and the teachers' staff. The assigned tasks were performed as requested demonstrating the efficacy of the so-called learning-by-doing method. The three-year initiative supported students' independence in developing digital communication plans to address scientific messages.

The encouraging results showed that science-based communication can raise students interests and develop their communication skills, especially when it is rooted into topics that practically affect the students' life, such as economic sustainability and food safety. If some reticence was perceived in the use of some social tools such as Facebook, felt more as a device for "private" communication, students appeared freer and more comfortable with the design and testing of other communication tools such as the video and the newsletters.

The revision system used by the project experts facilitated progressive learning and gradual acquisition of autonomy, as well as the students' capacity to work side-by-side with a network of adult researchers.

Last but not least, from a methodological perspective, the experiment to adopt training methods based on the peculiarities of the adult learning style for upper secondary school students was a successful experience in terms of appreciation by the beneficiaries and learning achievements. It encourages further application of this approach in similar contexts to prepare students to entering the labour market.

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STEM Molecular and Cellular Neuroscience Didactics for Human Health in High School

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Abstract

Neurons are specialized cells, the biophysics basic units of the nervous system with the main function to communicate and the synapses are the key of relationship between neuronal cells. Neuroscientists are researching how neuron can interacted which others to generate signals also in pathological conditions and how can organize storage and delete information in complex biochemical and physiological mechanisms. The mission of this project was to develop innovative didactic research about teaching and learning Molecular and Cellular Neuroscience with Interdisciplinary STEM methods. Different didactics neuroscience activities were realized to activate reasoned enquire approaches. Working as biologist didactic researcher - principal investigator in scientific international community, were realized innovative learning by doing strategies about Brain science topics for inclusive health education in curricular didactic actions. Surfing and searching in scientific selected international data base was also possible to guide students in analyzing historical aspects and modern biological concepts about human brain, scientific literacy about elements of biochemistry and cellular physiology for neurodegenerative disease. Brain science research for innovative STEM High School Research; cooperative learning actions with new strategies to promote dynamic knowledge about young people Health Education introducing Systems Neuroscience. Elements of Brain Science Evolution were promoted motivating students in ICT work and educating to correct communication and interpretation of modern neuroscience discoveries.
Two key concepts were important in this neuroscience project: neuronal plasticity and neuronal connectivity, analyzing with dynamic strategies the important role of Glutammate receptor proteins (NMDA and AMPA). In this educational path were useful STEM didactics approaches to realize together protagonist - students Health Education itinerary with "contamination" between different disciplines, linking innovative bioscience concepts, strategic cooperative teaching practices to realize constructive Neuroscience Orienting Education.

Keywords: interdisciplinary education, Neuroscience communication, Neurodegenerative disease, STEM didactics strategies, Neuroplasticity, Biologist-didactics researcher

Introduction

The main function of a neuron is the communication: it is also used to feel, to transform all the messages coming from the inside to elaborate these messages and to promote the action; besides neuron can converter electrical energy or chemical energy into mechanic energy. Didactic of Neuron and for Synapse is important to educate High school students to understand modern Brain science in interdisciplinary way promoting innovative role of Educational Neuroscience beginning from Biophysics concepts. This STEM didactic research project has created elements of interdisciplinary educational process about Neuroscience bases with elements of experimental neuroeletrophysiology history beginning from:

SCIENTIFIC QUESTIONS FOR STUDENTS

*What are the function of neurons and which is the difference between excitable and not excitable cells with example?
*What is synapse in human nervous system and how was realized discover by scientists?
*In which way do you think is possible to represent concepts of synapse also with a model?

Innovative research about strategic didactic activities for learning biological neuroscience of synapse also with innovative STEM elements from *International* 2017 *Neuroscience Meeting*. In teaching modern Neuroscience topics in High School is very important to link school research activities with science world, learning innovative developments and limits of modern Brain science. Biologist didactic-researchers have analyzed international synapse researches to construct STEM activities to improve neuroscience learning. The core of Neuroscience studies can be presented to High School classes in innovative way, also understanding different aspects of interdisciplinary neuroscientists' methods to investigate the brain. Modern didactic and communication for synapse working as didactic researcher-teacher with protagonist students as “active scientific community” were realized to present also modern concepts about *Neuroplasticity* with scientific STEM disciplines (biophysics, biochemistry, neuroelectrophysiology, ICT, cellular biology) in learning neuronal science using also international selected articles of scientists about this topics.

From lecture of simple neuroscience highly effective communication to complex neuroscience articles, also consulting with students www.brainfacts.org – Society of Neuroscience, Washington.

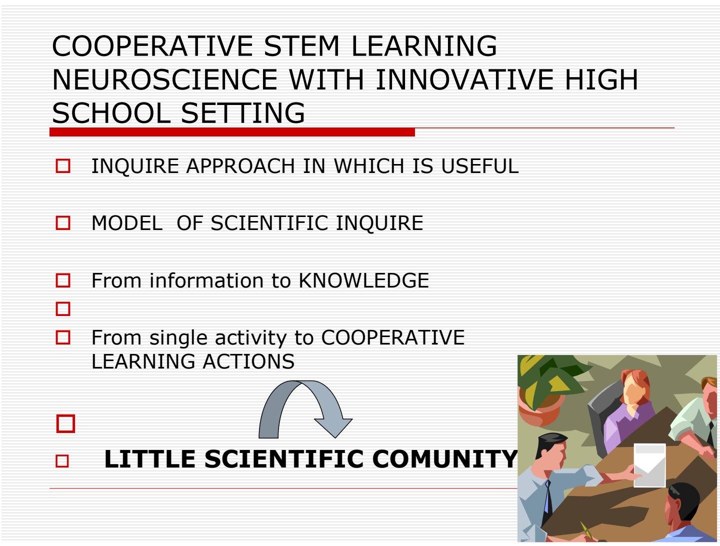

Fig. 1. Modern High School setting with innovative Neuroscience Didactics

Material and Methods

New idea in this didactic itinerary: to link High school' world with Research' world in Educational Neuroscience Itinerary with modern inspiring role of science research. "*Principal investigator*" with group *researcher-students* for Science Education Community in High School. During didactic itinerary was important Teaching and Learning in multidisciplinary way with Creativity and Flexibility, analyzing also history and evolution of experimental *neuroelectrophysiology techniques* useful for Biomedicine about Neuronal cell. The innovative STEM didactic itinerary was a part of large creative project realized to educate High school students in understanding evolution of modern biomedicine techniques with limits, difficulties, new applications.

From historical biophysic elements to modern molecular biology and neurophysiology techniques, guiding students in team work to understand scientific data in cellular membrane of excitable cells as neuronal cells. In teaching modern science topics was very important to learn innovative developments and limits of modern science techniques as in academic innovative itinerary. Modern class setting: educational didactic path to work with critical thinking and with historical approach to understand Systems Neuroscience into little scientific community as student- researchers.
Different phases were realized in this STEM project working High School' students that have created "*Bioglossary for Neuroscience with interactive images*", interpretation and representation action potential simulation creating possibility to determinate change of ionic concentrations after stimulus on the neuronal membranes. Each group of students have drawed with computer graphic model of neuronal cell and on the membrane the strutture of different proteins channels, reading articles and representing new concepts about synapse from some international scientific researches. Different curricular actions of students in cooperative learning Neuroscience were realized with enquire method:

1.	To tell history neuroelectrophysiology techniques
2.	To draw glossary in cooperative learning and to construct synapse model of neuron
3.	To represent interactive action potential simulation and protein channels activities
4.	To analyze, to reflect and represent about 2017 "synapse science" discovers
5.	To analyze in active way oxidative stress condition on microglial cells: neurodegenerative disease
6.	To comunicate as researchers in classes-miniworkhop

Tab.1. Different actions of cooperative "Learning Neuroscience Activities"

From this activity to "*Tell a neurotransmitters activity*" in which was realized by little group of students interactive works with ICT skills, innovative scientific posters about principal neurotransmitters. In "*Neuronal cells communication*" phase were realized didactic learning strategies teaching modern Brain studies about Biochemistry and Cellular neurobiology of neurodegenerative disease as Alzheimer' to improve impact of actually knowledge about this topic in Health Education.

Results

Didactic products (ICT rielaborations, Synapse Interactive model and others) were realized in all activities working with inquiry-based learning as in community of scientists. This research project has created conditions in which innovation is the core of new didactics strategies in student's groups to increase the levels of motivation, to activate collaboration in teaching, learning and planning processes. From the principal concepts of Neuroscience to modern Neuroinformatics didactic activities in surfing Brain Bioinformatic Bank, students have integrated different knowledge to realize correct communication and interpretation of Brain Science. Students have read also innovative scientific articles about modern synapse's discoveries (2017), analyzing in little groups some aspects of the Application SYNGO, "*Synapse Consortium – Synapse Gene Ontology*", a collection of information about genes in different species, proteins, experimentals, 3D images about synapse brain regions.

Discussion

Each group of students has drawed with computer graphic neuronal cells and on the membrane the structures of different proteins channels also reading and representing new synapse concepts. In "*Neuronal cells communication*" phase questions of biology researcher-teacher about "neuronal conversation" with international modern researches. From this activity to "*Tell Neurotransmitters*" on which was realized interactive work to neuroinformatic didactic surfing in Bioinformatic bank. Didactic learning strategies about modern brain studies in the classes also about biochemistry and physiology elements of neurodegenerative Alzheimer's disease. Others STEM didactics activities were realized about innovative Optogenetics that links genetics, pharmacology and optical control with the possibility to manipulate receptors with photoinactivation, the possibility to describe proteins conformations mobility and introducing new functions into proteins also positive and allosteric modulation of glutamate receptors. From the basic concepts about chemical synapses, the function of neurotransmitters in neuronal communication to promote an interdisciplinary analyse with proteins receptors important for Brain plasticity: *Glutamate receptors* (NMDA and AMDA). In terminal High School classes is possible to work with students about Glutamate Protein Receptors implicated in memory mechanisms and neurodegenerative diseases for little groups in *ICT surfing activities* using *Data Protein Bank (PDB)*, searching proteomic information about chemical structures (aminoacid numbers, per cent of alfa beta sheets, year of discoveries, receptors weight), the role of these proteins in normal plasticity during modulation of neuronal communication, potentiation or depression.

WHAT IS PLASTICITY FOR STUDENTS? Plasticity is a key concepts in modern science. Plasticity is the brain ability to reorganize itself by new connections between neurons THROUGHOUT LIFE
WHAT IS NEUROPLASTICITY CAUSED BY? 1. PHYSIOLOGICAL CAUSES (learning, automatic behaviour; reactions to positive damaging stimuli) 2. PATHOLOGICAL FACTORS (after a brain damage are consolidated circuits and brain areas replaced by parallel circuit: re-educational path)

Tab. 2. Neuroplasticity concepts for High School students

Conclusion

In this educational synapse path realized in High school classes, teacher - researcher write itinerary of didactic project in which students are protagonists. It was possible to guide students with motivating strategies to work as researchers also analyzing biochemical and physiological innovative dates, relationship between molecules of neuronal communication, learning by doing also about pathological mechanisms of Alzheimer' disease (AD). For better Learning Neuroscience was important to create new didactics STEM path with multidisciplinary Brain Science, analyzing normal and pathological condition and reflecting about importance of equilibrium of individual life style on cognitive functions. It was important for success of project to prepare flexibly actions for students of different classes, to programme active interdisciplinary lessons with protagonist students, to solidify learning with cooperative STEM class group-work. In this way should be taught elements of neuroscience in High School, with interdisciplinary approaches and with STEM enquire methods. From the basic concepts about neuronal physiology and chemical synapses to role of different neurotransmitters in neuronal communication, an interdisciplinary analyse of proteins receptors important for plasticity of the Brain: *Glutamate receptors* (NMDA and AMDA). Glutamate Protein Receptors implicated in memory mechanisms and neurodegenerative diseases to understand the role of these proteins in normal plasticity during modulation of neuronal communication, potentiation or depression to improve in modern way Health Education about Brain.

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Robotics Education

A Martian Adventure: An Interactive Geo-Edutainment Tool

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Abstract

Cooperative and simulation games can create an exciting and empirical learning environment. The participants of such games can develop competences which are overlooked in traditional educational methods. Geography as a subject has ample opportunities to apply games of this type during the learning progress.

The goal of the current paper is to present the game "Martian Adventure" which was designed and developed in the Institute of Geography and Earth Sciences of the University of Pécs, Pécs, Hungary. Our goal was to create an interactive teaching method, through edutainment and gamification, which helps students to develop navigational, programming and general STEM (science, technology, engineering and mathematics) competences. During the activity we applied Lego Boost robots on a theoretical Martian surface. The robots moved across various Martian landforms which enabled students to perceive these landforms and their terrestrial equivalents. Our findings indicated that that students' terminology increased in the field of planetary and general surface morphology.

Although high school students are regularly engulfed in astronomy and planetary sciences through popular media movies, still their education in Hungary is only based on conventional teaching methods. However, with the advent and the exponential development of robot and infotainment technology, general terms and definitions used in planetomorphology may be perceived, acquired, and clad with real scientific meanings via interactive gamification. The visual multimedia experience enhances the process of imprinting and students were able to apply the adequate terms in a complex context-valid way. As students used their own mobile phones, scientific resources are not necessarily implemented as traditional source of knowledge *obtained via conventional classes but rather attained through entertaining activities.*

Keywords: Mars, Martian Adventure, planetomorphology: Gamification, Lego Boost;

Introduction

The Red Planet has been in the focus of many humans and is a possible area of survival for humankind. News on satellite photographs, the landed Martian rovers and the new discoveries widely attract the scientific community in many aspects. The exploration progress of rover Curiosity and the landing of the *InSight* were watched with great interest by the public. This attention, however, is not novel. The perihelion opposition of 1877 amplified the scientific interest. Giovanni Schiaparelli the Italian astronomer, thought that there are artificial canals on Mars largely due to an accidental mistranslation from Italian to English. Percival Lowell (1855-1916) believed them to be artificial irrigation channels [1]. The new theories of Martian life became popular after H. G. Wells' novel entitled War of World. Nonetheless, with time, hypotheses on the existence of life on Mars have been refuted [2]. Nevertheless, the Mars has an ever growing and ongoing popularity.

A Games and Simulations in Science Education uses a practical approach [4]. It had a significant influence on the field of STEM (Science, Technology, Engineering and Mathematics) subjects and especially in geography. It summarized the advantages of games in education, and collected the games and simulations available for them. [4].

Also encouraged educators to create own games, and gave practical advises to developers and educators. The games that designed with clear educational purpose is called serious game [5].

There has been a lot of research on the application of games in education over the past years. Vigil-Cruz [6] studied PHARM in pharmacist training. The research explained that learning with the game increased the learning performance and it was the most popular learning way among students. Similar studies have been published about chess [6], *WiseMoney, Scrumia and Deliv*er [8]. Lev Vygotsky (1962) thought that games are the best way of children's development [3].

The objective of the current study was the design of the game "Martian Adventure" (MA) that facilitates the perception of the newest achievements in Mars exploration and the geomorphological features and landforms found on the surface of the red planet. The game simulates the activities of Mars rovers, by using Lego Boost robots on a playfield of a Martian land surface. The game provides an excellent tool to recognize Martian landforms and examine them in contrast to terrestrial terrain.

Students were also taught about the forces that formed unique Martian morphological features. Furthermore, the game, due to its remotely-controlled robot technology, functions as a competence developer tool.

Methods and Tools

The Martian playfield

A Martian surface of an arbitrary playfield pattern was created (Fig. 1) by using 25 satellite images (tiles) taken of the surface of planet Mars. These pictures were taken by the ESA Mars Express space probe [9]. The original resolution of the images ranged between 10 to 20 m per pixel. These surfaces, however are not directly adjacent to each other on the surface of the Mars and were arbitrarily adjoined by the authors.

We used large-scale pictures, where the relief's drop shadow did not differ significantly, therefore their boundary is gradual providing a better match between the adjacent tiles of the playfield. The original resolution of the individual tiles were changed, hence the landforms have various scales. This way the playfield had a more integrated look. We used the software GIMP to put the final mosaic together. The playfield was printed out at a 150 dpi resolution on a plastic sheet of 3x4 meters.

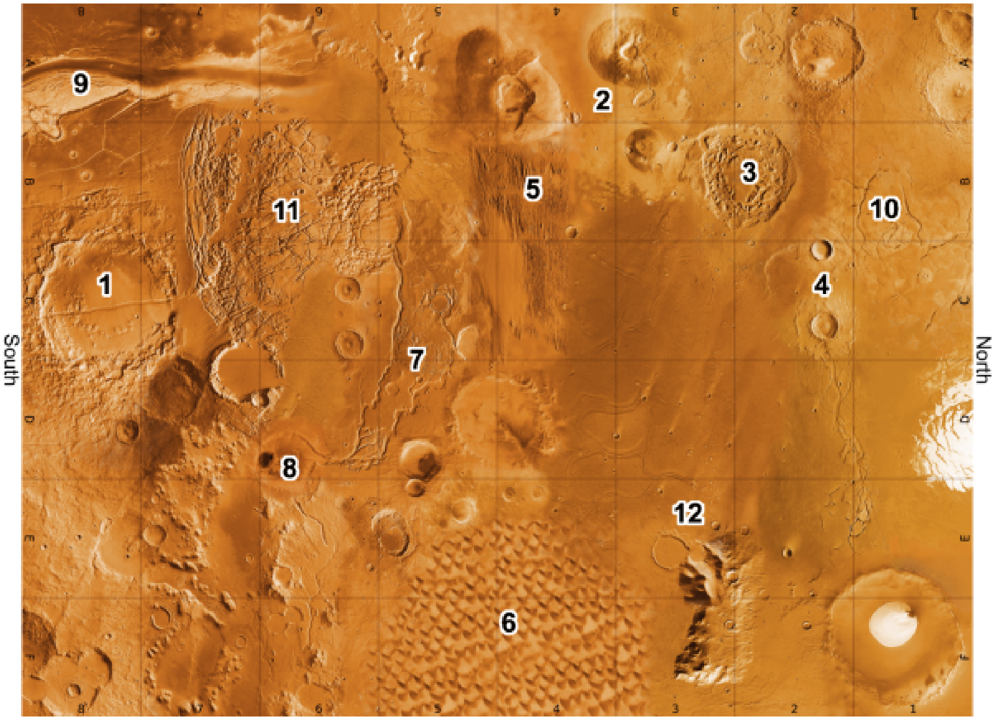

Fig. 1. The playfield of the Martian Adventure

The numbers indicate typical landforms found on the surface of planet Mars. 1: Fault lines in a crater in the Memnonia Fossae area, 2: Tharsis, Ceraunius and Uranius Tholus volcanic areas, 3: Ismenia Patera, 4: Hephaestus_Fossae, 5: Euminedes Dorsum, 6: sand dunes in Proctor Crater, 7: Valles Mangala, Osuga and Nanedi, 8: Crater in Mamers Valles, 9: a detail of Vallis Kasei, 10: Adamas Labyrinthus in Utopia Planitia, 11: Chaotic terrain in Iani Chaos, 12: 'hourglass'-shaped craters in Promethei Terra.

The playfield creates a north-south cross-section of the Martian surface from the North Pole to the South Pole. The landforms of the highlands of the southern hemisphere and the vast plains of the northern hemisphere as well as the shield volcanoes, dune fields and the ancient riverbeds, fault line structures are visualized on the playfield (Fig. 1). The Martian surface has been formed by the same internal and external forces that has been acting on the surface of the Earth. Although significant geomorphic differences do exist on the surface of the two planets, due to the intensity, scale of the processes and forces acting and also the characteristics and dimensions of the landforms, still their quantitative and qualitative comparison is feasible and may boost the relevant analytical skills of the students involved in the study.

Landforms created by internal forces

As the diameter of the Mars is only slightly more than half of the Earth's diameter it had weaker mantle convections during the tectonically active phase of the planet.

Therefore, the Martian lithosphere may have not been split into individual small tectonic plates. However *Valles Marineris* (one of the largest canyon systems in the Solar System) was likely created partly by tectonic forces [10]. Traces of smaller tectonic movements are also found on the surface of Mars, like the fault and thrust lines of 1.5 km width in a crater in the *Memnonia Fossae* area (Number 1 on Fig. 1).

Volcanism, has played a significant role in the geologic evolution of Mars, however there is no evidence of recent volcanism on the planet. Planet Mars, like Earth, had both effusive and eruptive past volcanic activity. These volcanoes were active up to 20 million years ago. The largest areas of past volcanic activity include the *Tharsis* and *Elysium* provinces, while many smaller formerly active volcanic areas are scattered across the surface of the planet. There is no active tectonics on planet Mars today.

Therefore, volcanoes are likely positioned above magma plumes generating hot spot-type intraplate volcanism, similarly to the Hawaiian volcanoes in the Central Pacific region or the Yellowstone supervolcano. The playfield shows three small volcanic cones (*Tharsis*, *Ceraunius* and *Uranius Tholus*) (Number 2) with small lava flows on their flanks. Next to them the collapsed caldera of a once-massive supervolcano is found (Number 3).

Landforms created by external forces

Planet Mars has a large number of impact features formed by comets, meteors and asteroids. Complex craters are formed in large craters with central peaks and terraces. The largest impacts created basins. The Martian Adventure's playfield visualizes both younger and older, eroded craters. The Mars has some unique crater types called rampart and pancake craters near the poles. These are surrounded by fluidized ejecta features (Number 4).

Despite the low air pressure in the Martian atmosphere, erosion, deposition and accumulation by wind is dominant process on the surface of the Red Planet. For instance, the parallel valleys of *Euminedes Dorsum* were formed by wind (Number 5 in Fig. 1). The accumulation and deposition of eoalian sediments are represented by an extensive sand dune field (Number 6) (NASA Mars Global Surveyor image).

To sustain human life on Mars the existence of liquid water is indispensable. In the past liquid water was more common than today on the surface of Mars. The space probes have found a large number of river valleys (e.g.: *Mangala*, *Osuga* and *Nanedi)* along the border of the southern highlands and northern plains (Number 7 in Fig. 1).

These river channels have created meanders and formed sandbars and islands similarly to the terrestrial rivers. Rivers of planet Mars flew into the northern periodically existing, ephemeral seas or crater lakes (Number 8). The outflow channels that drained seas and lakes, like *Kasei Vallis* (Number 9) had the highest discharges. With a few exceptions the features tend to appear fully sized at fractures in the Martian surface, formed either from chaos terrains or canyon systems or other tectonically-controlled, deep graben-like landforms.

The surface temperature of Mars is usually below 0 °C, therefore water is mainly found in a frozen state on both the surface and subsurface. The largest volume of water ice is locked on and around the north pole during the winter season. The ice there is mainly found in the form of frozen CO_2. The whole Mars has a huge volume of ice under the surface in a form of permafrost. That is reflected on the surface in the northern plains (Number 10) and the chaotic terrain of the southern plateaus (Number 11). The chaotic terrain was formed by the removal of subsurface water or ice. Glaciers have eroded the land and built moraines, like inside the hourglass-shaped craters (Number 12).

The aims of the game design

Our aim for game design is to create a game that teaches children of various age geology and planetomorphology through the learning-by-doing educational approach.

With the usage of robots on a theoretical Martian surface we can help the participants to perceive the real Martian landforms and find their terrestrial counterparts.

Henceforth, the MA game helps to convert the knowledge into comprehensible and adaptable knowledge and skills. The interactive experience with tablets and engaging robots and spectacular Martian terrain allows pupils to develop navigational and programing skills.

It helps to move science closer to the next generations. Besides that, our educational system has to concern the pupils' affective domain [11]. The MA game creates a positive environment where pupils can learn from each other in a mutual manner.

Furthermore, we can help students to understand the true values of technology by using robots as part of the game.

The gameplay

The Martian Adventure game is designed for participants of 2 to 3 teams. Each team has 3 to 4 members. The team main goal is to perform tasks with a Lego Boost Mars rovers. The tasks mainly focus on Martian terrain and comparing it to our planet's surface. The game starts with a short lecture, where the teacher shows the playfield's main features and talks about the evolution of the Martian landforms.

After the lecture, the turn based game starts with a ruffling, using a spinner with different Landforms and tasks on it. After spinning, students receive a Landform found on the Playfield (Fig1). Both team has to maneuver the Lego Boost rover there, by using the controller tablet. After reaching the square that contains the landform, students pick up an object with the fork of the rover. They have to retrieve the object to the starter position. The rovers always depart from the Martian Research Base of the specific team. The base is transferred to a different position on the field in every turn.

There are random effects which can be triggered by the turn starter spinner. For example, the players can activate Martian dust storms that prevent them to pass over certain field squares affected by storms. The mobility of the rover is also influenced by the terrain. Dirty or hilly surfaces slow down the movement of the rovers. The teams have to account for the changing circumstances when planning their route.

The gameplay depends on the time available. The difficulty level of the game and the gaming time can be adjusted to the level of the game-players.

Conclusion and future research

The Martian Adventure game as a geo-edutainment tool can bring the geology closer to the pupils while their controlling skills and other competences are improving.

The Martian Adventure game enhances the students' problem-solving and decision-making skills via an entertaining gamification activity. These development areas are considered of primary importance by the European Commission and they are crucial parts of science visibility and popularization monitored by the PISA assessment. Via teamwork skills obtained during the game also help to improve both social and individual skills and on the long run it may contribute to well-functioning interrelations at social level.

The Martian Adventure is favorably applicable in conventional frontal classes or as an optional extra-curricular lessons, activities outside the classroom and at Science Fairs or academic Open Days.

One of the key factors of designing scientific games is based on teachers' and students' reflections [3]. Game designers should avoid the development of excessively challenging or insufficiently engaging game by responding and reacting to the participants' reflections. To further explore the teaching efficiency of the Martian Adventure our future research attempts to test the game on students of various age groups in different schools and compare the outcomes with students of control groups where participants were not familiarized with the game of Martian Adventure.

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Science and Environment

Active-Learning Strategies to Increase the Students' Engagement to an Environmental Science Course in a Distance-Learning Program

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Abstract

The universalization of World Wide Web (WWW) and Information and Communication Technologies (ICTs) has fostered a great development of on-line and distance-learning courses, and a fast growth in the number of students enrolled in such programs. Besides, on-line and distance-learning programs have been able to overcome a number of handicaps that face-to-face programs have, mostly due to great flexibility that on-line programs offer to students regardless of their location and/or time availability. As a drawback, students enrolled in on-line and distance-learning programs might feel isolation and lack of motivation. In order to overcome these problems, this research aims to study how active-learning teaching strategies influence the students' study approaches, their motivation and strategy to learn environmental science in a distance-learning program along with the Revised Two – Factor Study Process Questionnaire (R-SPQ-2F) employed. The study was carried out in the National University of Distance Education of Spain in the Environmental Science undergraduate program during the 2017/18 course. The results of the study indicate that the active-learning methodology implemented in the course helped the students to reach a deep approach to the learning, their motivation to the course and to achieve better learning outcomes.

Keywords: Environmental science; active-learning; distance-learning; motivation

1. Introduction

The important growth of distance learning programs could be attributed to the fact that distance learning programs satisfy many of the obstructions that conventional campus-located educational programs have, such as the need to attend classes that normally means a geographical relocation, conflicts between work and course schedules and family commitment conflicts [1]. The main difficulties that students enrolled in such programs are due to the fact that students and professors do not share the same physical and time space. This situation causes a growth of an "isolation feeling, lack of self-direction and management, and a decrease in motivation levels" because of the lack of interaction [2]. The effects of this isolation not only influenced the students' academic achievements, but also the promotion of negative attitudes and dissatisfaction with the learning experience causing even course abandonment [2].

The selection of proper learning strategies is crucial in the acquisition of knowledge [3]. Active learning is defined as any instructional method that engages the students in the learning process, and requires the students to do meaningful learning activities and thinks about what they are involved more cognitive processing and meaning building [4].

The student approach to learning (SAL) theory [5] assumes that each student has a unique approach to solve a particular learning task. Biggs' study [5] established that a deep learning approach is characterized by an interest for the topic from the students, its willingness to understand the topic and a feeling of joy when studying. A surface learning approach is characterized by memorizing facts, routine learning and by doing the minimum to pass test or the course.

2. Research aims

This research aims to explore how the implementation of active learning methodologies, adapted to a distance-environmental science course, influences the students' approach to learning, their motivation and their strategy to learn environmental science.

3. Methodology

3.1 Sample

This study was carried out the Environmental Science program of the National Distance University of Spain during the course 2017/18. A total of 64 students participated in the study (53% female and 47% male) with and average age of 48 years old. Fig. 1 summarizes the demographics information of the sample.

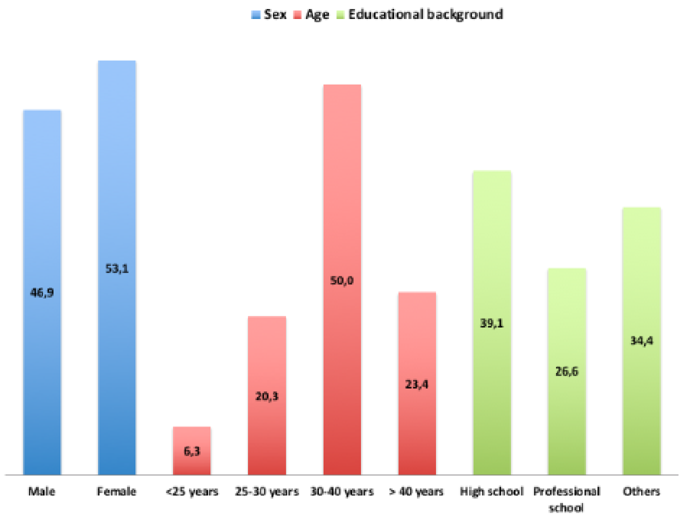

Fig. 1. Demographics information of the study sample

3.2 Research instrument

To collect the students' information the R-SPQ-2F questionnaire (*Revised Two-Factor Study Progress Questionnaire*) was employed. This questionnaire as it was described by Biggs [5] and consists of 20 items Likert-type (5 levels) and allows to gauge the students deep approach (DA), surface approach (SA), deep motive (DM), deep strategy (DS), surface motive (SM) and surface strategy (SS) to the students learning processes. The questionnaire was validated and its reliability was assessed by means of Cronbach test. The questionnaire was submitted to the students before and after the course, in order to assess the influence of teaching methodology implemented in the course.

3.3 Course design

This subject is structured in 10 chapters dealing with different aspects of the atmosphere, its pollution, pollutants distribution and analysis, and the local, regional and global environmental consequences. It also includes the aspects of engineering control of air pollution and environmental laws and regulations. The course is taught by followed a distance-learning program, and according with the course syllabus, the students need 125 hours to complete all the contents and assessments exercises.

The students are given all the course materials at the beginning of the course together with a student's guide.

For this course, an active learning methodology was followed, consisting of different "case study activities" to apply the specific contents taught during the course.

In addition, the students are provided with interactive instructional materials through the virtual campus, such as podcast, hot potatoes exercises, lectures presentation, conceptual maps and summaries of theoretical contents. Some of these activities are applied as a source of on-going feedback with the aim to improve teaching and learning and consequently as a tool of formative assessment [6]. For each case study, the students need to submit a report addressing all the questions and solving the situations states in the case studies. The submission of all proposed activities is mandatory. The course final grade consists of the grades obtained in the different activities arranged during the course together with a final exam. Portfolio was other assessment tool employed to analyse the student's evolution in terms of learning contents and competences. Each student's portfolio includes self-assessment results, on-line and in-person test evaluations and the students' opinion surveys. Portfolio was a multimodal tool in the learning processes [7].

3.4 Data analysis

The analysis of the collected data was carried out according to Biggs *et al.*, [5].

To get the students' score for DA or SA, points given by students were summed up for each group of questions (DA or SA), thus the maximum score for each approach could be 50 points per student. To assess the students' motivation and strategy to learning, similar analysis was carried out considering four different subcategories of the questionnaire, that were DM, DS, SM and SS.

4. Results and discussion

The data collected from the questionnaire was organized and analysed after the course completion. Fig. 2 summarized part of the results obtained for each of the students participating in this research. These results indicate that the number of students with a DA score over the mean value, considering the whole class, increased at the end of the course, and a significant difference was appreciated when data from the pre- and post-test were considered. Besides, it is also remarkable the decrease of the number of the students who scored a SA below the mean value. Different studies [8] indicated that DA scores over the mean value denotated a DA in the learning of the study subject.

	Nº Item Deep Approach (DA)										DA TOTAL	Nº Item Superface Approach (SA)										SA TOTAL
Estudiante	1	2	5	6	9	10	13	14	17	18		3	4	7	8	11	12	15	16	19	20	
ALC	1	4	5	4	2	2	4	3	1	1	27	1	1	1	3	1	1	1	2	1	1	13
AAAM	5	5	5	5	4	4	5	4	4	3	44	1	3	1	2	4	2	2	2	2	2	21
ABC	5	5	4	4	5	5	4	2	4	4	42	1	3	1	1	1	1	1	2	2	1	14
BMERL	4	4	4	3	3	4	4	3	3	3	35	1	2	1	2	1	2	1	1	2	1	14
BCEA	4	4	5	4	4	3	4	3	2	2	35	2	3	1	1	2	2	2	3	3	2	21
BSA	4	5	4	2	4	5	4	3	4	3	38	1	2	1	1	1	2	2	3	2	2	17
BSVF	4	4	3	4	4	5	4	4	4	4	40	1	3	1	2	2	1	2	3	4	3	22
BCFJ	5	4	4	5	4	3	4	2	1	4	36	2	4	1	1	1	2	1	1	1	2	16
BNRA	5	5	5	5	5	5	4	3	2	5	44	1	1	1	1	1	1	1	1	1	1	10
CRL	4	4	5	4	4	3	4	2	1	2	33	2	4	1	2	2	3	3	3	2	4	26
CPR	5	4	3	2	4	4	2	2	2	1	29	4	4	3	1	1	2	1	1	1	3	21
CLJ	5	5	4	4	5	4	4	3	4	4	42	2	3	2	2	2	1	2	2	3	3	22
CSB	4	5	5	4	3	4	3	2	2	2	34	1	1	1	2	2	2	1	2	2	2	16
CCFR	5	5	5	2	5	3	5	2	4	3	39	4	5	1	1	4	3	2	3	3	3	29
DVJ	5	5	5	5	5	5	5	5	4	5	49	1	1	1	1	1	1	1	1	1	1	10

Fig. 2. Scores given for each student to each item of the R-SPQ-2F questionnaire at the end of the course (only a portion of information is shown)

Regarding the students' motive and strategy to study, the results obtained indicated that the teaching methodology contributed to achieve a deep approach, however relevant differences were determined between the students participating in the research. A DM is related with a higher interest in the learning process while a DS regards a meaningful significance of the learning. Finally, when a relation between the learning approach and the students' outcome is analysed, it is observed that there is a positive correlation between DA scores and higher grades, and a negative correlation between SA scores and lower grades. Similar results were obtained when motivation and strategy were analysed.

5. Conclusions

This research assessed how active-learning teaching strategies influence the students' study approaches, their motivation and strategy to learn environmental science in a distance-learning program along with the R-SPQ-2F employed. The study was carried out in the National University of Distance Education of Spain in the Environmental Science undergraduate program during the 2017/18 course. The results obtained in this research allowed to describe how was the students approach to the study process and allowed to classified them based on their deep or surface approach, motivation and strategy to learning. The results also indicated that better grades are obtained when a deep approach is reached.

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Educational Concept for Hands-On Energy Science Workshops

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Abstract

Achieving a sustainable energy future is a tremendous challenge for society that requires broad education in its importance as well as in the underlying science. We present here a workshop that has been developed by the Collaborative Research Center (CRC) 1073 at the University of Göttingen for school students on the topic of renewable energy. The goal of the workshop is to pass an appreciation of the science behind renewable energy conversion on to school students. By educating our youth in the science and technology of energy conversion, we aim to empower them to evaluate political and social discussions about renewable energies and to actively shape our future.

The workshop introduces the students to the broad concept of the "hydrogen economy", and then to the interdisciplinary sciences needed to understand hydrogen generation and storage. These include semiconductor physics and redox chemistry, which are both important topics in German school curricula. The students first isolate TiO_2 nanoparticles from commercial sunscreen, measure the particle size with scanning and transmission electron microscopes and then build a solar cell with them. The effect of the particle size on both the solar cell and the sunscreen is discussed. Second, they demonstrate hydrogen generation by electrolysis using commercial solar cells and by photocatalysis using zinc sulphide nanoparticles. Finally, the students calculate and compare the efficiency of solar cell electrolysis and photocatalysis for hydrogen generation from water. The comparison reveals the high potential of photocatalysis, but at the same time the need for further research.

Keywords: Energy, research, hydrogen, photocatalysis, solar cell

1. Introduction

The Collaborative Research Center in Göttingen entitled “Atomic Scale Control of Energy Conversion” (CRC 1073) is one of many CRCs funded by the German Research Foundation (DFG). The CRC consists of three project groups dealing with energy losses (A), energy conversion of optical excitations (B) and energy storage (C).

Both physicists and chemists work together in the three groups to gain a fundamental understanding of energy conversion, with the eventual goal of developing tactics to improve conversion and storage efficiency [1]. In this way, the CRC 1073 aims to contribute to the urgently needed energy revolution. The reason is not simply the limited fossil fuels like mineral oil or natural gas, but also the climate change caused by greenhouse gas emission and the fine dust pollution associated with health risks for human beings. The German decision to stop using nuclear energy by 2022 makes an increase in the use of environmentally friendly renewable energies even more urgent. Nonetheless, non-renewable hard and brown coal, mineral oil, natural gas and nuclear energy are still the main energy sources in Germany.

2. Educational concept

A sustainable energy future can of course not be achieved by the CRC alone.

Everyone and in particular the next generation need to contribute. For this reason, the CRC researchers have joined with Chemistry Education students to develop a concept for public outreach (s. Fig. 1) to connect the CRC with school students and the general public. The outreach activities should educate both male and female school students in energy science and attract them to physics and chemistry Bachelor programs in order to guarantee the next generation of energy-conscious scientists.

The final goal is that students acquire the skills and motivation to actively contribute to shaping a sustainable future.

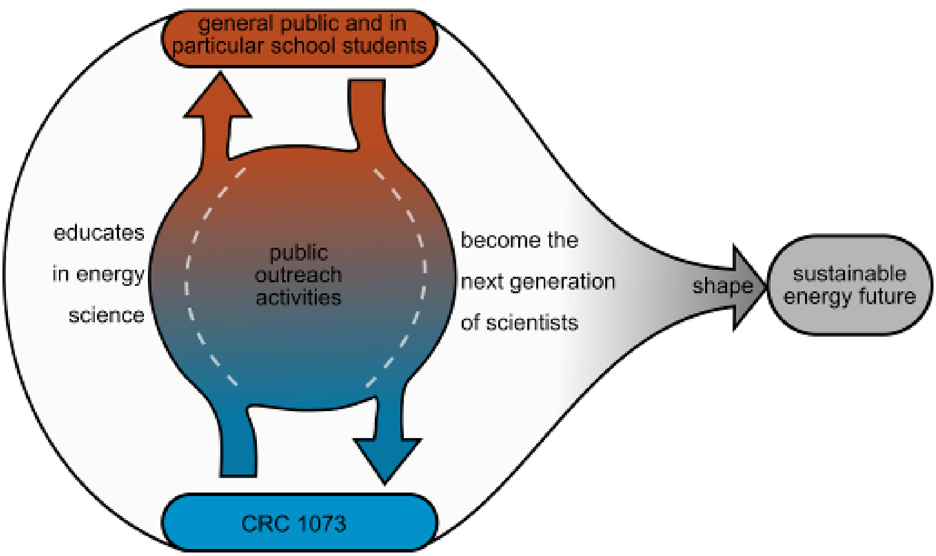

Fig. 1. Concept for public outreach of the CRC 1073

The public outreach activities consist of multimedia work through the CRC homepage, newspapers, TV and YouTube, the participation in public events, the collaboration with the XLAB which is a laboratory for young students and “Hands-On Energy Science” workshops. The workshop on the subject of the hydrogen economy exemplifies the educational concept of the CRC public outreach. It targets upper secondary level school students who already have basic knowledge in semiconductor physics and redox chemistry. Building on their school knowledge, students learn how fascinating technologies like solar cells work. They thereby understand the value of their school knowledge, which can motivate them. At the same time, they acquire a deeper understanding of the basic concepts “energy” and “donator/acceptor” that are part of the German school curricula. Moreover, they learn to reflect on and evaluate science with regard to socially relevant issues like technological development and a clean and safe environment. During several discussions, they additionally learn how to use scientific language and to argue based on well-founded knowledge.

In order to reliably inform students about climate change, which is often the subject of contradictory media reports, the workshop starts with statistics of the German Federal Statistical Office which verify global warming and point out the acute need for action. It is a good “warm-up introduction” for the workshop, as it activates and clarifies students’ knowledge about the problem the CRC tries to tackle. Afterwards, the workshop is divided into two units related closely to the CRC project groups B and C. They deal with solar cells as an example for an environmentally friendly way to generate electric energy and with hydrogen as an example for a sustainable way to store energy.

In the first unit, students learn how a solar cell works, thereby acquiring required German physics curriculum content about the band model, band gaps, doping and pn junctions. They learn that commercial solar cells convert only a small part of the captured sun energy into electrical power and thus understand why the CRC project group B works on new, more efficient ways to convert light to electricity. In addition, they are introduced to other research approaches like tandem, thin-film and polymer solar cells. In the experimental part of the first unit, students build a dye solar cell with TiO_2 nanoparticles. They isolate the nanoparticles from sunscreen, measure their size with a scanning electron microscope (SEM) (s. fig. 2) and with a highly advanced transmission electron microscope (TEM) which is capable of resolving atoms. The high resolution microscopes are usually quite impressive for the students and arouse their interest in science.

In the second unit, student engagement is in high demand, since the unit mainly consists of discussions that evaluate the efficiency and environmental impact of different energy storage methods. Students first learn that renewable energies require storage, in contrast to coal and nuclear energy, because they depend on weather and seasonal fluctuations. Afterwards, they learn about using hydrogen to store energy, about the hydrogen economy and about current political and corporate strategies for its advancement. But they also learn that hydrogen is currently generated by steam reforming. They are asked to evaluate this method. The expectation is that they argue that steam reforming is neither sustainable nor environmentally friendly due to the use of natural gas and the emission of CO_2. Following discussions about alternatives, they are guided towards the next experiment which is water splitting using solar cells. But calculating the efficiency of hydrogen generation by water splitting using electricity generated by solar cells reveals that it is quite low. A promising alternative is photocatalytic water splitting where the sun energy is directly converted into hydrogen.

This research approach is investigated in the CRC project group C and included as the final experiment of the workshop. The idea is that direct conversion is more efficient than a two-step conversion of sun energy to electrical power in a first step and then to hydrogen in a second step. However, the photocatalytic experiments reveal that photocatalytic and solar cell water splitting currently have approximately the same efficiency. Thus, the final conclusion is that more research is required to develop efficient and environmentally friendly ways to store energy and generate electricity.

Fig. 2. Left: School students at the SEM. Right: SEM image of TiO_2 nanoparticles isolated from commercial sunscreen

3. Hands-On Experiments

The workshop experiments aim to inform about the research projects of the CRC and to transfer both process-related and content-related skills to students. The latter are mainly experimental skills, but students also learn the scientific workflow.

3.1 Building a dye solar cell

The CRC project B02 has the long-term objective to develop a new, more efficient type of solar cell. By analogy students build dye solar cells using different dyes [2] and attempt to identify the best one. Thereby, they:

- apply their acquired knowledge about the operating principle of solar cells,
- practice basic electrochemical measuring techniques.

3.2 Working with electron microscopes

Students measure the TiO_2 nanoparticle size with the professional electron microscopes of the CRC. The educational objectives are that students:

- understand why the size of the TiO_2 particles is important in sunscreen and transfer this knowledge to solar cells,
- learn how an electron microscope works and explain similarities to light microscopes,
- experience the everyday life of a scientist by operating the SEM themselves.

3.3 Electrolytic water splitting

The CRC project $C0_2$ aims to understand and control the elementary steps of water splitting at the atomic scale. In fact, the scientists have observed how a water molecule is split at the surface of a catalyst in the exact same TEM used by the students to measure the nanoparticles. During the workshop students perform in principle the same experiment as the researchers. They:

- apply their school knowledge about the galvanic series and overvoltage,
- hypothesize and prove how many solar cell modules are necessary to split water,
- hypothesize which gas is generated at which electrode and prove their hypotheses with detection reactions for H_2 and O_2,
- learn the scientific workflow.

3.4 Photocatalytic hydrogen evolution

Hydrogen is generated by illuminating ZnS nanoparticles in a Na_2S/Na_2SO_3 solution (s. Fig. 3) [3]. Students

- tackle the problem of finding the right LED for the photocatalytic hydrogen evolution,
- understand the relation between light wave length and band gap by problem-oriented learning.

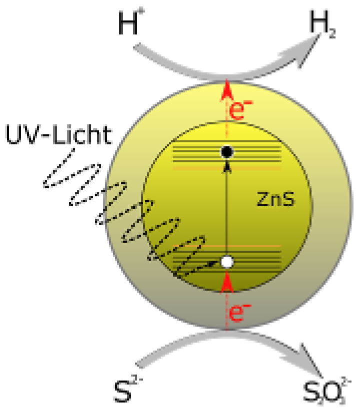

Fig. 3. Illustration of photocatalysis

4. Conclusion and Outlook

The CRC 1073 has developed an educational workshop in which students learn the basics of energy science and reflect on and evaluate science with regard to its role in society. The workshop empowers and inspires students to contribute to a sustainable energy future. By repeating the workshop at regular intervals, the Göttingen CRC hopes to make a difference in how our society uses and thinks about energy. In the next phase of the CRC, we hope to measure the impact of the workshop using a survey study of participants.

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Educational Connections to Ongoing Research Projects (E-CORP)

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Abstract

The field of environmental education is challenged to look for new ways to develop relationships, partnerships, funding and strategies to further support our role to continuously develop an environmentally literate citizenry. The FAU E-CORP (Palm Beach County, Florida, USA) program is a internationally replicable model that highlights the collaboration between research scientists and environmental education programs by providing curriculum and field experiences to K-12 students. Researchers benefit from education professionals in the field of environmental education developing and disseminating a high quality, mission-driven, standards-based curriculum relating to their research. Drawing on current research in one of the most important lagoons in the US, the E-CORP RESTORE program focuses on the issues concerning fisheries populations and how they are impacted by changes in our natural habitats. During the 2-year pilot, a total of 109 students from three area schools participated in classroom lessons as well as field experience. Through these experiences, students developed an understanding of populations in natural and disturbed areas, and the considerations and actions that must take place for an area to be restored for the benefit of the local environment. Pre- and Post-test data as well as survey data of program outcomes are presented, and the implications of student engagement are discussed.

Keywords: E-CORP; environmental research; collaborative partnerships

1. Introduction

Many studies have demonstrated a lack of student interest in science [1]. Teachers often struggle to convey complicated science concepts to students in meaningful ways that lead to science literacy. However, traditional science teaching methods wherein the teacher presents science content within the confines of a classroom (transmission) can lead to student disengagement [2]. Research suggests that students disengage from school subjects because they fail to see a clear connection between their education and their lives [3] Thus, there is a need for students to see the relevance of science and make connections to the real world. In addition, there is an increasing demand for science, technology, engineering and mathematics (STEM) workers in the United States, yet US student performance in science ranks nineteenth out of thirty-five OECD countries [4]. Consequently, some analysts suggest that the U.S. is on track for a shortage of 1 million STEM workers [5]. In order to ameliorate this situation, various initiatives have been created to engage students in STEM education in the K-12 classroom. These initiatives are designed to familiarize students with the tenants of scientific practice so that they may learn the discipline-focused values of science (such as open-mindedness, objectivity, and accuracy) as well as the norms, values, beliefs, expectations, and actions of scientists [6]. In doing so, the hope is that students will be able to see themselves as the kind of person that could engage in scientific endeavors, think rationally and understand the world scientifically, and therefore be more likely to choose a STEM related career [6].

Shaner *et al*., [7] found that students who engaged with scientists had a more statistically significantly increase in attitudes toward science. Conversely, there is developing requirement internationally for research scientists to develop educational outreach programs (also known as broader impacts) as part of their research proposals [8].

One such initiative that is connecting students and scientists is the FAU Pine Jog Environmental Education Center (FAU Pine Jog)'s ECORP. The objective of this paper is to fully describe this program and the impacts that it had on students.

2. The Program

The E-CORP Restore Program was developed in partnership with Dr. Scott Markwith, Professor in FAU's Department of Geosciences, as part of a 2-year grant with The Curtis & Edith Munson Foundation. Markwith's research focuses on analyzing the habitat use and migration patterns of two game fish, common snook (*Centropomus undecimalus*) and gray snapper (*Lutjanus griseus*), in Lake Worth Lagoon (LWL) and examine the effects of restoration efforts on adult game fish populations.

In 2017-2018, 109 students from three schools (public and private) in Palm Beach County, Florida participated in the program. Classes ranged from 8^{th}-12^{th} grade with approximately 40 students from each school. Participating schools were identified through our existing network of science teachers.

FAU Pine Jog developed a series of in-class lessons and field experiences utilizing the BSCS 5E Instructional Model (2006) as a framework. The program included two teacher-led classroom lessons, a field experience with the grant PI and other professional scientists, and the preparation and presentation of their findings. See Table 1 for an overview of the lessons.

5 E's	Lessons and Field Experience	Lesson Objective
ENGAGE	Faux seining activity & Internet Scavenger Hunt	To introduce students to recent restoration efforts in the Lake Worth Lagoon, some of the fish species found and techniques for calculating the species diversity index.
EXPLORE	Field Experience in the Lake Worth Lagoon (LWL)	Connecting students with the scientists and learning how they conduct research in the lagoon.
EXPLAIN & EXTEND	Preparing PowerPoint Presentation of Research Findings	Analyze the data collected and synthesize the information learned on the field experience
EVALUATE	Final Presentation	Presenting what they learned to their peers.

Table 1. Overview of the 5 E's Lessons developed for ECORP Restore Program

The initial classroom lessons were designed to orient students and introduce them to the concepts they would encounter in the field experience.

In the faux seining activity, students learned about fish diversity. Using a large net fixed with magnets would collect laminated photos of fish which students would identify and then calculate the species diversity index. This activity was followed by an internet scavenger hunt wherein students would learn about the various restoration projects within the LWL.

For the field component, students worked with the scientists to collect data to compare the recently restored area of the lagoon with the degraded and unrestored areas. Data collected included water quality, turbidity, water temperature, and fish species diversity. Fish data were collected using two different sizes of seine nets (70 ft and 600 ft) with different net mesh sizes that are designed to sample different communities and populations of fish. In addition to the PI, Florida Fish and Wildlife Conservation Commission's (FWC) Fish and Wildlife Research Institute provided three scientists for each trip.

After the field portion of the program, students continued back in their classroom to synthesize what they learned by creating a PowerPoint presentation analyzing the field collected data, which was then presented to their peers.

3. Results

The results of this program were evaluated by looking at student knowledge gains from a pre-/post-test comparison, as well as from feedback from a Google Survey. The pre-/post-test was given to the students by their teachers at the start and end of the program in year 2 only. The survey was distributed to students with 102 of the 109 students completing the survey.

The pre- and post-test with 10 questions was implemented to evaluate the learning outcomes for the students who participated in the program. The following chart summarizes the average improvement in test scores between pre-program and post-program delivery. Students who answered the least number of questions correctly prior to the program showed the greatest improvement, averaging an increase of more than 5 correct answers after program delivery.

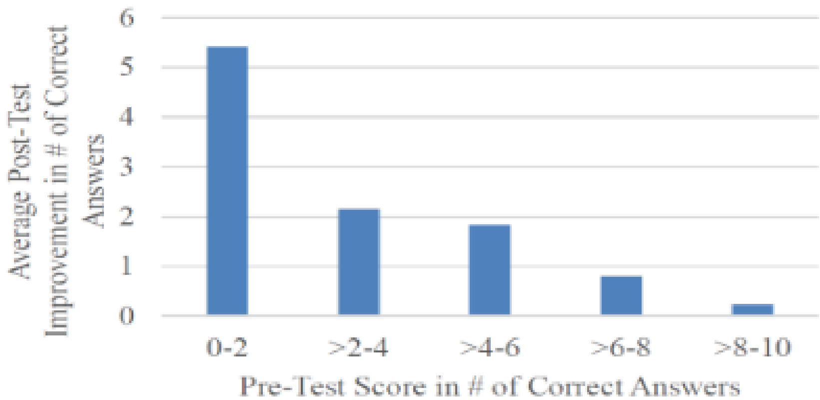

Fig. 1. Average number of correct answers between the Pre- and Post-test

Survey results suggest that students valued the program as shown by their responses to the survey items listed in Table 2. In addition to the pre-/post-test, students were asked what they like best about the program and what their "light bulb" moments were. One of the most common responses was interacting with and learning from the scientists (16). Students had the opportunity to learn from FAU scientists as well as FWC scientists. One student said that they enjoyed talking about potential research opportunities and indicated that they wished to explore them further. Two students also mentioned that they enjoyed hearing about the scientists' career paths. One of those students commented that she really liked sitting with scientists after the large seine to discuss her career and journey in science. Learning about various restoration projects and why they are important was also highlighted by several students (17).

Students also enjoyed the hand's-on field aspect of the experience (20) and liked that they could make the connection between what was learned in the classroom with the activities that they did on the field trip (5). One student said that they liked "being able to see things in the real world rather than just a textbook." Another commented that all of the students were really involved in handling the fish, analyzing the data, etc. "instead of just sitting back and listening to lectures." One student even said, "I loved it so much, I might even consider going into environmental science."

Item	1	2	3	4	5	6
I learned valuable information from the in-class lessons.				15	27	60
I learned valuable information from the field experiences.				3	10	89
The field activities were implemented in an interesting and stimulating manner.				3	14	85
The lessons increased my content knowledge about restoration ecology.				4	22	76
The program provided me with useful information about future career opportunities in science.		1	3	14	17	67
I enjoyed interacting with the scientists.				5	19	78

Table 2. Student feedback from survey regarding the program (n=102) where 1 is strongly disagree and 5 is strongly agree

4. Discussion and Conclusion

The ECORP Restore Program was intended to increase student engagement and interest in science by participating in an authentic science activity, rather than the usual theorized experience that is typical of the science classroom.

Through this program, students drew upon their scientific knowledge to ask scientifically oriented questions, collect and analyze evidence, develop explanations, and communicate those explanations with their peers as well as professional researchers.

By partnering with scientists from local agencies, we were able to provide students access to people that are working in the field on local environmental issues, and enable them to perform tasks as professional scientists would.

Their participation and their willingness to work with the students at no cost to our facility increased our capacity to provide this experience to more students. Students benefited from working alongside the scientists and talking to them about their experiences. Students were exposed to a variety of different types of STEM related careers as the students were able to have informal, candid conversations with the scientists as they discussed their job descriptions and career pathways.

While, many schools have expressed interest in participation in the future, the limitation is the availability of the researchers to interact with the students. Steps are being taken to reach out to other FAU departments that are doing scientific research for potential partnerships. In addition, several large government granting agencies are beginning to require educational components that reach K-12 students as part of their educational outreach (broader impacts). We anticipate that as this trend progresses, there will be more of a need for partnerships such as this one.

Although the first two years of this program was grant-funded, with the proven class-tested curriculum that required minimal management from Pine Jog, the program was able to move to a fee based model in its third year. The program now operates fully supported through fee collection from each school that covers all direct and indirect costs.

This easily replicable model provides opportunities for students that rarely exist in the traditional classroom, yet is called for by numerous studies in student engagement.

The outcomes of this program indicate that the objectives of increasing student content knowledge and engagement in the scientific process were achieved.

Acknowledgements

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H2O to Go! Connecting Youth to Research in Environmental Issues

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Abstract

H2O to Go! is a dynamic residential program in which high school students are immersed in a summer institute of learning that is a highly replicable model. H2O to Go! provides a learning experience focused on studying water-related environmental issues. During a week-long program, students work with scientists and educators in the field of environmental research to learn about the research process and the interconnectedness of South Florida water systems along with the corresponding environmental issues. Connecting students with various research centers and local, state, and governmental agencies that study components of a local watershed (such as the Riverwoods Field Lab on the Kissimmee River) forges an understanding of the system by focusing on the interrelatedness of its parts. H20 to Go! provides a working model for other university, school and environmental center partnerships. The replication possibilities for this model can be applied to any university conducting research on environmental issues. With the increasing competition between universities for quality students, there are significant recruitment gains in opening university opportunities to students contemplating post-secondary education programs. The H2O to Go! presentation will showcase the educational gains and outcomes of the program.

Keywords: H2O to Go!; environmental research; collaborative partnerships

1. Introduction

Water quantity and quality, as in many areas of the world, are two of Florida's most critical environmental issues. The draining of South Florida's fresh water aquifers, the pollution from large agricultural processes such as those involved with citrus and sugar cane farming, and issues associated with septic systems and flooding all contribute to water complexities on which all Floridians should be well versed, but are not adequately addressed in our classrooms [1]. For example, current methods of teaching science generally involve a traditional classroom where students receive often disjointed parcels of pre-packaged content knowledge through direct instruction and planned activities [2]. This approach neglects the need for students to develop a deeper understanding of the practices of science, and how practicing scientists do their work, and often can alienate and disengage students. The challenge lies in finding ways to both build students' environmental literacy and potentially cause shifts in cultural beliefs and practices that may be required if the goals of environmental education are to be realized. Since the mid-1990s, an educational approach called Place-Based Education (PBE) has been attempting to achieve just this by directing at least part of students' school experiences to local phenomena ranging from culture and politics to environmental concerns and the economy. Emphasizing hands-on, real-world learning experiences within a context that students are familiar with, this approach to education increases academic achievement, helps students develop stronger ties to their community, enhances students appreciation for the natural world, and creates a heightened commitment to serving as active, contributing citizens [3]. Community vitality and environmental quality are improved through the active engagement of local citizens, community organizations, and environmental resources in the life of the school [3]. PBE provides opportunities for students to think independently (inquiry), collect, analyze, synthesize and evaluate information (data), address community concerns (civics) and create knowledge and solution-based ideas (innovation). PBE pedagogy shifts the process of knowledge transfer from a linear process (sage to student) to a team of collaborative learners engaged in inquiry based learning [4]. The internalization of the inquiry process embedded in PBE results in learning how to think as opposed to just learning content or what to think. PBE learning is process based. A process that formulates questions, tests solutions and assesses results.

Recently, Florida Atlantic University's Pine Jog Environmental Education (FAU Pine Jog), one of the oldest environmental education centers in the US, completed a strategic planning process resulting in new program directions. One conceptual shift is the connection of environmental education programs to ongoing environmental research projects. In this shift, a cadre of new programs was created that emphasize strong academic learning, create lasting social relationships and immerse young learners in the natural environment in which environmental research is being conducted. FAU Pine Jog refers to this model of programming as Academic Social Immersion (ASI); a model built on the pedagogy of Place Based Education (PBE).

The goal is not only to deliver a strong environmental education program designed to increase environmental literacy and change behavior and attitudes but also to connect participants to each other and to field-based professionals working in E-STEM fields. Research shows that residential EE programs provide greater gains in students' environmental literacy than a classroom experience [5, 6]. The immersion of students in such a program can demystify the college experience and provide opportunities of access to educational avenues previously undiscovered. Most importantly, scientists have the opportunity to share their passion with the next generation, increasing the probability of future interest in the work to which they have dedicated their lives.

This model differs from other residential immersion summer camps by combining "fun" outdoor experiences such as kayaking and snorkeling with scientific inquiry activities alongside professionals in the field.

2. The Program

The H2O to Go! Program is a partnership between Pine Jog Environmental Education Center (FAU Pine Jog) with Harbor Branch Oceanographic Institute (HBOI) and the Florida Center for Environmental Studies' Riverwoods Field Laboratory (Riverwoods). The purpose is to provide a unique learning experience in environmental issues investigation for high school aged students from South Florida school districts based on research being conducted in these university research centers. This program looks at connections between fresh and salt water systems and the impact of humans on both. During this week-long residential program, students work side-by-side with scientists who are working in the field of environmental research to learn about the research process, how scientists do their work and the interconnectedness of South Florida water systems and the environmental issues facing them. All of the activities are designed to heighten awareness and provide knowledge as to the complexity of challenges South Florida faces in dealing with the protection of our water resources.

This awareness and knowledge serves to inspire more responsible personal behavior as it relates to personal water stewardship and the protection of water resources.

All students who participate in H20 to Go! earn dual-enrollment credits with FAU.

During the five day, four night residential experience, students meet researchers, scientists, professors and educators at the following locations:

FAU MacArthur Campus: Students are based at the FAU MacArthur campus in Jupiter, Florida, where they are introduced to the basics of Everglades Ecosystems and the historical alterations that have affected them. Topics include geology and hydrology, endangered species, chemistry and restoration of this unique watershed.

Each day participants are transported to specific Everglades research areas or to relevant university or environmental agency sites.

FAU Riverwoods Field Laboratory: Students are immersed in wetland ecology, learning about the Kissimmee River restoration project and native flora and fauna.

Aboard the Kissimmee Explorer, a 20 passenger pontoon boat, students work alongside trained scientists and researchers to participate in educational activities that focus on real life research on the historic and restored river and watershed. Students learn how to test water quality parameters including dissolved oxygen, pH and clarity.

They also learn how to identify native and exotic wetland plants. In addition, by conducting diversity and abundance bird surveys, students track and identify native wetland birds that have returned to the restored Kissimmee River.

FAU Harbor Branch Oceanographic Institute: Students work with HBOI research scientists and engineers who are working on coastal ecosystem health research, sea-life, aquaculture, and most recently the production of electricity utilizing electric generators powered by the movement of ocean currents. Topics include research projects on the conservation of land and environmental issues facing the Indian River Lagoon, and an understanding of how to provide solutions to related environmental problems in our community.

Arthur R Marshall Loxahatchee National Wildlife Refuge and Grassy Waters Nature Preserve: Students compare and contrast the aquatic environments while continuing further data collection via canoe and kayak expeditions. This further develops understanding of this delicate ecosystem in the heart of Florida. Students have the opportunity to meet with lead scientists from the South Florida Water Management District who introduce them to LILA (the Loxahatchee Impoundment Landscape Assessment) Living Laboratory to learn about cutting edge research on wetland systems.

During the week, students keep a field journal in order to keep notes and process the information that they have learned each day. As a culminating project, students prepare a 20-30 slide powerpoint presentation on what they have learned, which they are required to present to a local community group or to other students within their school.

3. Results

All students in the program are required to complete a pre-test prior to program implementation and a post-test upon completion of the program. Of the participants in the 2018 program (n=123) only one scored a passing grade (<60%) on the pre-test and the class average was 14%. However, by the program's completion, less than one week later, all but 3 students earned a passing grade. More than half of the students (n=63) scored greater than 90% on the post-test, with a class average of 87%.

In addition to the pre- and post-test, students completed a feedback survey.

Survey results suggest that students valued the program as shown by their responses to the survey items listed in Table 2.

Table 2. Sample of feedback from student survey regarding the program (n=121) where 1 is strongly disagree and 5 is strongly agree

Item	1	2	3	4	5
I learned valuable information through this course.	0	0	1	26	94
The course topics were facilitated in an interesting and stimulating manner.	0	0	8	49	64
I would recommend H2O to Go! to fellow students.	2	1	5	18	95

In the qualitative section of the survey students indicated that earning college credit and exposure to scientific research were two main motivators for enrolling in the program. Making friends was the next most often reason cited for enrolling.

When asked what part of the program they enjoyed the most, common answers were learning about Florida environmental issues and gaining real-life experience with environmental studies.

4. Discussion and Conclusion

One of the main goals of H20 to Go! is to connect student learning to the place in which students live. In 2000, the United States Congress enacted the Comprehensive Everglades Restoration Plan (CERP): the largest hydrologic restoration project undertaken in the United States and possibly the world. CERP will result in a demand for related environmental occupations and researchers. With the Everglades in their backyard, students are making the connections between academics and the world around them.

As was evidenced by the scores on the student pre-tests, students knew very little about the basic workings of Florida's water systems and the environmental issues that face them, prior to participating in the program. The improvement in the scores for the post-tests attest to the success of this program.

This success has led to program replication with additional courses, all of which are fee-based covering both direct and indirect. FAU Pine Jog now offers *H20 to Go! Restoration* in which students focus more on restoration projects underway in South Florida, and *H20 to Go! Sea Level Rise*, in which students learn about the risk that our coastal communities face as a result of rising sea levels due to climate change.

While FAU Pine Jog's H20 to Go! programs focus on environmental issues in South Florida, the success of this program illustrates the value of replication to focus on any local environmental or science issues.

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Since and Nature

Teaching Evolution with Austrian Biology Textbooks

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Abstract

Evolution is the central theory of biology; therefore it should be used as a guiding idea in biology school textbooks to construct meaningful learning progressions for the students. This study is a qualitative follow up study with the focus on two widely used biology textbook series in lower and upper secondary schools in Austria. In the previous study 63 biology textbooks of 17 available textbook series were analyzed. Two exemplary results there were the sloppy use of "adaptation" as one of the most common terms with and without evolutionary context. The other one is the nearly complete absence of the term and the concept of "population". The main research interest in the present study was the following: how are the evolutionary concepts in the textbooks linked to each other horizontally (within one textbook) and vertically (between textbooks of different grades of the same series). The coding was guided by a concept map which linked the core evolutionary concepts (like variation, selection, population etc.). We started with the NGSS strandmaps as potentially meaningful learning pathways to construct the concept map. This concept map was then the guideline for analyzing first and then depicting the results from grade 5 to 12. One exemplary result is the prevalent fragmentation of the concepts during the compulsory school years. Especially in lower secondary grades only artificial selection is presented in a satisfying manner, all other concepts occur occasionally but not linked to each other or are totally left out (e.g., population). Another result is the misleading presentation of natural selection. The fact that natural selection selects at the individual level but the results can only be seen at the level of populations over the generations is not represented; the causes and effects are mixed up. This is problematic, because adaptation is very often seen at an individual level – this is a prevalent teleological and anthropomorphic student's concept and the textbooks even strengthen this concept instead of opposing it.

Keywords: Evolution, Biology textbook analysis, Austria, learning progression, concept map

1. Introduction, Theoretical Background and Research Aims

Evolution education, which includes teaching and learning about evolution, is very demanding for all involved: teachers and learners. Moreover, as it is a theoretical pivot point of modern biology and therefore key for understanding biology as a scientific discipline, a lot of biological phenomena and processes, can only be understood with evolutionary background knowledge [1]. Textbook in schools are an important source for learning, it is even said that textbooks are the secret curriculum [2]. But how can textbooks help in learning evolution? A few studies at hand [3, 4, 5, 6] showed several findings for different countries. Some of the studies found out that evolution is often treated in an isolated way [3, 4, 5] a resulting critique is that evolution cannot serve its universal function of an explaining theory. In Austria the curriculum in secondary schools mentions evolution only twice [7, 8, 9], nonetheless in an analysis of the most common textbooks (63 books from 17 series) it could be shown, that books can compensate this lack of the curriculum, although they create other problems [8]. For example the use of the concept of adaptation was found highly problematic as well as the population concept, which was found very seldom and fragmented itself [8].

This study is a follow up analysis where two textbook series from lower and upper secondary schools that are most commonly used were analysed in a qualitative study for the coherence of the topic evolution and its single concepts.

1.1 Learning Progressions

Textbook analysis can be done in many ways. This contribution follows the theoretical background of learning progression (LP) [10, 11, 9]. In this framework for LPs cumulative learning means gradual cognitive development of conceptual knowledge. As evolution is not only one concept but encompasses several interlinked concepts (population, reproduction, heredity, variation, different forms of selection, time) coherence of learning content and the sequence of the single concepts play an important role for possible learning pathways [12]. In a carefully planned LP about evolution learning can take place by learning this related set of concepts step by step over the years. One good source of LPs for a lot of science topics are the so called strandmaps, which were developed after the release of the “Next Generation Science Standards (NGSS)” in the United States [13]. Therefore it is important to look at textbooks whether the single concepts are linked horizontally (within one textbook) or vertically (between the textbooks of the different grades) to get an impression of textbook coherence [14].

Our research aim is to deepen the knowledge about the coherence of the concepts and the overall topic of evolution within two selected biology textbook series for lower and upper secondary schools.

2. Material and Methods

A previous study took 17 biology textbook series with 63 textbooks and made a qualitative content analysis with predefined categories which were the central concepts of evolution [8]. For the recent study two series [15, 16], with seven textbooks each, were selected. Criteria were that the series includes lower and upper secondary grades and that these books are widely used. In Austria the two chosen are under the three mostly used series in the whole secondary level [17]. In the 11th grade in most school types there is no biology taught, therefore there are no textbooks available. Overall the methodology followed the procedure of a study of Roseman *et al.*, [12]. The topic analysed is arranged in a hierarchical concept map following the logic of a LP, where the single concepts are linked for coherent and assumed learning pathways. For the analysis of evolution in those biology textbooks the categories of the previous study [8] were taken and the corresponding strandmaps of the NGSS [13] (“heredity” and “biological evolution”) were used to construct a concept map as a blueprint for analysis, applied as steps of a qualitative content analysis [18]. Additional information came from literature about learning evolution to create a sequence of concepts. This concept map (see Fig. 1 in the results) was then applied to each individual textbook and only appearing concepts and the respective links were left, all others were deleted. One coding entity was the whole concept, not only the single words without evolutionary context. Therefore each resulting concept map shows the treated concepts of the respective grade.

3. Results & Discussion

3.1 Learning Progression of Evolution – the tool for analysis

In Fig. 1 (see below) the concept map is shown. The concepts were translated and simplified for this contribution. In the original map the concepts were coloured and their links are displayed with arrows. Those arrows show the planned direction of LPs.

The two broken boxes frame those concepts where the concept of “deep time” (outer box) is crucial as well as the inner box, which stands for processes within populations.

This concept map helped to structure the single concepts found in the textbooks and made visible whether they were linked or not. A colour coding system (not showed in this contribution) made it possible to combine the concepts into one overview to make repetition of one concept in consecutive textbooks visible.

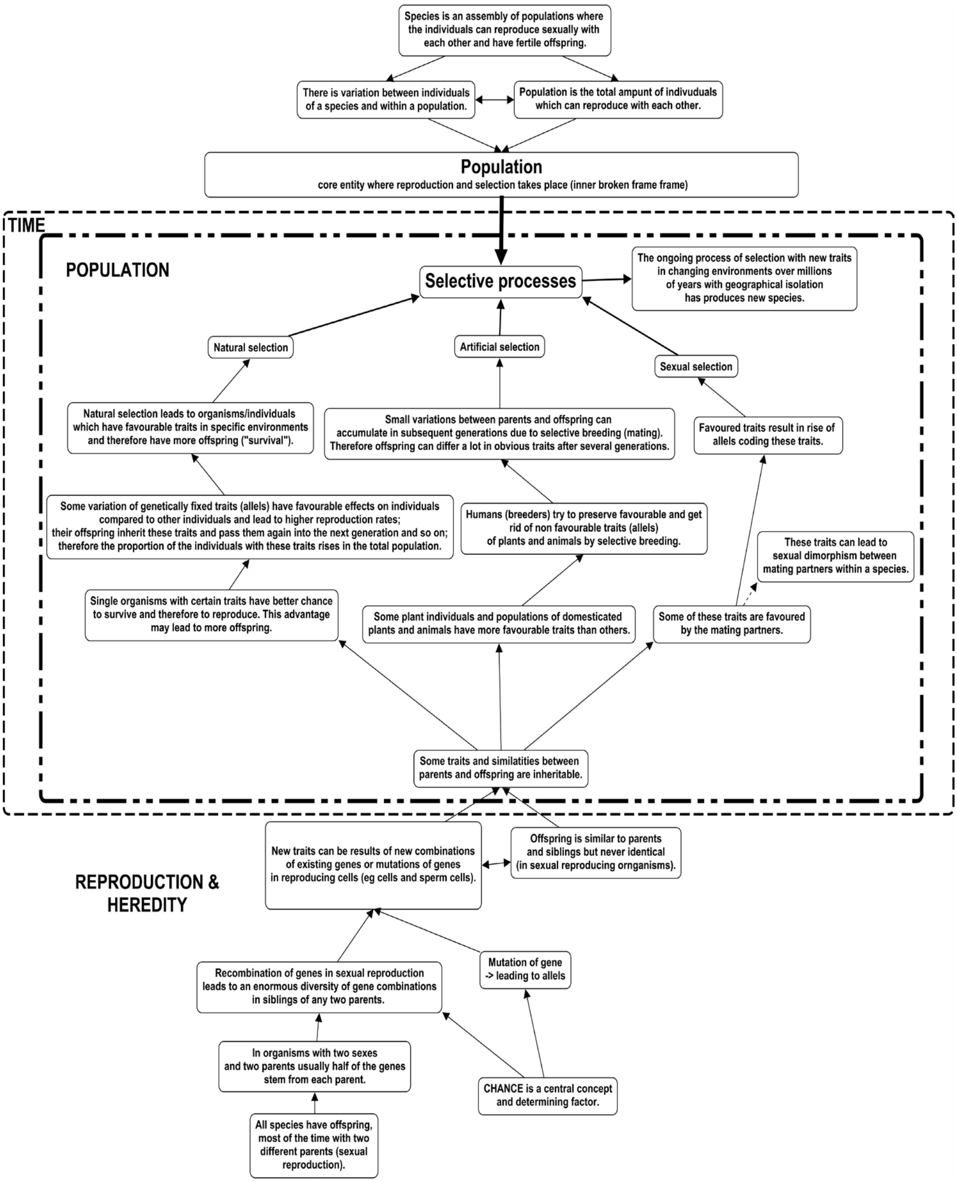

Fig. 1. Learning Progression for Evolution.
The concepts are linked in a hierarchical scheme.

3.2 Exemplary Results and Discussion

The concept of time was not well represented in the textbooks. Only a few times and associated with small concepts (e.g., artificial selection) this issue was explicitly mentioned in one series [16], while it was more included in the other series [15], but mainly in upper secondary grades. In both series are the huge time spans really applied in grade 12, only at the end of the school career. In an overview of the five textbooks of compulsory schooling (in Austria up to the age of fifteen or grade 9) this can be seen, because time issues are only broached along two small concepts dealing with artificial selection in grade 5 and 7 [16] and respectively 5, 7 and 8 [15].

Big numbers and time spans are difficult to grasp, especially for young students.

Therefore many different representations and repeated inclusion should be made to consolidate this important aspect for evolution processes.

Another finding is the fragmented and missing concepts around reproduction and heredity. In the LPs these concepts are located at the bottom, because they are the cause for variation, different reproduction rates and therefore basis for population thinking. Linked with the time aspect, the thinking in generations is the foundation for population thinking. In both series [15, 16] most concepts about reproduction are tackled only once (mainly in grade 7) and remain isolated with respect to evolution.

Only in grade 10 and 12, again very late, these concepts are dealt with in context of evolution. This is an aspect with high potential of improvement, because reproduction is a common everyday process for humans, pets, and plants with a lot of possible opportunities for experience for the students. Therefore these concepts could easily be integrated with artificial selection and therefore used for evolution education.

One further aspect is the topic of population related concepts. This concept is hard to grasp for students [9] and not widely included in Austrian biology textbooks [8].

Population concepts are not well represented in compulsory schooling grades in both series and not linked to evolutionary concepts. Also in both series in lower secondary texts use singular when writing about animals, therefore student thinking cannot be developed into the direction of population thinking or even previous students' conceptions consolidate (e.g. typological thinking, where individuals are not recognised as individuals and all are the same, therefore build an entity, the species). This finding links to the previous findings [8] that natural selection has its effects at an individual level (see above) and therefore leaves out population and generation thinking. Another aspect is the mixture of the biological term population and the everyday use with respect to human population. Even the books mix both meanings and therefore cannot help learners to develop sound understanding about populations. Again, definitions and evolutionary context is only built up at the end of the school career.

Concluding remarks: the only topic which is widely represented in the textbooks is artificial selection, while sexual selection is found very scarce. It can be inferred from the results, that learning about evolution with the textbooks is only possible in aspects; at the moment the teacher has to compensate a lot for the learners. Whether this is possible and done in evolution education in the schools is left open. The method we applied was very informative about our focus evolution and with reference to our aim, to get systematic insight into textbook coherence. Other topics could as well be analysed with this approach, to get wider and deeper information about textbook coherence in complex biological topics.

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Science and Society

Creating Better Science General Education Courses through a Comprehensive Curricular Redesign

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Abstract

The higher education landscape is changing rapidly in in the United States, requiring educators to respond to external and internal pressures. This presentation documents the multi-year process of re-aligning curricula across the University to create a cohesive and coherent educational experience for students that is outcomes-based and measurable. The General Education (GE) curriculum was the perfect place to start the University's move towards effective and distinctive programming as it crosses all school and departmental barriers, is the foundation of all curricula, and allows for cross-disciplinary, collaborative efforts. In this university-wide realignment, all elements of existing curricula were examined and redesigned, foregoing isolated approaches in favor of integrating skills such as writing, quantitative reasoning, and oral communication holistically in a scaffolded manner. Through this process we redesigned the Science curriculum in the GE program; it now meaningfully aligns with the University's mission and institutional learning outcomes. The faculty considered recent trends in GE curricular design which included outcomes-based course design. This approach ensures that learning outcomes shape the course content and that competencies are taught through assignments aligned with the outcomes. The missions, values, and traditions of the University were used as a design framework for curricula that met the diverse needs of a 21st century demographic. This approach values preparation for both immediate career goals as well as lifelong learning and wellbeing. Thus, faculty adopted learning outcomes to expand the traditional scope of science GE courses; these now include the application of disciplines to illustrate connections among science, technology, and society. Furthermore, all aspects of the curricula were designed to address diversity in terms of issues related to difference (such as race, culture, gender, class, sexuality, etc.) and to ensure that course assignments and evaluative criteria are equity based, which had not previously been addressed in curricular expectations. As universities nationally and worldwide struggle to reinvent themselves in challenging political and economic times, the takeaways from our recent self-evaluation and subsequent redesigns are topical and timely.

Keywords: Curricular Redesign, General Education, Science and Society

The landscape of American higher education is experiencing internal and external pressures rooted in well-studied and documented factors, including demographic changes and shifts in the desired outcomes and concerns of students and parents affected by a recent recession. Institutions of higher education – whether universities or colleges, public or private, open-access or selective – are compelled to offer a curriculum that provides students with the job-focused skills and the intellectual tools that allow them to succeed both in their immediate future's career goals, as well as in rapidly changing professional landscapes in their more long-term future. This curriculum must be adaptive and forward-facing, while true to an institution's traditions and mission. The latter is of special significance as many small institutions strive to be distinctive in an increasingly competitive educational environment. As a response to these pressures and to ensure relevance and competitiveness, Dominican University of California (Dominican) decided to address the multitude of challenges through a comprehensive curricular redesign over the last two years, using the General Education (GE) program as the catalyst.

The GE program is the common curriculum that creates the focus of learning for all students in most U.S. American institutions grounded in the notion that higher education be broad enough to address the common good; at Dominican, it was the natural place to start such an effort as it is a distinctive aspect of the University's programming. All students entering the university as first-year students are required to fully participate in it; thus, it has the ability to shape a university-wide educational experience while offering the opportunity to teach and reinforce skills and intellectual approaches throughout a student's years. Furthermore, all of the schools and departments participate in this curriculum, so the effort of redesigning this foundational programming has the added benefit of bringing all faculty together in a collaborative effort.

Dominican's curriculum redesign was a two-year process, initiated through a year-long self study process by faculty and direct assessment of student work in addition to surveys and focus groups concerning the existing GE curriculum. The process was then completed with an external review which included conducting on-campus conversations with administrators, faculty, and students. The results, documented in a report and shared with the entire campus community, indicated that the curriculum should focus on being more coherent and suggested two strategies for implementation: one option focused on using the integrative efforts already underway at Dominican; the other option suggested the creation of themed tracks. Ultimately, the Dominican faculty deemed the latter approach one more suited to a large institution and opted to proceed with the former strategy with its focus on creating a new curriculum that would be aligned with its Institutional Learning Outcomes (ILOs) and measurable.

The Institutional Learning Outcomes (ILOs) are intended to permeate all curricula have the four broad goals of:

1. The Exploration and Acquisition of Knowledge
2. The Development of Intellectual, Professional, and Artistic Skills
3. The Practice of Civic Skills and Social Responsibility; and
4. The Cultivation of Well-Being

To allow all four ILOs to be holistically woven into the entirety of the curricular experiences (though not all four components are required appear in each course or curricular activity) it was essential that all elements of the existing curricula be examined and redesigned simultaneously. One key advantage to undertaking a broad curricular redesign was the opportunity to meaningfully integrate skills such as written and oral communication, information literacy, quantitative reasoning, analytical thinking, and the exploration of relevance and meaning across the disciplines. The design approach shifted from a content-based distribution model to an outcomes-focused backward design process. Thus, the GE curriculum came to meaningfully align with the institutional learning outcomes and the University mission by ensuring that outcomes and competencies in each class are attained through the embedding of assignments aligned with the intended outcomes. It was re-visioned as a Core Curriculum.

This re-visioning of pedagogical goals addressed the concern of students (as determined by the self-study) that their GE classes be 'applicable' and 'relevant' to both their present lives and issues, as well as their future career paths. In particular, there was an emphasis on ensuring that students should be prepared to be active, thoughtful learners who have the background and tools to engage with a complex, ever-changing world. In the sciences, this meant pivoting to move courses away from the traditional approach that saw a GE offering as a mere introductory course to a major or discipline to one that is purposefully designed as an opportunity for students to apply their newly acquired knowledge and skills to relevant inquiries in their own intended career as well as to complex issues in the greater world. To foreground this important change, the title of this component of the GE program was changed from Natural Sciences to Science for Global Citizens.

To implement this new focus, an appointed small faculty group, the Science for Global Citizens GE Redesign Subgroup, articulated three specific outcomes to be met by prospective courses in order to be included in the GE curriculum. Two of the outcomes are typical of a science curriculum: the first focuses on laboratory and hands-on explorations of the science to observe and collect data, and the second focuses on the analysis, evaluation, manipulation and interpretation of data. However, the third outcome is indicative of the shift away from existing approaches. This outcome expands on the fundamental principles of the discipline by requiring that the course highlight and illustrate the discipline's approach to making connections between the science, its application to technology and technological advances, and its relevance and importance to society.

The original traditional outcomes had been designed to address two key ILOs: 1) The Exploration, and Acquisition of Knowledge; 2) The Development of Intellectual, Professional, and Artistic skills. The former had been met through the metric of increasing students' breadth of knowledge; the latter had been met by focusing on critical thinking, qualitative and quantitative reasoning and information literacy. Now the understanding of both of those ILOs was expanded while the third and most unique ILO was addressed in the new Science for Global Citizens curriculum: The Practice of Civic Skills and Social Responsibility. This now encompasses a commitment to sustainability and social justice. Making sustainability and social justice a required focus of the program and its courses has required science faculty to redesign their classes to have these topics holistically embedded in their assignments and activities, which is a significant change from more traditional, introductory classes.

These new Core Curriculum courses were developed according to the principles of backward design in addition to being student-centered in their design. They began by identifying how they would address each of the ILOs as encapsulated in the new Program Learning Outcomes (PLOs). The new outcomes also daringly foregrounded the third ILOs and read:

Students will:

1. Examine and apply the fundamental principles of the scientific discipline (true for each course) in a manner that illustrates connections among science, technology, and society;
2. Engage in the scientific method through laboratory and fieldwork to examine key elements of the science and conduct independent exploration, using observational and direct measurement techniques for primary data collection;
3. Analyze, evaluate, manipulate, and interpret data to draw conclusions.

The expectation was that the learning outcome would shape course content and that assignments would be created to develop competencies in alignment with the outcomes and permeate the course. For each course, professors needed to indicate how the ILOs would be addressed using learning strategies (such as course themes, texts, and activities) and how graded assignments would be used to scaffold and assess learning as they related back to the ILOs.

As one of the motivating factors driving this university-wide curriculum change was an understanding that the demographics and needs of students in the United States is rapidly changing, it was essential that the new curricula directly address diversity and equity issues. As courses were proposed for inclusion in the newly designed Core Curriculum, professors were required to indicate how they would help students develop subject specific knowledge and skills about issues related to differences in race, culture, gender, and class, identifying instructional strategies for diversity and equity that would be implemented both in the classroom, and would be specifically integrated in assignments and evaluation to further support diversity and equity.

The end result of these changes is a university-wide science Core program that is more robust, inclusive, and relevant to the people it serves, which is the population of students who have chosen to not study science as their primary field. By putting all aspects of the curriculum on the table and adopting a larger, holistic redesign program rather than a piecemeal one, the resulting product has more cohesion, a shared vision and purpose, and is part of a strong, uniform backbone, i.e., Core Curriculum that the other university programs and disciplines can rest on and use as support or foundation. By looking at the needs of the faculty and students and anticipating how those needs might change as the educational landscape changes, we have built a bold, innovative, comprehensive new science curriculum for a changing world.

Development of STEM Outreach Material that Incorporates Argumentation for Science Classrooms

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Abstract

The main goal of this project is to merge best practice in STEM outreach/informal/non-formal education and argumentation research to create an effective programme for teachers and outreach practitioners. This is due the fact that many outreach activities to date have limitations that prevent successful development and implementation from both parties [1; 2]. The majority of STEM education research is carried out within the formal learning environment. The OECD [3] describe formal learning as an intentional, organised event, with learning objectives. This project is a shift away from curriculum-based education, however, that is not to say that the educational experience cannot be linked to the curriculum. The rationale for using argumentation is largely due to the fact it is recognised as one of the four key areas required to improve scientific literacy. The use of argumentation practices in education can help improve critical thinking, higher order processes and public reasoning on top of numerous other skills [4]. Thus, developing the use of argumentation in STEM outreach programmes should help foster more expansive and joint pedagogical approaches by teachers and outreach practioners alike. This paper will focus on the development and trial of an outreach lesson that will incorporate argumentation techniques [5]. This study took place in Irish classrooms and utilised information from both in-service Science teachers and STEM outreach providers.

Keywords: STEM Outreach, Argumentation, Science Outreach, discourse

Introduction

Science Outreach in Education

Outreach programmes are unique in the fact they can take place in formal environments, while also taking place in non-formal and informal settings, depending on the goal of the programme [6]. Although formal schooling is the main provider of educational experiences, the informal education sector can be a critical element of STEM education [7]. This places emphasis on the importance of creating mutually beneficial material for outreach practitioners and the formal education community. The main aim of science outreach and engagement is to “increase the size and diversity of the science workforce” [2, p. 49]. It is an essential part of building scientific literacy and a crucial way to keep future scientists interested in a subject. The overall intention of outreach is assisting in the important growth of social and economic development in

Ireland [8; 9]. Walker [10] has described science outreach as a way of improving the recruitment and retention of pupils, while also recognising its importance for promoting the vulnerable physical science subjects. Universities and additional organizations have realised the impact outreach can have on Primary and Post-Primary pupils through improving pupil engagement and acting as a direct support for education in the classroom [11].

Table 1. Key contributors in STEM outreach in Ireland [adapted from 12]

Contributor	Key Characteristics
STEM Outreach Practitioner	• Motivate pupils • New learning experience • Select content • Engage • CPD for Teachers
School Staff Member/ Teacher	• Select suitable content • Select suitable activities for classroom • Select pupils • Select time frame
Pupils	• Participate • Engagement • Motivation towards STEM

Outreach involves many different stakeholders (Table 1), all of whom have similar, yet different aims in relation to areas of study, overall goals and funding opportunities.

Many science outreach providers are looking to expose pupils to areas that they may not have experienced at school [13].

What is Argumentation

Argumentation is an instructional approach, and an educational goal for science education [14]. It utilises evidence-based justification of knowledge and claims and supports reasoning across all STEM domains [15]. It can be described as a discourse through which arguments are constructed and evaluated using evidence, justifications, and rebuttals [15]. An effective science education programme enables a pupil to apply their knowledge and understandings of science in real-life situations based on public issues [16].

Argumentation is considered as a key pillar of developing scientific literacy, due to the fact it entices pupils to develop their critical thinking and communication skills [15; 4]. In recent times, argumentation has become an important process in science education practices in Ireland. It has been included in the new Junior Cycle curriculum, as one of the eight key skills being promoted to improve student's literacy. The key skill involves being able to "plan, draft and present scientific arguments, express opinions supported by evidence, and explain and describe scientific phenomena and relationships." [17, p. 8].

The importance of incorporating argument, critical reasoning and nature of science has been highlighted by the research [5]. Concentrating on incorporating argumentation practices into science education allows students experience science as it is [5]. Scientists are aware that arguments are key elements in the process of convincing the scientific community about their findings [18], however, it often gets lost in science education [16]. It is recognised that argumentation has significant relevance on the development of our future citizens, as everyone must make personal and ethical decisions about a range of socio-scientific issues at some stage [19]. This leaves an opening for a framework to be developed and utilised.

Science outreach has a long history of working with schools to improve both, participation in science and scientific literacy [8]. As argumentation contributes to the development of the student, there is an opening for this pedagogy to be used effectively in the development of material. This research will aim to bridge the gap between informal/non-formal and formal learning through developing a defined pedagogical approach aimed at meeting the goals of both sectors.

Methodology

The initial information that guided this research involved outreach providers participating in a baseline questionnaire. they were selected using information from a previous study in Ireland [8], in addition to an in-depth search of new and recently formed research centres and outreach providers was carried out by the researcher.

A sample size of ~60 STEM Outreach Providers in Ireland were contacted by an email which contained the details of the study, and the requirements involved for participation.

Once the questionnaire was completed and analysed both outreach providers and teachers were contacted to take part in the semi-structured interviews. An email was used to recruit the participants. In total, there was ten participants five teachers and five outreach providers. The outreach participants were selected at random from this pool of people who took part in the questionnaire. There were five participants, one male and four females. The participants were located across different regions of Ireland including the South-East and the South-West of Ireland. The teachers had previously been in contact with the researcher and came from a variety of schools including vocational, community college and voluntary. One male and four female teachers took part in the project with varying levels of experience.

Development of Activity

The outreach providers questionnaire provided some key insights to Questionnaires were sent to 59 outreach providers, and 30 (51%) replies were obtained. In terms of developing material, each outreach provider is going to have their own desired goals.

These goals will be dependent on their funding bodies, area of interest and the target group of the project. However, one of the questions to the outreach providers was about the provision of guidelines when developing the material. This yielded some interesting results as 63% (n=19) of the participants stated they have guidelines to follow, while the other 37% (n=11) did not have guidelines to comply with. This allowed for the activity to be open when in development.

On top of the questionnaires both outreach providers and teachers were interviewed. The interviews outlined certain themes that had to be dealt with which are outlined below in table 2.

Table 2. Key themes from interviews

Key challenges Identified in Cycle 1	Design Solutions Implemented for Design of resource:
Teacher self-efficacy	A teacher information sheet was placed at the beginning of each lesson to give them an insight in to the area and allow them to improve their knowledge.
Teacher Questioning	Have both lower and higher order questions for the teachers. This will allow them facilitate the class.
Real-life contextualised science	Each lesson related to research currently taking place In Ireland.
Curriculum and time constraints	Related all lessons to the new Junior Cycle Learning Outcomes/ Transition Year. Or Leaving Certificate curriculum.
Lack of goals	Clear outline of what is happening and what the pupils will know at the end of the activity. Learning objectives clearly defined.

With these themes in mind 6 topics were chosen based on Irish research, each lesson was developed under many different headings including and outline of the lesson, key questions, type of argumentation activity and a student hand out. Table 3 below shows an example of how we linked all the information together.

Table 3. Sample Activity.

TITLE	Outreach Topic	Brief Outline:	Irish Research Link	Argumentation Activity
Spot the difference	Graphs and spectrometry	Discussing how variances in graphs and results can differ.	Spectroscopy in a Suitcase (SIAS) – numerous outreach visits per year.	A common point of argument for scientists is when data are inconclusive and can support two or more views about their interpretation. How does one resolve the situation where there are many varying measurements of the same phenomenon

Future Work

Data analysis is currently being carried out all information gathered from the lesson implementation.This will inform the next phase of the project.

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International Funding Programmes for Scientific Research and Science Education

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Abstract

The European Commission, through different funding Programmes provides opportunities to enhance international cooperation in Science education, training, research and innovation. The Europe 2020 strategy provides the background to the current European funding Programmes.
The main two funding Programmes offering lecturers and researchers opportunities to finance their scientific research, the implementation of innovative educational strategies as well as opportunities for career development are the Erasmus+ and the Horizon 2020 Programme.

Keywords: International Cooperation, Science Education and Research, International Projects, Erasmus+, Horizon 2020

The Political Framework

Europe 2020 is the growth strategy of the European Union that aims T creating the conditions for a smarter, sustainable and inclusive growth. Five key targets have been set for the European Union to be achieved by the end of the decade. These are:

1. Employment (75% of the 20-64 year-olds to be employed).
2. Research and development (3% of the GDP to be invested in Research & Development).
3. Climate change and energy sustainability (greenhouse gas emissions 20% – or even 30%, if the conditions are right – lower than 1990); 20% of energy from renewables; 20% increase in energy efficiency
4. Education (reducing the rates of early school leaving below 10%. At least 40% of 30-34–year-olds completing third level education)
5. Fighting poverty and social exclusion (at least 20 million fewer people in or at risk of poverty and social exclusion).

The Europe 2020 strategy is structured in seven main priorities and the initiatives to be implemented to achieve the planned benchmarks: innovation, the digital economy, employment, youth, industrial policy, poverty, and resource efficiency.

More information on Europe 2020 can be found at: https://ec.europa.eu/info/strategy/european-semester/framework/europe-2020-strategy_en

Erasmus+ Programme

Erasmus+ is the European programme for education, training, youth and sport. The aim of the Erasmus+ Programme is to contribute to the achievement of the objectives of the Europe 2020 Strategy, as well as of the objectives defined within the strategic framework for European Cooperation in Education and Training (ET 2020).

In order to achieve the mentioned objectives, the Erasmus+ Programme implements the following Actions:

KEY ACTION 1 – MOBILITY OF INDIVIDUALS
This Key Action supports:

- **Mobility of learners and staff** provides opportunities for students, trainees, young people and volunteers, as well as for professors, teachers, youth workers, staff of education institutions to undertake a learning and/or professional experience in another country;
- **Erasmus Mundus Joint Master Degrees** supports high-level integrated international study programmes delivered by consortia of higher education institutions worldwide;
- **Erasmus+ Master Degree Loans** offers loans guarantee schemes backed up by the Programme to be used by students to follow abroad for a full Master Degree.

KEY ACTION 2 – COOPERATION FOR INNOVATION AND THE EXCHANGE OF GOOD PRACTICES
This Key Action supports:

- **Strategic Partnerships** aimed to promote innovation, exchange of experience and know-how between different types of organisations involved in education, training and youth.
- **Knowledge Alliances** between higher education institutions and enterprises aiming to foster innovation, entrepreneurship, creativity and multidisciplinary teaching and learning;
- **Sector Skills Alliances** involving VET institutions and companies in the analysis and anticipation of job market and specific economic sectors needs in order to delivery joint vocational training curricula, programmes and innovative training methodologies;
- **Capacity Building** projects promoting the cooperation between European and partner countries to support modernization and internationalization processes of Higher Education institutions and systems.

KEY ACTION 3 – SUPPORT FOR POLICY REFORMS

- **Structured Dialogue** taking the form of meetings, conferences, consultations and events promoting the active participation of young people in democratic life in Europe.
- **Partnerships** to explore and develop proposals for systemic reforms in the field of education and training

JEAN MONNET ACTIVITIES

- **Jean Monnet Activities** support excellence in teaching and research in the field of European Union studies worldwide.

SPORT ACTIONS

- **Collaborative Partnerships**, aimed to combat doping at grassroots level, to fight against match-fixing, to contain violence and tackle racism and intolerance in sport.
- **Not-for-profit European sport events**, granting individual organizations in charge of the preparation, organization and follow-up to a given event.

The Overall Budget for the Erasmus+ Programme is 14.77 Billion Euro for the 2014-2020 period.

KA1 (around 63%) of the total budget
KA2 (around 28%) of the total budget
KA3 (around 4%) of the total budget

Further information on the Erasmus+ Programme is available on the European Commission's website at: http://ec.europa.eu/programmes/erasmus-plus/index_en.htm

Horizon 2020 Programme

Horizon 2020 is the programme that finances research, development and innovation activities.

The main general objectives of the Horizon 2020 Programme are:

- Raising the level of excellence of Europe's scientific research through the support to researchers in order to explore and implement their innovative ideas
- Making Europe an attractive location for the world's best researchers.
- Making Europe a more attractive location to invest in research and innovation by promoting activities where businesses set the agenda
- Pooling investments in key industrial technologies and help innovative SMEs to grow into world-leading companies.
- Gathering together resources and knowledge across different fields, technologies and disciplines to address strategic challenges for the future wealth of European societies
- Supporting activities aiming to foster the passage from research to market with a new focus on innovation-related activities, such as piloting, demonstration, test-beds, and market uptake.

The Horizon 2020 Programme is organised in three Pillars.

PILLAR 1 - EXCELLENT SCIENCE

Pillar 1 aims to reinforce the excellence of the EU's science base and to make the EU's research and innovation system more competitive on a global scale. The 1st Pillar also provides opportunities for individual and group researches according to science-driven nature. Pillar 1 is mainly 'bottom-up' and investigator-driven.

The Pillar is divided in four actions:

- **The European Research Council (ERC)** provides flexible funding opportunities to enable talented and creative researchers (individually and in teams) to pursue the most promising frontier research.
- **Future and Emerging Technologies (FET)** supports collaborative research for advanced and paradigm-changing innovation. It finances scientific collaboration across disciplines on radically new, high-risk ideas to accelerate development of the most promising emerging areas of science and technology.
- **Marie Skłodowska-Curie Actions (MSCA)** finances opportunities for researchers' training and career development through their cross-border and cross-sector mobility.
- **Research infrastructure**s ensures access to world call research facilities

PILLAR 2 - INDUSTRIAL LEADERSHIP

Pillar 2 aims to make Europe a more attractive location to invest in research and innovation by promoting activities where businesses set the agenda.

The Pillar is divided in three areas:

- **Leadership in enabling and industrial technologies (LEIT)** provides support for research, development, demonstration, standardisation and certification of highly innovative products and services in three topic-based areas identified by the Programme:
  - Information and communications technology (ICT)
  - Nanotechnologies, advanced materials, biotechnology, advanced manufacturing
  - Space
- **Access to risk finance** offers financial support to overcome deficits in the availability of debt and equity finance for R&D and innovation-driven companies.
- **Innovation in SMEs (SME instrument)** provides a SME-tailored funding scheme to stimulate all forms of innovation in SMEs, targeting those with the potential to grow and internationalise across the single market and beyond.

PILLAR 3 - SOCIETAL CHALLENGES

Pillar 3 aims to address major concerns shared by modern societies through a challenge-based approach, bringing together resources and knowledge across different fields, technologies and disciplines.

Funding focus on topic-based challenges, already defined by the Horizon 2020's Workprogrammes, published every 2 years.

The 7 challenges are:

- Health, demographic change and wellbeing
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy
- Secure, clean and efficient energy

- Smart, green and integrated transport
- Climate action, environment, resource efficiency and raw materials
- Europe in a changing world - inclusive, innovative and reflective societies
- Secure societies-protecting freedom and security of Europe and its citizens

The total budget for the Horizon 2020 Programme for the 2014-2020 period is 70 billion euros:

- Excellent Science: 24.4 Billion Euro
- Industrial leadership: 17 Billion Euro
- Societal challenges: 29.7 Billion Euro

Further information on the Horizon 2020 Programme is available on the European Commission's website at: http://ec.europa.eu/programmes/horizon2020/en

Examples of Successful European Projects in the field of Science Education

- MATHE - Improve Math Skills in Higher Education

The project was funded by the European Commission in the framework of the Erasmus+ Programme, KA2 - Strategic Partnerships for Higher Education. The aim of the MathE project is to implement innovative assessment methods to help higher education Maths lecturers to identify knowledge gaps of their students so as to identify, on the basis of the assessment made, the best possible learning pathways aligned with the learners' needs.
https://mathe.pixel-online.org/

- FICTION - Functional ICT Instruction On the Net

The project was funded by the European Commission in the framework of the Erasmus+ Programme, KA2 - Strategic Partnerships for School Education. The aim of the project is to promote the use of digital technologies for the teaching and learning of scientific subjects at secondary school level.
https://fiction.pixel-online.org/

- ALCMAEON

The project was funded by the European Commission in the framework of the Erasmus+ Programme, KA2 - Strategic Partnership for Higher Education. The aim of the ALCMAEON project is to overcome the gap between clinical practice and historical perspective of medical humanities, through the representation of the historical scenarios and the integration of historical evidences in specific educational contents.
https://alcmaeon.pixel-online.org/

- SMiLD – Students with Mathematics Learning Disabilities

The project was funded by the European Commission in the framework of the Erasmus+ Programme, KA2 - Strategic Partnership for School Education. The aim of the SMiLD project is to provide secondary school maths teachers with the skills to facilitate the learning of mathematics by students with learning disabilities.
https://smild.pixel-online.org/

- DO WELL SCIENCE

The project was funded by the Erasmus+ Programme, KA2 - Strategic Partnership in the field of School Education. The project aims at increasing secondary students learning results in STEM subjects (maths, physics and natural sciences) through the development of a STEM teaching package addressed to both Teachers and students.
https://www.dowellscience.eu/project/

- ZOE - Zoonoses Online Education

The ZOE European project, funded by the European Commission in the framework of the Erasmus+ Programme, KA2 Strategic Partnership in the field of Higher Education aims to create teaching resources in the field of veterinary medicine focusing in particular on the identification, monitoring and control of malaria.
http://zoeproject.eu/

- E-LEARNING FROM NATURE

The E-Learning From Nature project funded by the European Commission in the framework of the Erasmus+ Programme, KA2 Strategic Partnership in the field of School Education aims to improve secondary school students' basic skills in scientific subjects.
http://enature.pixel-online.org/

- SOFTIS-PED - Softskills for Children's Health

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On FAIR Data Principles of Institutional Data and Information of Universities

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Abstract

In scientific research, it costs a lot to reproduce experiments succeeded in the past. For efficiency of research, scientific researchers come to reuse research data of the past research. To do so, it is necessary not only to archive research data, but research data should be arranged confirming to FAIR data principles. FAIR is acronym of "findability", "accessibility", "interoperability" and "re-usability". To realize FAIR data principle, fulfillment of metadata and persistent identifier on data is significant. On the other hands, institutional data on education and institutional management are coming to be recognized significant for university management to secure fundamental information of universities. In that context the FAIR data principle is effective to facilitate collecting institutional data as well. However, generally speaking, as the technical situations of institutional information are different from university to university, it is difficult to acquire a general resolution. We study the problem to make institutional data and information to be abstract using ontology engineering, and consider the design of institutional data and information that meets FAIR data principles.

Keywords: FAIR data principle, open science, institutional research, ontology

1. Introduction

FAIR Data Principle (Fig. 1) has been proposed by FORCE11, the community for research academics, librarian and research funders, aiming at good data management for scientific research data [1]. From 2011, FORCE11 started to discuss and output the guide line in 2016. EU adopted FAIR Data Principle for Open Data Policy Pilot.

"FAIR" is an acronym for four attributes of scientific research data; to be Findable, to be Accessible, to be Interoperable and to be Re-usable. In order to realize the principles, research data need to be indexed by PID (persistent identifier), to be enriched with meta data, to be deployed on database system, and to be on networks.

Institutional Research is aiming at supporting decision making and planning for universities and research institutions by analyzing data analysis and supplying strategic information. The data and information are required to be comprehensive, exhausted, period-continuous and indexed as possible. As FAIR Data Principles meet these requirements, FAIRness is necessary principles on institutional data and information for institutional research.

This study gives a method to describe metadata of institutional information and data using ontology in information science.

FAIR Data Principles

TO BE FINDABLE:

F1. (meta)data are assigned a globally unique and eternally persistent identifier.
F2. data are described with rich metadata.
F3. (meta)data are registered or indexed in a searchable resource.
F4. metadata specify the data identifier.

TO BE ACCESSIBLE:

A1 (meta)data are retrievable by their identifier using a standardized communications protocol.
A1.1 the protocol is open, free, and universally implementable.
A1.2 the protocol allows for an authentication and authorization procedure, where necessary.
A2 metadata are accessible, even when the data are no longer available.

TO BE INTEROPERABLE:

I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
I2. (meta)data use vocabularies that follow FAIR principles.
I3. (meta)data include qualified references to other (meta)data.

TO BE RE-USABLE:

R1. meta(data) have a plurality of accurate and relevant attributes.
R1.1. (meta)data are released with a clear and accessible data usage license.
R1.2. (meta)data are associated with their provenance.
R1.3. (meta)data meet domain-relevant community standards.

2. Ontology in Information Science

A "Domain knowledge" is a system of knowledge containing, for instance, within computer software or business procedure. Ontology in information science is a technique to describe formal representation of concepts and relationships between those concepts in domain knowledge. For instance, Common European Research Information Format (CERIF) has defined an ontology in the form of diagram like (Fig. 2), but normally ontology is described in XML format.

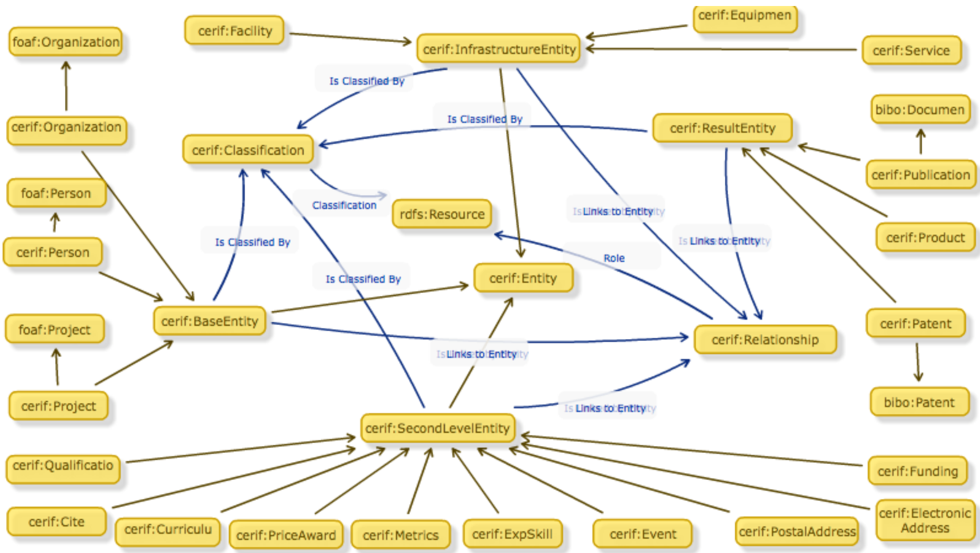
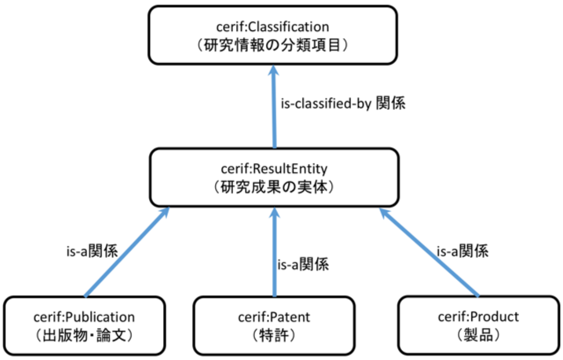


Fig. 2. Ontology of CERIF 1.3 (Quoted from [3])

In ontology engineering, concepts in domain knowledge are called 'Class'. Class has rank, which is called 'Relation'. 'Is-a relation' expresses relation between upper class and lower class. In some case, a set of classes is described as a class, then we have 'part-of relation' which means relationship between set-class of classes and its element-class. Attribute of class is expressed 'attribute-of relation'.

If the relationship between the classes is kept to the minimum necessary, the designer may arbitrarily add. Generally, it is said that there is no unique way to create an ontology for any knowledge system, and from various viewpoints utilizing the ontology to be constructed, it is only necessary to make it appropriate system according to necessity [2]. Therefore, the ontology of university information shown here is one possibility, not a suggestion as the only solution.

For example, in the ontology of CERIF in Fig. 2, the class cerif:Publication (publication) is a upper class of cerif:ResultEntity (is-a relation), and arrows are drawn from the lower class to the upper class. Furthermore, cerif: ResultEntity is one of the items in cerif:Classification (classification of research information) (is-class fied-by relationship) (see Fig. 3). The last is-classified-by relationship is an additionally introduced class relation. This is an example in which relationship can be flexibly introduced in ontology engineering. This ontology represents the following description:



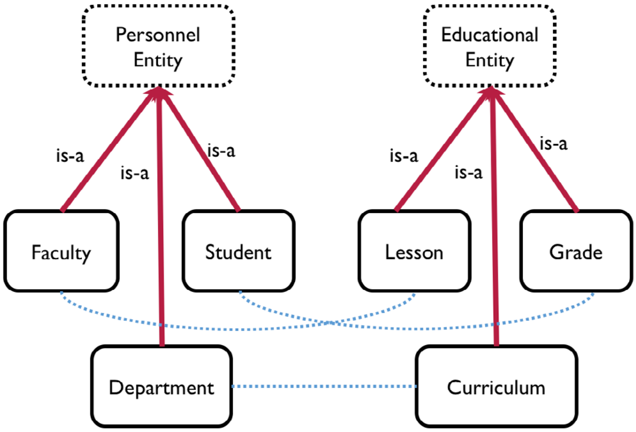
Research results consist of papers, publications, products and patents. The research outcome is one item of research information, and information on basic object (BaseEntity) and infrastructure (InfrastructureEntity) are also included as items of research information.

We can see that ontology engineering is used to expresses concepts and relations efficiently in the domain knowledge of CERIF.

3. Construction of The Ontology for Institutional Data: example

In this section, as an example of an ontology, we prototype an ontology of information on education and its outcome. The following six items are listed as possible classes.

1. Student
2. Faculty
3. Department
4. Lesson
5. Curriculum
6. Grade



Lesson and Curriculum are clearly an is-a relationship. Looking at the ontology of CERIF, engagement of Organization and Person are comprehended by introducing an upper class called BaseEntity.

Following this, it is conceivable that for Student, Faculty and Department we can construct unification-class by introducing upper classes like PersonnelEntity. In summary, we can propose the ontology as shown in Fig. 4. Solid arrows indicate.

The relationship between the classes mentioned above is shown, and the broken line shows what is undefined due to the relationship of the class which needs to be considered.

4. Conclusion

In this paper, in order to apply FAIR Data Principles to institutional data and information, it is necessary to describe those metadata. The method of ontology engineering is helpful to understand the structure of metadata. As an advanced example, we introduced CERIF ontology. Based on the ontology structure used there, we examined the method to be carried out in this research in the future.

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Regional Strategies for the Development of Higher Education and Human Capital Upbuilding

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Abstract

The article analyzes ways of overcoming the negative trends towards the human capital degradation in Russian regions and other Eastern European countries. It has been shown that technical universities located in small towns of the region should play an important role in the processes of solving the problem. The development of universities should be carried out in accordance with a specific strategy, the purpose of which is to train qualified specialists and students who will live and work in their own region in the future. Also presented is a set of requirements for such strategies, which are based on the idea of the institutional design of the University Technopolis. The purpose of the article is the formation of strategies for the development of universities and other higher education institutions, which should ensure the social needs. Information obtained as a result of research should be used to improve the theory and practice of strategic development of educational institutions of the regions. The research's tasks are the analysis of the employees' educational level at enterprises and business groups in the region; the analysis of the social role played by the technical university in the region; the application of the institutional approach to the development strategy of a technical university; the consideration of the technical university as part of the regional innovation system and the formation of its development strategy. It has been established that in order to overcome the unfavorable tendency, universities and other higher educational institutions should follow a special development strategy, the purpose of which is to train qualified specialists from local young people. This strategy should be based on the institutional design of the University Technopolis – the socio-economic system of the meso-level, in which students participate in the processes of generating new knowledge, and which is based on the principles of public-private partnership and the ideas of the triple helix concept. Such a technical university – Technopolis is part of the national innovation system and is integrated into the global educational space.

Keywords: Higher education, human capital, institutional designing, regional development, technopolis

1. Introduction

After the Soviet system collapse, the countries of the Eastern Europe and Russia in the last two decades show the tendencies to decreasing a quality level of the human capital. The numerous researches analysed the different aspects of the problem, such as the demographic setting [1]; investment in the human resources [19]; role of the human capital and level of the management quality, as a reason for the appearance of the gap in production level indexes between the Eastern and Western Europe [18]. All of them agree, that the main reasons for the mentioned problems are the features of the transition from the totalitarian society to the societies, based on the mechanisms of the market economy (that differ in one country from another), and the influence of the worldwide globalization processes.

In the regions of Russian provinces, the basic reasons for the degradation of the human capital are the following:

- a considerable decreasing of the professional activities' creativity of the substantial percent of the population, the reasons for which are the laying of the numerous high-technology production enterprises and people's leaving a creative sphere for the primitive commerce, government service, office work and other activities with a low level of the intellectual and creative component;
- decreasing of the efficiency and effectiveness level of the universal secondary education and substitution of the educational values by the pupils' preparation for the primitive Concluding State Attestation procedure as a goal;
- decreasing of the effectiveness level of higher and secondary professional education: the reason for such tendency is the job shortage in the high-technology sphere and disbelief of the substantial percent of students in the prospects of getting a job, which would answer the student's special subject [11].

Besides the aforesaid, in the last decades in Russia increases the level of the inequality in a property status as a key social stratification, and a gap between the life quality and development prospects level between the people of the capital and the cities, and the people from provinces (small towns and villages), also increased the people's outflow level (first of all – the most educated part of them) from the provinces to the cities, and the flight of the human capital. The reason is the dislocation of the majority of the higher professional education institutions in the capital and the cities, as the hands-on experience in the Soviet period [7].

2. Methods

The major research methods adopted by the author's scientific work are the descriptive method, typical for social and economic sciences, the method of analysis and synthesis. Author also use a human capital theory [4], theory of the firm [5], [20], the triple helix theory [16] and the institutional designing methodology [9]. For the empirical studies, author used common statistical methods.

3. Education of employees from South Russian enterprises (status for 2018)

We investigated some of the significant features of the professionals' educations.

All of the investigation participants are the employees at the enterprises of the Southern Federal District of Russia. The numerous enterprises are situated in the Rostov region, Volgograd region, Krasnodar region, and Adygeya Republic. There was examined the education of 2138 professionals of 137 enterprise. This number of the participants and enterprises means that the results of the research are representative.

There were investigated the big enterprises and business groups with more than 950 employees. The exception was made for the finance organizations (the most of them are the regional branches of the commercial banks and finance companies with the All-Russian volume of activity), and also for some small trade enterprises. The "Mechanical engineering" group of the enterprises includes also the enterprises of the metallurgy and metal working industry, the "Chemical industry group" includes the cement production and production of the building materials. More than a half of the enterprises, which employees took part in the investigation, are situated in the small towns of the Southern Federal District of Russia.

A special attention is paid to the professionals, which are the graduates of the higher education institution of the Southern Federal District of Russia. We also demonstrate the difference between the graduates, who studied in the higher education institutions of the cities (regions' centres) and ones who studied in the towns of middle and small size. As the regions' centres of the Southern Federal District of Russia we assigned Rostov-on-Don, Krasnodar and Volgograd. The most of the regions' universities and other higher education institutions are situated in these three cities.

In the table 1, we present a structure of the enterprises' employees, based on the location of the institution, where they got their professional education. In the table 2, there is information about how the employees' professional activity conforms to their graduates' chief subject. The data given in table 1 and 2, obtained as a result of a study conducted by the authors in 2018. According to the information in the tables, we can make a conclusion, that the most of the regional enterprises' employees are also the graduates of the higher education institutions of the same region. The number of the Moscow and Saint Petersburg universities' graduates at the enterprises of the region is very small. It's the prove for the above said idea that the students of these universities don't see any reasons for getting jobs in provinces (even if the provinces is their birthplace).

The table 2 shows, that a significant amount of the specialists at the enterprises got the jobs, which greatly differ from the special subject that they studied in the higher education institution. One of the reasons of that is the people's inability to get a job that was coinciding with their special subject, in their home region, and changing a place of living to get a job is not typical for Russians' national traditions [10]. In other hand, a meaningful number of these specialists later got a postgraduate education, some of them – in the educational institutions of the foreign countries.

Table 1. Description of the employees of the enterprises in the Southern Federal District of Russia as of the Higher Education Institutions graduates in 2018

Sector of the national economy	Number of the examined enterprises	Percent of the employees, which are the graduates of:				
		The institutions of higher education in Moscow and Saint-Petersburg	The institutions of higher education in the cities of the Southern Federal District	The institutions of higher education in the towns of the Southern Federal District	The institutions of higher education in the other regions of Russia	The institutions of higher education in the foreign countries
Engineering and production departments						
Mechanical engineering	13	1,1	33,5	39,6	22,4	3,7
Chemical industry	9	1,9	20,1	37,7	23,5	11,2
Food industry	11	0,3	18,6	39,0	12,0	8,1
Agriculture	13	0,4	13,9	59,7	15,2	11,6
Building	8	0,5	22,2	54,8	14,1	10,1
Transportation	7	0,4	20,9	57,2	11,6	8,1
Trading	12	0,5	25,0	49,3	13,0	11,3
Finance organizations	11	1,1	35,5	33,1	20,8	8,1
Economic and marketing departments						
Mechanical engineering	13	0,8	24,5	31,9	18,4	2,2
Chemical industry	9	1,0	26,2	32,5	19,2	20,2
Food industry	11	0,5	21,7	33,1	16,3	28,4
Agriculture	13	0,1	19,5	40,9	13,4	27,0
Building	8	0,3	19,1	41,8	22,3	16,9
Transportation	7	0,6	18,9	45,2	26,1	10,3
Trading	12	0,6	20,2	48,1	20,1	10,6
Finance organizations	11	1,0	19,9	30,8	19,1	9,6

Table 2. Description of the employees of the enterprises in the Southern Federal District of Russia: how the graduates' chief subject answers the purpose of their professional activity in 2018

Sector of the national economy	Percent of the employees, and how their chief subject answers the purpose of the professional activity			
	Completely answers	Partially answers	Doesn't answer	Answers because of the post-graduate education
Mechanical engineering	30	27	21	22
Chemical industry	33	24	13	30
Food industry	20	26	40	13
Agriculture	16	28	46	10
Building	20	23	34	23
Transportation	19	26	31	24
Trading	8	25	45	22
Finance organizations	22	24	9	45

4. Development Strategy of the professional education in the region: the specific role of Technical University

The University, if it is placed in the provinces, is the best-fit educational institution for kind of development of human capital in the region, because of its key competences and other features of the activities. First, we speak about the “classical” University, which’s curriculum is based on the ideas of natural science, technical University, and other institutions of the higher professional education. The graduates of these institutions then become the employees in the real sector of the economy.

Therefore, the development of regional strategies for the development of higher vocational education should be closely linked to the development of strategies for the development of universities located in the region. Working out a development strategy for the technical University should be based on the understanding of their major task: generating a new knowledge; and the universities themselves should be regarded as an important part of the national and regional innovation systems. The efficient generating of the new knowledge in general, and especially in the technical University, requires the appropriate institutional environment. This environment is to be developed in conformity with the strategic goals and tasks. Following the ideas, presented in the well-known work [14], [3], [8].

Working out a development strategy of the technical University is a particular case of the institutional designing – a special kind of activity, which’s goal is creating or transformation of the institutional environment.

Organization of the education processes, which’s goals list include the salvation of the aforesaid problems, should take in account the universally recognized features of the efficient learning process, typical for the education of the 21st century [6]. The set of these features includes the cooperative work of the students, cooperation in the workgroups instead of the competition between them. The practical utility of the knowledge that students get is also very important. The subject that the students of the new generation are trying to pursue is getting the information, which practical utility is evident.

Technical University, which is situated in a region, and has a number of the described above features, is one of the full-fledged parts of the region’s innovation system. The University Technopolis is the most efficient as a part of the innovation system.

The concept of the University Technopolis enables the realization of the most successful models of state-private partnership [15]. To realize this model, the participants should achieve a consistency of the agent’s interests; taking in account that each of the agents may act in a different economic environment (with different traditions of the institutional organization). That is why in the last years the projects with a state-private partnership have been often presented in a context of the development of the triple helix model (University-industry-government) [16].

Analysing of the conditions of the Southern Federal District of Russia gives us a possibility to draw a conclusion that the South-Russian State Polytechnic University (situated in Novocherkassk) meets all the requirements to do its best during the creating of the University Technopolis. Now the administration is making an attempt to create the University Technopolis on the base of this University.

The efforts of creating the University Technopolis were undertaken during the working out of the SRSPU (NPI) strategic development program. The idea was to solve three basic problems that exist during the University’s scientific project development. Fist problem is the lack of the stable relations to the corporative sector of the real economy. The second is the insufficient development of the research and development departments and poor infrastructure for the commercialization of the technologies. The third – a loss of the scientific authorities (in the universities, in comparison with the institutions of the Russian Academy of Sciences).

5. Conclusion

Most of the countries of the Eastern Europe (including Russia) in the last two decades show the tendencies to decreasing a quality level of the human capital. This tendency is very brightly appeared in the provinces.

To overcome the unfavourable tendency the universities and other higher education institutions, which are situated in the provinces, should follow a specific development strategy that's goal is training of the qualified specialists, and to take as the students the local young people, which are going to live and get a job in the region in future.

The strategy should be based on the institutional projecting of the University Technopolis – a social and economic system of mesolevel, in which the students take part in the processes of generating the new knowledge, and that is based on the principles of the state-private partnership and the ideas of triple helix concept.

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Scientific Literacy: Who Needs it in a 'Black Box' Technological Society?

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Abstract

This paper will question the widely accepted position that there is a need for widespread, scientific literacy that spans a broad range of topics if that literacy lacks the conceptual depth, and/or intellectual rigor, to provide any basis for rational, scientifically informed, choices. The paper will present an argument that, in fact, it would be more effective if functional, widespread, scientific literacy were only taught in Key Stage 3 (age 11-14) where it would focus almost exclusively and in greater depth on those areas of science relating to human health with some basic chemistry and physics – the biggest of the 'big ideas'. With science in Key Stage 4 (age 15-16) reverting back to a more traditional 'science for the future scientist' and that studying biology, chemistry and physics at Key Stage 4 would become an option rather than a core requirement. We will also argue that, in a 'black box' technological world, individuals can be, and indeed are, very effective users of technology, and the underlying science, without the need for them to be scientifically literate.

Keywords: Scientific literacy, black box

Introduction

Other than the occasional dissenting voice [1] there is a shared belief within the scientific and science education communities [2] of the need for wide-spread scientific literacy. This article argues that widespread, functional, scientific literacy, that would enable the average individual who ceases to study science at age 16 to make rational, scientifically based, choices about a *broad* range of socio-scientific issues, is both unrealistic and unachievable.

This does not mean ceasing to teach scientific literacy but rather recognising the need for a more tightly focused form of scientific literacy. This would enable individuals to make rational, scientifically based, choices but *only* in a *narrow* range of socio-scientific issues. These issues would focus primarily on human biology, along with some aspects of chemistry and physics – the biggest of the 'big ideas' [3], all of which could be taught by the end of KS3 (age 11-14). With the teaching of tightly focused scientific literacy completed by the age of 14, biology, chemistry and physics would, like history and geography in England, become optional subjects. This would enable the teaching of science to refocus towards science content – a move away from what

Sir Richard Sykes, Rector of Imperial College London, stated [4] as being a “dumbed down syllabus” towards educating students wanting to pursue a science subject post-compulsion i.e. science for future scientists.

This article suggests that a feature of living in a scientifically advanced society is that we cannot have a sufficient depth of knowledge, across all topics, to be able to make rational, scientifically, informed decisions and so must rely on experts. Indeed, in our view, an individual’s ability to use technology effectively does not depend upon their being scientifically literate – mobile phones, USB sticks, and in-car satellite navigation systems – can all be used *without* any scientific understanding of how or why they work.

Five arguements have been provided [2] as to why people should know something of science and we will consider the evidence for and against each in turn.

The economic argument

Whilst science-based industries need highly qualified scientists, by which we mean those leaving university with degrees in science subjects, they have little need for students leaving school with a benchmark GCSE qualification in science at 16. Yet even here the economic argument overlooks basic principles of supply and demand [1] that would suggest that if practising scientists (as against science graduates working in corporate finance) play a vital role in the economic prosperity of the nation – then their salaries should rise to attract and retain them. Indeed, despite claiming to need ever more scientists 74% of those who graduate in the US with a major degree in science, technology, engineering and maths find employment outside of these areas [5] with similar findings [6] in the UK.

What is also still missing from the economic argument is research-based evidence that GCSE science provides industry with employees with essential levels of *useable* scientific knowledge and skills without which those industries would be unable to function. Science-based industries would not function without science graduates but would they also not function if, for example, their reception clerk did not have a GCSE in a science subject? Whilst having GCSEs in science can sometimes enhance individual earning potential this can owe more to the fact that having science GCSEs are placed as a requirement for certain careers, such as primary teaching, and again research is needed to ascertain the extent to which those working in such careers use their GCSE knowledge and/or skills. Primary teachers still teach history and geography to their pupils without having to have a GCSE in those subjects themselves.

The democratic argument

This argument suggests that science knowledge enables individuals living in a scientific society to engage in debate and decision-making in contexts that involve scientific information. For example, it could be argued that individuals considering whether to build a local wind farm close to their home would benefit from an understanding of the nature of global warming, the pay-back time to off-set the embedded carbon dioxide in the concrete turbine towers (and any access roads), dangers to wildlife, the viability of carbon capture for fossil fuel power station alternatives and for the safe storage of nuclear waste – including an understanding of half life – for nuclear power station alternatives.

However, this argument fails to consider the level of scientific conceptual understanding that is required to make scientifically rational informed decisions.

The fact that highly qualified scientists can disagree on, for example, the dangers associated with the use of nuclear power raises the question as to what can realistically be expected of students, with very basic scientific GCSE content knowledge, in terms of this and other arguments. Indeed, if we rely on a doctor for a medical diagnosis, or a pilot to fly us around the world, is there any reason not to rely on nuclear physicists to guide/advise us about the safety of nuclear power stations?

Furthermore, there remains little objective evidence as to the extent to which individuals, even those with a high level of science education, make decisions based on their scientific knowledge. People are more often influenced in their decision making by their personal beliefs and values [7] and, for example, with regards the construction of wind farms 'NIMBYism' (an acronym for the phrase "Not In My Back Yard) and, in particular the impact on local house prices and vistas, probably plays a much larger role in an individual's decision making process than an understanding of global warming.

The utility argument

This argument suggests – again there is a lack of research evidence about the level that this needs to be at – that science knowledge is of value to individuals living in a society dependent on science. From this perspective it is important to teach science in order for students to develop the knowledge they will subsequently utilise in decision making about science related issues at an individual level (for example, nutrition, health and safety) thereby enabling them to make rational, scientifically, informed choices as consumers [8].

However, consumer choices often appear to be based on a host of different factors, other than scientific knowledge, and the need for scientific knowledge in everyday life situations seems to be overly exaggerated. There is no evidence that physicists, for example, have fewer car accidents because they understand mechanics better than non-scientifically literate people. Indeed, despite science being a core subject in England we have an increasing rate of childhood obesity and type 2 diabetes which shows that the dietary choices made by those children, and their parents – who also probably had a core science education up to the age of 16 – are more likely based on convenience and cost rather than scientific knowledge.

The social argument

This argument points to the need to link science, and scientific research, and the wider non-scientific society. It has been argued [2] that the increasing specialisation and remoteness of much scientific knowledge has created a gap between society at large and science, which threatens both. It can be argued that a scientifically educated individual – it is unclear what level of science education is required – would feel less alienated from science and scientific research, and perhaps better sympathise with the aims of science. Of course this leaves unanswered, and un-researched, the question of whether individuals who might be considered as being scientifically illiterate actually do feel alienated from science or whether that alienation is, erroneously, attributed to them by scientists who are unable to accept that some people are very content to simply use the products that science provides and rely on experts. Do passengers who fly on jet planes actually feel alienated from science because they lack an understanding of Bernoulli's principle, or Newton's third law, or is it the case that they just get on the plane and the question of how hundreds of tons of metal not only stays up in the air, but also moves very rapidly through it, either does not even occur to them or, if it does, the answers are simply of no interest to them?

The cultural argument

If science is one of the defining cultural products that characterise our society then part of the role of education is to transmit that cultural heritage to successive generations. Whilst we see this as the strongest of the five arguments for the teaching of science to *all* students, we question whether, and on what basis, science is any more important in terms of cultural heritage than history, music or art: none of which are compulsory subjects in Key Stage 4 (age 15-16). Furthermore, we might reasonably ask to what extent does the teaching of school science inculcate an awareness and appreciation of the contribution made by science to our cultural heritage and might such an awareness and appreciation be better taught in history?

Conclusion

The reality of the complex society in which we live is such that we depend on experts and professionals. Most of us are not scientists or designers of technology and yet irrespective of our academic achievements are all able to use mobile phones, send e-mails and fly around the world without needing to know, or in many cases having any desire to know, anything about the underlying science that enables such technology to function. Whilst there is undeniably a need for a level of functional scientific literacy in our society this should essentially be focused onto those areas of science that relate to human health and some basic chemistry and physics – all of which could be effectively taught by the end of Key Stage 3 (age 14). Beyond this point we argue that there ought to be three, optional, academic subjects: biology, chemistry and physics that are taught to those who *want* to study these subjects and a general science that would be an option for those who might require some basic level science in a future job and/or apprenticeship.

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The Work-Related Stress among Members of Integrated Rescue Service and Influence of this Stress to Couple Relationship

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Abstract

Integrated rescue system members (firefighters, police officers, and rescue workers) are affected by specific stress factors for example: intercourse with death and human suffering, health damage, or feelings of helplessness [1]. Their work is usually psychologically, physically and emotionally demanding and they must work in shifts [2]. It can affect couples and family relationships. A working stress can be transferred to family members. Fallowing this, as more than 50% of marriage end with divorce, it is particularly important to determine how much the performance in profession can affect family stability [3]. Unfortunately, not only in the Czech Republic, the issue of the partner life of IZS members has been given very little attention [1]. However, with regards to occupational health and life-safety workloads and increased work-related stress, it would be advisable to prepare IRS members and their partners for this situation [4]. *Using effective coping strategies, it could have a considerable positive impact on partners' life, but also on the work performance of both partners as well [2]. Of course there are also positive impacts on the whole society, because society needs this professions and its members.*

Keywords: working distress, transfer of stress, couple relationships, integrated rescue system, IRS

1. Introduction

Several studies reports on the context of the two-way influence on the performance of the profession and on the partnership or family cohabitation [5, 6, 7]. There does not seem to be any reason why this connection should not be expected in assisting professions (firefighters, doctors, rescue workers, nurses, police officers ...) [3], following the number of divorce marriages (reported more than 50%), point out that one of the aspects affecting family stability may be the performance of the profession.

Unfortunately, there was a deficiency in research into the partner life of members of the helping professions, despite the fact that these are very important circumstances influencing the performance and employment of workers responsible for the safety, health and life of citizens [8, 9, 10]. The aim of this paper is to outline the psychological and sociological specifics stemming from the performance of the profession within the integrated rescue system (referred to as IRS). However, it is obvious that even the specific background of partner cohabitation of IRS members can lead to common partner conflicts. Deepening knowledge on this topic can appropriately influence the education and training of newly-arrived members and staff.

2. Specifications of individual individuals in the field of IRS

Members of IRS are exposed to a usual work-related stress. But we have to focus on specific factors of their works whose can determine their working self-efficiency and couple relationship too [1, 11]. Factor analysis of coping with the stress after the intervention discovered four basic strategies: seeking of meaning; mastery through individual action); regaining mastery through interpersonal action and philosophical self-contemplation [12].

2.1 Police

Police work is generally considered one of the most stressful e.g., [10]. Due to their work, policemen are often more suspicious and alert, generally less likely to be distrustful of people and their motives. They are also more cynical and their partners often feel “as if interrogated” [13, 14]. Police officers are more likely to experience stress: irritability/anguish; greater isolation from the family (spends more time without her); lower engagement in family events; more often they have unsatisfactory marriages [15]. Many police officers tend to create “intensive zone protection” around their people-trying to keep them away from their experience at work. Sometimes, when they ask for support from a partner, they suddenly pull back and do not want to talk about it. However, this approach may negatively affect marriage [16]. In addition, it has been found that policeman suffering PTSD also affect their partners and they may also suffer more often from psychological problems and more often from domestic violence [17]. The impact of police work on the family is generally understood to be negative. Severe negative factors are perceived: shift work, long working hours, holiday cancellation. Conversely, no impact has been identified: risk/dangers of work, work with people of the opposite sex [18]. As a result of it, the police officers should be systematically prepared to control their emotions and how to communicate their negative experiences of work to their partners, as evidenced by studies [19, 20]. If superiors provided more work-emotional support to police officers, they showed lower impacts of work-related stress and emotional strain, as well as better functioning in family and partners life [21].

2.2 Firefighters

It is evident that in the profession of firefighter there is presence of concrete specifics e.g., contact with human misfortune, health and life injuries etc. Therefore, the firefighters may suffer from PTSP [22]. There is no evidence that the male firefighters would divorce more often than the rest of the male population. However, this does not apply to female firefighters with more than three times the prevalence of divorce in the US than for other women in the population [23]. In addition, it appears that firefighters tend more often to commit the suicide or have the suicidal thoughts.

These factors are appeared to be the most threatening: lower position in the hierarchy of firefighters, shorter length of practice, membership of voluntary fire brigade units, experience of interference with the suicide attack or death, and experience of active military service [24]. On the other hand, the more senior firefighters are claiming they don't feel that strong social support (they don't feel appreciated and supported by their surroundings) and have a lower perceived personal efficiency [25].

Women practicing the profession of firefighters involved in suicide also show more severe psychiatric symptoms and are at increased risk of their own suicide (compared with colleagues without exposure) [26]. It is rather probable that one of the important factors for the presence of the suicidal thoughts and behaviour is increased level of alcohol consumption (to which may the firefighters tend to) [27].

The consequences of performing the profession must then be balanced by their partners. The most frequent threatening aspects were: shifts and different working hours and their impact on the family; transferring experiences from traumatic and dangerous situations to the family; a social atmosphere linked to firefighting [28]. The marriage may be very important for the firefighters as the married firefighters tend less to alcoholism and depression [23].

2.3 Rescue workers/paramedics

Rescue workers were identified to be the high risk group for PTSP and other psychiatric symptoms linked with trauma because of the unique requirements for their work. [29, 30, 31, 32]. Rescue workers are daily exposed to actions that include human pain and suffering. They are very often the witnesses of violence caused by one person on the other. Even though they are used to these situations, sometimes they are, under the circumstances, led to create the connection with the victim or his /her family. If it happens, the rescue workers have the increased level of traumatic stress [33]. This could be one of the reasons for which, rescuers can also appreciate the availability of professional emotional support through their intervention [34].

It should be mentioned that under the influence of acute stress, rescue workers may carry out mistakes in investigations, care provision and dossier completion [35, 36].

One of the strategies how to cope with the stress is emotional insensitivity– filtering emotions and focusing on cognitive aspects of work [33]. However, this could lead to negative effects in marriage, as the result may be lack of interest, separation, emotional unavailability, or reduced ability and willingness of parents to interact with their children [37].

3. Conclusion

The high risk of a profession of a police officer, rescue worker, or firefighter may even increase the negative impact on the family. These people are put into an extreme situations and have to cope with very different physical, mental and emotional burden than the other profession do. It is hard to assume, that it is always possible to manage the traps resulting from the exercise of their profession without psychological and emotional stress even though they are carefully selected and trained. Despite the often high efforts of their members, these stressors spill over into family life. The stressor and support factors in the IRS family members should be given more attention. Find proven and functional solutions for couples (families) that have overcome professional trauma, gain information about relationship development, and help to prepare or inform young couples and families to ensure their care and work-life balance.

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Science Education and Special Needs

Access to Information for People with Special Needs: Experience from Academic Course

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Abstract

In 2010, the European Union adopted the European Disability Strategy 2010-2020: A Renewed Commitment to a Barrier-Free Europe. The report describes ways for European institutions to meet the terms of the Convention on the Rights of Persons with Disabilities and implies the commitment of each European nation towards achieving a barrier-free participation of its citizens in the economy and community life. Correspondingly, Bulgaria developed the National Strategy for Persons with Disabilities (2008-2015; 2016-2020) and the Action Plan of the Republic of Bulgaria to implement the Convention on the Rights of Persons with Disabilities (2015-2020). Accessibility improvements such as distance training for people with special needs and the inclusion of accessibility curricula in appropriate disciplines is now required in Bulgaria's higher education sector. As a result of the strategy, the University of Library Studies and Information Technologies (ULSIT) introduced an Access to Information for People with Special Needs elective course in the professional field 3.5. Public Communications and Information Sciences. This paper introduces the contents, the teaching methods and the student assessment mode applied in the course. Special attention is given to teaching methods that enhance student empathy and motivation and increase student involvement in a variety of extra curricular activities such as volunteer missions that address disability and special needs issues.

Keywords: people with special needs, higher education, extra curricula activities, Bulgaria, European Disability Strategy 2010-2020

1. Introduction

In 2010, the European Union (EU) adopted the European Disability Strategy 2010-2020: A Renewed Commitment to a Barrier-Free Europe [5]. This strategic document sets out the measures for implementation of the Convention on the Rights of Persons with Disabilities (CRPD) of the United Nations (UN) by the European institutions and suggests the commitment of all stakeholders at national and European level.

The term 'persons with disabilities' is defined in article 1 of the Convention and has the following meaning: "Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others”. In accordance with this document, disability should not be considered a reason to compel persons with disabilities to a lifestyle determined by such disability.

They have the right to live independently and to take part in all aspects of life: to have their own home like every other member of the society, equal access to everything: transport, education, information, communications, as well as to public institutions and services [4].

In pursuance of its engagements as a EU member state, Bulgaria implements: National Strategy for Persons with Disabilities (NSPD) (2008-2015), National Strategy for Persons with Disabilities 2016-2020 and Action Plan of the Republic of Bulgaria on the implementation of the UN CRPD (2015-2020) [6, 7, 2]. The analysis of the legal regulations governing the rights of persons with disabilities in Bulgaria shows that as an EU member state our country has implemented the Community’s legal practices in its legislation trying to specify these regulations in accordance with the Bulgarian conditions. Most of the international documents, including CRPD of the UN, are ratified, thus guaranteeing the protection and interest of all citizens, including persons with disabilities, under its jurisdiction. Special legislation is developed, however our general legislation contains provisions aimed at not allowing discrimination. However, despite the modern structure of the laws and regulations, the actual situation in our country *leads to the conclusion of serious discrepancies in the practical application of the legal regulations*, and the main reasons to this end comprise: lack of consistent and targeted investment policy of the government; unnecessary bureaucracy and varied barriers to accessibility in all respects; ineffective coordination with the organisations for persons with disabilities and slow changes in the public mind-set and formation of adequate and modern attitude. In short, we are of the opinion that we can find effective solutions to these problems only by means of continuous dialogue and targeted joint actions of the executive power, government institutions, organisations and representatives of persons with disabilities, with the active attitude and participation of the civil society.

2. Access to Information for People with Special Needs Academic Course

The implementation of the NSPD (2008-2015) requires to introduce disciplines on this topic in universities’ curricula, to improve the access to higher education for all citizens and to ensure opportunities for distance training for people with special needs. The University of Library Studies and Information Technology (ULSIT) has met this need of academic study of students by means of the introduction of such thematic courses. This report highlights a good practice by studying the experience from teaching the elective academic course “*Access to Information for People with Special Needs*” for education and qualification degree “Bachelor”, specialty “Library and Information Management”, introduced during the AY 2011/2012. The course gives students theoretical and practical knowledge on access to information and education for people with special needs and the role of libraries and other cultural institutions in this process. The discipline studies the problems faced not only by people with different disabilities, but also of other groups of people with special needs, for example, elderly people at the age of 65+, people who are sick or suffer temporary disorders, people in isolation due to different reasons, etc. Forms of interaction with the organisations of and for persons with disabilities are presented. Knowledge about the following requirements is taught: accessibility of environment; compulsory instructions for the development of adapted services for people with varied disabilities; financial instruments; legal and other aspects of provision of library and information services to people with special needs. Traditional approaches to library and information service of people with varied disabilities are examined, as well as the abilities of advanced information and communication technologies for ensuring equal access to information and knowledge of all citizens. The curriculum and its topics are updated on annual basis to reflect the changes in the European and national legal regulations, to cover topical matters, while taking into account the interests of the students.

3. Voluntary Initiatives in the Teaching Methodology

Volunteering is cross-sectoral social phenomenon, an exceptional manifestation of civic consciousness, of high ethics and compassion for important causes, people and/or institutions suffering any kind of difficulties. It may be defined as a way of thinking and worldly mind-set to support those in need – without expecting any return. From pedagogical aspect, voluntary work may be considered: as object of study where volunteers learn alone; as subject of study – in this particular case, the volunteer gains knowledge, skills and habits and changes their attitude to the surrounding world through their voluntary activity thus improving themselves as personality.

During the academic course "*Access to Information for People with Special Needs*" classes, in the form of lectures, presentations, videos and materials giving examples from the European Commission's Access City Award, students are provided with theoretical knowledge and information about the practical application of adapted technologies and effective solutions [1]. The lecturers prepare assignments and cases to be solved, good practices of leading Bulgarian and foreign libraries and other cultural and public organisations for provision of access to information, education and culture for all citizens, including for people with special needs, are examined.

Exercises are aimed at developing skills to solve problems, to find interdependencies, to analyse and apply acquired theoretical knowledge in new situations.

We applied *an experimental approach* within the frames of the exercises planned for the AY 2016/2017. The third and fourth year part-time bachelor students studying the discipline were proposed to participate in voluntary initiatives for people with special needs. In order to achieve best results, upon giving such kind of assignments students needed to be given clear and detailed information about the opportunities provided by this assignment and about the approaches for its performance. Several working meetings were organised to acquaint the students with the missions they could participate in. They were required to make an online registration on the *TimeHeroes* website [8] and the *ULSIT team* was established. As a component of the assessment of students' knowledge in the discipline, during the examination, every student made a presentation of the voluntary activity they had participated.

The results from the study process are impressively positive. 34th students were involved in varied voluntary activities. Students showed greatest interest to participate in the *"Be My Guide"* initiative, addressed to improve access to electronic information for the blind [3]. The idea of *"Be My Guide"* was to show blind people the world through the eyes of blind volunteers. Descriptions of different images, pictures and videos, in the form of text, accessible for blind people via screen readers and synthesizer of speech were collected and published on the *bemyguide.org* website. Participating students created 212 descriptions, being 39% of the entire content of descriptions on the *"Be My Guide"* website at the end of 2017. The categories of literatures, sings, food, animal, flags, nature, tourism, movies, etc., were filled-in most actively. Another project in which the students were involved was the initiative *"Give me a Story!"*. It started in 2014 thanks to hundreds of reading volunteers who put the beginning of a rich supporters' fund comprising works of varied topics and genres recorded in audio format. People with sight disorders whose access to books in Bulgarian language was quite limited started to use the created audio fund very actively. Volunteers read aloud and recorded in mp3 format poems, stories, novels, articles, research materials or other works that they liked or that were requested by blind readers. The third project with the participation of students were *Wheelmap* [9] that helped people with locomotor disorders to move more freely across public spaces and to have independent way of life. Subject to pre-registration on *OpenStreetMap*, students indicated buildings, establishments, stores, cultural, educational and other public institutions accessible with people with special needs and wheelchairs. We distinguished the contribution of students in the Active Environment blog. This was a non-profit project aimed at promoting civic participation. In the blog we published texts describing the aims and tasks of the active society, as well as materials on personality development and on good practices of other countries. Students created their own texts-stories about the voluntary actions, articles on personality self-improvement and civic society.

Volunteering influences the formation and development of spiritual and value mindset of students in library and information science. It helps them to rationalize the new role of libraries as partners in personality development and in facing the challenges of the information society.

4. Conclusions

In the *Access to Information for People with Special Needs* Academic Course special attention is given to teaching methods that enhance student empathy and motivation and increase student involvement in a variety of extra curricular activities such as volunteer missions. Students are given the opportunity to give meaning to the study content by means of practical assignments and to support the enrichment of the information environment of blind people, as well as to make other improvements aimed at reaching the social model of interaction with people with special needs ensuring their full-value integration and equal participation in public life. We could highlights course results and proposes the course as a potential best practice for other institutions interested in meeting the goals of the EU strategy as well as their own national efforts to improve accessibility.

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BLIC & CLIC: Bringing Life Into the Classroom Use of Mind Maps on the Chemistry Class

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Abstract

The present article is based on an Erasmus+ project named Blic & Clic which uses mobile learning pedagogy to promote an effective inclusive education. The inclusion of students with special needs in classroom activities is an enriching experience for all students. Mind Maps have been integrated into emerging teaching techniques such as the Flipped Classroom and can be particularly effective with students since it engage them, it encourage creativity and teach how to learn rather than memorizing contents [6].

This research study using Flipped Learning, as pedagogical methodology, was developed in a Chemistry class of the 12th grade. A student with special motor cerebral palsy worked with non-disabled peers used the APP-Popplet, to make the report of the laboratory activity "A Copper Cycle". In a 10th grade class, students with cognitive difficulties and Asperger syndrome prepare aqueous solutions used by their 12th graders colleagues. This study concluded that the activities proposed allowed all students to have new opportunities to deepen and apply their previous and new learning. There was also the promotion of cooperative learning in the development of social and cognitive competences of the students. It increased their autonomy, their organizational management of work, their nterpersonal relations and their motivation for learning.

Keywords: Mobile Learning; Inclusive Education; Mind Maps; Flipped Classroom

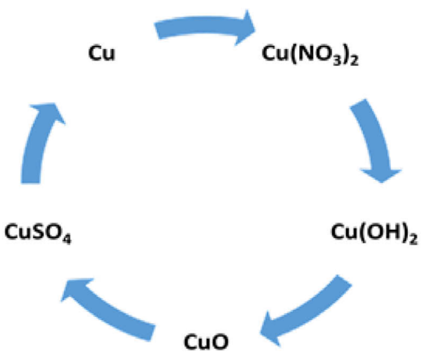
Introdution

Six European schools (Agrupamento de Escolas da Maia - Portugal, Colegiul Tehnic Edmond Nicolau Focsani – Romenia, 1st Lyceum of Rhodes Venetokleio – Greece, IIS M. Filetico – Italy Zsespol Zscol im.por. Jozefa Sarny w Gorzicach – Polond and Toki Halkali Anadolu Imam Hatip Lisesi – Turqy) and the University of Minho have developed an Erasmus+ project in a strategic partnership for innovation. The main goals of this project are to share experiences between teachers and students, to disseminate their practices and to build collaboratively pedagogical innovation practices in learning thanks to the use of mobile devices.

The potential of multimedia applications, adapted to the contexts of teaching and learning, can be seen as important teaching tools in the different dynamics of the classroom [5]. In addition, there is a great popularity and familiarity with mobile devices present features which will enhance potential users [4]. The rise of these resources is a fact that can be explored in the educational process, using the pedagogical model called Mobile Learning [4], [5]. Mobile devices are necessary tools that can be used to facilitate learning. We need them to supplement schools resources, to extend learning process outside the class walls, to prepare students for working life after their graduation [8].

The Education and Training 2020 Strategic Framework [3] emphasizes that educational systems need to provide the successful inclusion of all learners. Students from disadvantaged backgrounds, with special needs or migrants must have an equal chance to succeed. The inclusion of students with special needs in classroom activities is an enriching experience for all students.

Mind Maps have been integrated into emerging teaching techniques such as the Flipped Classroom and engage students, encourage creativity and teach how to learn rather than memorizing contents. [6].These activities used Flipped learning as pedagogical methodology consists of the realization and observation of a sequence of reactions involving the element copper of the Chemistry students of the 12th grade, with or without disabilities. The proposed reaction cycle converts the copper according to the following scheme:



[A] $Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2H_2O(l) + 2NO_2(g)$

[B] $Cu(NO_3)_2(aq) + 2NaOH(aq) \rightarrow Cu(OH)_2(s) + 2NaNO_3(aq)$

[C] $Cu(OH)_2(s) \rightarrow CuO(s) + H_2O(l)$ by heating

[D] $CuO(s) + H_2SO_4\,(aq) \rightarrow CuSO_4(aq) + H_2O(l)$

[E] $CuSO_4(s) + Zn(s) \rightarrow Cu(s) + ZnSO_4(s)$

Fig. 1. Copper Cycle

With the photos and videos taken during the experimental procedure students drew up a report using the APP – Popplet.

Objectives

The goals of the Copper Cycle experiment are: to characterize the reactivity of metallic elements, taking as an example the Copper reactivity; to recognize the importance of recycling copper and the potential of recycling of metals in general and to identify some pollution problems related to the recycling of copper.[7]

Methods

During this activity teacher used Flipped learning as pedagogical methodology. Initially students answered a quiz individually, then they were divided into groups:

students read a text or watch a video about the “Cupper Cycle” [1] (reading and research scenario) (figure 2). After that, they performed the experimental activity, took photos or recorded videos (figure 3) (collaborative and practice scenario).

Fig. 2. Students read a text or watched a video


Fig. 3, 4. Students took photos



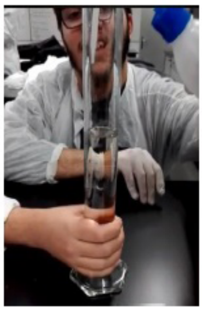


Fig. 5, 6 and 7. Special needs students working (cognitive difficulties, Asperger syndrome and motor cerebral palsy).

Afterwards using the APP Animoto, students produced a video [9], figure 8, with the experiment procedure using the Mind Map, Popplet, students wrote a lab report [2], (collaborative and production scenario) Before starting the report, they divided the different tasks of the report among them deciding who was doing what. Then one of them enter his/her Popplet account, create a new Popplet and add the other colleagues of the group as collaborators. When the mind map was finished, students exported it as a jpg, sending it to the teacher and answering a quiz individually (evaluation scenario).

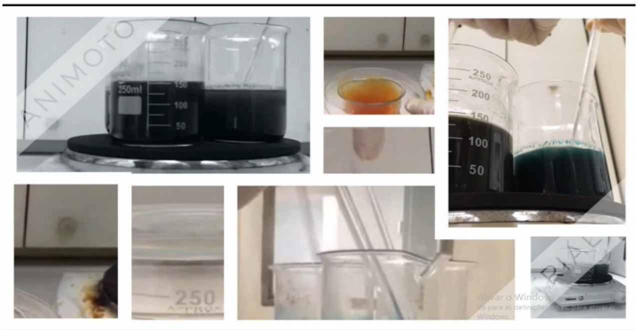


Fig. 8. Example of a video produced by the students

Results

Students used the Popplet mind map to write the experimental activity report, figure 9. Each student was responsible for one part of the report. In figure 9 we can see the distribution of tasks, carried out by the students responsible for the report.

Each student appears in a different colour. The teacher evaluated the preparation of the experimental report done by each student Using the Animoto application, the students produced a video with photos and videos of the practical activity they have performed and added to the popplet.

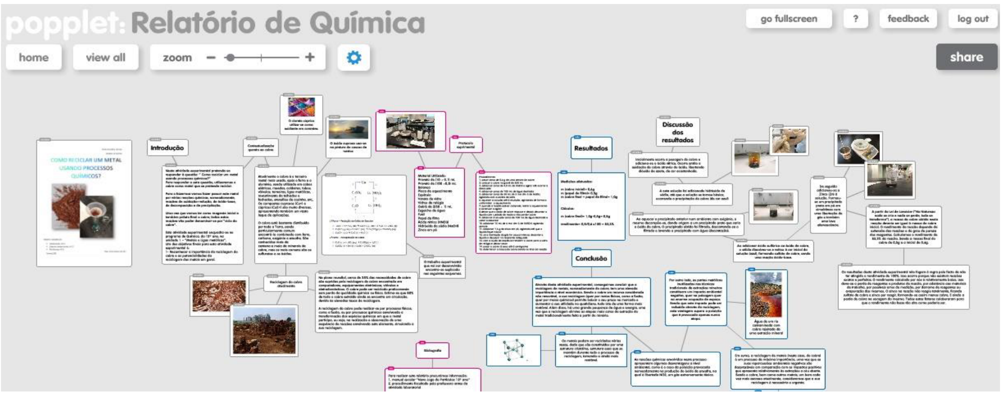


Fig. 9. Lab Report using the Mind Map Popplet

Conclusions

The activities proposed allowed all the students to have new opportunities to deepen and apply their previous and new learning. There were intentional contents somehow explored by the different students according to their competences; there was the promotion of autonomy, organizational management of work and interpersonal relations. Special needs students brought new strengths into the *classroom and* *helped to enhance* a climate of giving. The teacher had a more tutorial role, intervening with those who needed it most and whenever requested. Throughout this process, the students had to reflect on their learning, had to question more, had to reread or revise concepts.

Acknowledgments

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Inclusive Biology Education – How Do Pre-Service Teachers Think about Inclusion?

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Abstract

German school law guarantees barrier-free and equal access to biology education for all students. However, there are still some obstacles for students with special needs, e.g. during experiments or field trips. This results in our research questions: a) How do biology pre-service teachers rate different inclusive settings? b) Do their attitudes and self-efficacy influence their ratings? c) Which reasons do they give for and against inclusion? Positive attitudes can be predictors for the implementation of inclusive structures at school [2]. Self-efficacy beliefs are fundamental for education and teaching [5]. Self-efficacy describes personal judgement, of how well a person can execute courses of action that are required to cope with prospective situations [1]. Therefore, we expected attitudes and self-efficacy to be positive predictors for pre-service teachers' ratings of inclusive settings. Our sample consisted of 119 pre-service biology teachers (M_{age} = 20.5 years; n_{female} = 95). We confronted participants with four vignettes and asked them to rate each setting with ten bipolar adjectives, e.g. positive – negative [6]. We applied a self-report questionnaire on attitudes and self-efficacy towards inclusive schooling [2]. Findings show that pre-service teachers rated the four vignettes differently. Most positively, they rated a child with a learning disability, least positively a student with multiple disabilities. Overall, regression analyses revealed the significant influence of attitudes and self-efficacy in three of four settings. However, in most regression models only attitudes towards the arrangement of inclusive lessons became a significant predictor. At first glance, findings do not support the importance of self-efficacy beliefs. Because our pre-service teachers lack real teaching experience, they might not yet have developed realistic self-efficacy beliefs.

Keywords: biology education, special needs, inclusion, attitudes, self-efficacy

1. Introduction

Following the United Nations, "States Parties shall ensure an inclusive education system at all levels" [9]. In Germany, the inclusion of students with disabilities into regular schools is an important issue. Therefore, German school law has been adapted. In Lower Saxony, now it guarantees barrier-free and equal access to education for all students [3]. However, due to the former separated and exclusive school system, there are still some obstacles for students with special needs. For instance in Bremen, the principal of a high school has sued against the introduction of inclusive classes. She argued that there is still a lack of equipment and staff to ensure successful inclusion. Concerning biology education, there might also be subject-related obstacles. For instance, while experimenting or during field trips. Furthermore, biology classes often take place in specific laboratory classrooms, which might cause problems. Therefore, it seems necessary, to have a closer look at inclusion from the perspective of biology education. Following [8] “there is widespread acceptance that teacher training institutions must ensure that new teachers are trained to teach effectively in classrooms where there are students with a variety of learning needs”. Since we also see the potential pre-service teachers have to implement inclusive attitudes in schools, we focused on aspiring biology teachers. Predominantly three research questions have guided our research:

a) How do pre-service biology teachers rate different inclusive settings?
b) Do their attitudes and self-efficacy influence their ratings?
c) Which reasons do pre-service biology teachers give for and against inclusion?

2. Theoretical Background

Depending on students’ specific disability, the demands on the school environment and on biology classes might differ. Seifried [6] developed vignettes for four specific inclusive settings. Each setting described a student with its specific special needs.

Teachers were asked to rate each setting. A significant difference in the ratings of these settings was found [6]. The assessment depended on the type and severity of disability. Most positive rated was the inclusion of a gifted student with behavioural problems. Lowest rated, was the inclusion of a child with multiple disabilities [6]. In our study, we expected a similar rating of these four vignettes in the context of biology classes.

Attitudes are important concepts in classroom practices. They can drive classroom actions and a person’s individual actions [4]. Positive attitudes can be predictors for the implementation of inclusive structures at school [2]. Self-efficacy beliefs are fundamental for education and teaching [5]. Self-efficacy describes the personal judgement of how well a person can execute courses of action that are required to deal with prospective situations [1]. Former experiences of success or failure influence a person’s self-efficacy. In-service teacher’s attitudes and efficacy significantly predict participant’s intentions to include learners with disabilities [7]. Therefore, we expected attitudes and self-efficacy to be positive predictors for pre-service teachers’ ratings of inclusive settings.

Our last qualitative research question focused on pre-service teachers subject-related concerns to include learners with disabilities in their biology classrooms.

3. Methods

We applied a self-report questionnaire to the participants. The evaluation took place at the University of Vechta. There was only one measurement. Our sample consisted of 119 pre-service biology teachers (M_{age} = 20.5), 95 of them being female.

In our questionnaire, we confronted the participants with four vignettes, which were adapted [6]. All vignettes related to biology classes. Pre-service teachers rated each setting with ten bipolar adjectives, e.g. ranging from positive (=3) to negative (=-3).

A 7-point Likert scale was applied. Participants also gave reasons for their ratings.

The first vignette characterized a gifted student with behavioural problems. This child quickly felt under-challenged and reacted with impatience and aggression towards classmates and teachers. The second setting described a student with a learning disability. This child had problems with reading and calculating. Therefore, it needed additional explanations and more time. The third vignette characterized a visually impaired child. It was not able to read the normal typeface and learnt braille.

This student needed additional descriptions and had orientation problems, even with everyday actions. The last setting was about a child with multiple disabilities. This child communicated via face and body language, needed a wheelchair and was fed artificially. Cronbach's alphas ranged for these vignettes from $\alpha = .867$ (child with learning disability) to $\alpha = .934$ (visually impaired student).

We measured attitudes and self-efficacy with an adapted version of the KIESEL questionnaire [2]. Each construct consisted of three subscales with four items. A 5-point Likert scale was applied from "I do not agree" (=0) to "I completely agree" (=5).

In detail, we looked at attitudes with regard to a) the arrangement of inclusive lessons ($\alpha = .770$), b) effects of inclusive lessons ($\alpha = .727$) and c) the influence of student behaviour on inclusive lessons ($\alpha = .690$). The subscales on self-efficacy focused on self-efficacy regarding a) the arrangement of inclusive lessons ($\alpha = .765$), b) dealing with classroom disruptions ($\alpha = .650$) and c) the collaboration with parents ($\alpha = .651$).

4. Findings

One-way repeated-measures ANOVA (four levels) showed a significant difference in the ratings of the four settings ($F(2.7, 308.0) = 8.98$, $p < .001$). The child with learning disability ($M = 0.66$, $SD = 0.94$) and the visually impaired student ($M = 0.39$, $SD = 1.2$) were rated significantly more positive than the student was with multiple disability ($M = 0.01$, $SD = 1.25$).

A multiple regression analysis was carried out for each setting. Predictors were the subscales on attitudes and self-efficacy. Overall, regression analyses revealed a significant effect for three settings. For instance, the regression became significant for the vignette "learning disability" ($R^2 = .28$, $F(6, 108) = 6.95$, $p < .001$). However, only the subscale on attitudes towards the arrangement of inclusive lessons was a significant predictor ($\beta = .33$, $p = .024$). In the case of the student with multiple disabilities, we also found a significant effect ($R^2 = .26$, $F(6, 108) = 6.15$, $p < .001$).

The subscale on attitudes towards the effects of inclusive lessons appeared to be significant ($\beta = .28$, $p = .013$). Subscales on pre-service teachers' self-efficacy did not significantly contribute to the ratings.

Regarding inclusive schooling in biology classes, pre-service teachers expressed several concerns. Overall, they mentioned 18 issues that might become a problem specifically for inclusion in biology classes. However, they also gave 24 reasons why biology education is particularly suitable for inclusion (e.g. subject is concrete, vivid, arouses interest). Negative comments referred to experiments that might be too dangerous. One participant even gave into consideration the issue that the teacher should be able to pay attention to all students during experiments.

5. Discussion

Findings indicate that pre-service teachers differentiate between inclusive settings. It makes a difference to them, what kind and severity of disability students in their biology classes have. However, the sequence of ratings was different from the findings of Seifried [6]. One explanation might be that in our study we asked aspiring biology teachers. Biology lessons place different demands on the students (e.g., during experiments). Furthermore, most pre-service teachers might lack real teaching experience. However, findings show that it is worth taking into account different forms of disabilities in research. Students' specific special needs make a difference for educational settings (e.g., biology education). Furthermore, biology teachers have to meet the demands of individual students at school.

As we had expected, attitudes can be predictors for pre-service teachers' ratings of settings. In particular, attitudes with regard to the arrangement of inclusive settings became significant. Pre-service teachers who believe that biology lessons can be made inclusive to all children show significantly more positive ratings. In our last setting (multiple disability), attitudes towards the effects of inclusive lessons became significant. Therefore, a differentiated look at attitudes might be of benefit as well.

However, pre-service teachers' self-efficacy did not significantly contribute to our regression models. Since pre-service teachers lack real teaching experiences they might not yet have developed a realistic self-efficacy. Here, it would be interesting to follow the progression of their self-efficacy during university studies and in their first years at school. Specific trainings could support them with teaching methods to meet the diversity of students and develop adequate self-efficacy.

Overall, only few biology specific reasons for or against inclusion were identified.

Depending on the setting, reasons differed in quantity and quality. We appreciate that pre-service teachers emphasized reasons for the inclusion of children with special needs. They argued that biology is a vivid, illustrative and concrete subject. However, possible dangers, e.g. during experiments, were mentioned, as well.

Finally, we are convinced, that politics and schools must work together to enable barrier-free and equal access to the German education system. Together, they can create a framework to enable inclusion. However, biology teachers need additional support (e.g., teacher trainings). Together, we can contribute to successful and meaningful inclusion in biology classes.

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Inclusive Pedagogical Books: Strategies and Options to Build Accessible Resources

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Abstract

Education, in Portugal, suffered recent legal changes that increased inclusion principles for students with Special Needs. Those laws generate new opportunities and actions, involving new pedagogical resources that must be accessible to children with or without disabilities. There are still few of these adapted products to use in the education context, whereby a multidisciplinary team from the Polytechnic Institute of Leiria (composed of teachers, researchers and students) is developing the project Learning Products for ALL (ProLearn4ALL). This project intends to create ludic and pedagogical products that create awareness in children from Primary School toward inclusion and respect for people's diversity. From those new products, we emphasize books with a pedagogical inclusive mission in their subjects and also with strategies and accessibility options that allow them to be explored by ALL users, trying to reduce communication barriers. For such a result, we assumed Design for ALL basic principles, creating products that respect human diversity. To empower this work, Education, Arts and Social Sciences get together, validating productions in a sequence of critical reflection, dialog and continuous improvement. This process occurred in several stages, starting from the texts made by higher education students to focus on awareness of disability. Those initial texts resulted in simple but accessible prototypes to be developed by Arts and Design students, with augmented books with different communication possibilities, such as bigger font letters, Braille, audio text, symbols and haptic illustration. All these communication strategies and options served the purpose of making books for children that can be used at school, at home, or in any other significant learning context where children can use these books as ludic and pedagogical objects.

Keywords: Inclusive Education, multi format books, accessible communication, ProLearn4ALL

1. Introduction

Inclusion is a basic principle which should frame any sort of educational response, considering an approach based on the rights of every student, seeking to ensure that children and young people with specific needs are not excluded from regular education.

The main focus is on the quality of strategies and methodologies adopted in the education that is provided to all students, instead of it being placed on the type of institution that receives the children, aiming to consider the presence (access to education), participation (quality of the learning experience) and the success (processes and results of learning) of every student" [1, p. 12].

In Portugal, the recent legal changes in the scope of Inclusive Education come to reinforce these universal principles and values for an education adjusted to the characteristics of each student, underlain by the "investment on an inclusive school where each and every student, regardless of their social and personal situation, finds the answers which allow them to acquire a level of education and training that facilitates their whole social inclusion" – Decree-law no. 54/2018 [7, p. 2918]. This paradigm of inclusive character allows for the implementation of different support measures and appropriateness for the students who, according to their individual characteristics, may benefit from them. Thus, a prominent place is taken by the inclusive educational practices which implement support strategies based on principles of equity, social cohesion, conviviality and diversity.

As well as the methodology to be adopted by the teachers, the need to make available accessible resources is evident, which provide a real and effective response to all students, regardless of their characteristics and limitations.

2. Pedagogical resources accessible to different student profiles: children's books

Given that the school is an institution which receives all children, it is necessary to consider the way in which pedagogical resources are created and used there, in order to allow the access and benefit of students with different learning profiles.

When creating resources, the recognition of difference and singularity, the inclusion of diverse perspectives and the input of who experiences the difference, the context for which it is being worked on and the possible resulting impact must be taken into account. Dimensions of a design process intended to be inclusive, and which stands for something that becomes functional to different individual characteristics, is something that becomes functional for all.

Over the last few decades, the area of children's literature has produced proposals that seek to present alternatives to conventional books [9]. However, innovative resources directed towards every student, with or without a disability, are scarce, hence arising "(…) the need to structure and adapt attitudes, strategies and materials in the sense of minimizing the differences and giving children the possibility to increase their self-esteem, autonomy, and ease or eliminate their incapacity to communicate and socialize" [3, p. 61].

For such, it is necessary to respond to the accessibility characteristics of different student profiles, according to their needs, difficulties or disability domains (visual, hearing, cognitive and motor), in the way that is structured the intervention line for the project introduced henceforth.

For blind students, the didactic resources must meet perceptive and communicative characteristics that underlie the creation of tactile images, haptic illustrations which allow "to explore multiple experiences of our body in contact with objects and the environment" [9, p. 79].

In the case of deaf students, attending to the particularity of a community which affirms itself with a language of its own (Sign Language), the opportunities for inclusion come associated with the potential of a bilingual education, which translates into advantages for the deaf and for listeners, by powering the interaction among the students of both communities, enriching their personal, cultural and social relationships [6].

Students with a cognitive impairment can resort to the pictograph illustrations and systems which, besides being appealing complements that facilitate the exploration of resources, aid memorization of the contents explored in the books [3].

Students with a motor impairment can also benefit from these alternative or increased communication systems according to their motor and perceptive characteristics, being it still relevant the format embraced by the book itself, which includes such basic aspects as flicking through the pages.

For non-disabled students, it is also possible for these characteristics to improve the access to books by stimulating the different senses.

3. The Project ProLearn4ALL

ProLearn4ALL – Pedagogical kits for ALL is a Portuguese project developed by the Polytechnic Institute of Leiria (IPLeiria), in partnership with the Polytechnic Institute of Coimbra, the *Cooperativa de Ensino e Reabilitação de Crianças Inadaptada* (the CERCILEI) and the Municipal Hall of Leiria. It arises with the objective of creating ludic-pedagogical products for the awareness of diversity and the characteristics of disability, directing their action to an age group of high intervention and attitude formation potential (ages 6-10). "Developmental and social psychological research has shown that children begin to reveal biases that favour their social group and prejudiced attitudes around the age of 5 years" [8, p. 88]. Thus, the intervention in the Primary School expects to empower citizens who are more knowledgeable of their peers' characteristics and difficulties, and, consequently, inclusion attitudes. Hence, in accordance with the pedagogical approach to the characteristics of the various domains of disability (visual, hearing, cognitive and motor), the project ProLearn4ALL intends to provide the principles and challenges of inclusion, with solid proposals for accessible and innovative didactic resources [5]. In accordance with these framing lines, the approach performed throughout the creation of the ludic-pedagogical resources is then described, particularly the accessible books, which was the aim of several options considered in virtue of the principles of diversity and inclusion.

3.1 Creation process of accessible books

The process of creating accessible books began with the gathering of existing resources, carried out by students of the course of School of Education and Social Sciences of IPLeiria .These students identified a shortage of inclusive and accessible or multi format books for different student profiles. In face of this reality, they created new proposals directed at the specific audience of the project and forwarded them to students of the illustration course and Graphic Production of the School of Art and Design of IPLeiria, who worked on them and improved them.

The methodology used in this process was based upon problem solving, focusing the learning on finding solutions for a complex problem, which does not have only one correct answer. The learning of contents was carried out through experimentation, encouraging reflexion on what was learned and the efficacy of the approaches carried out. The starting point for the learning was, therefore, a question/problem and not a theory [4].

In order to optimise the creative process of the students involved in the creation of graphic material, specifically the creation of books which introduce characters associated with different types of disability, it was necessary and useful to have the students understand some aspects of different profiles of people. In the search for creative solutions, the aim was to recreate situations which put each student in the place of a person with a certain kind of characteristic, causing a reflection and production in which one relates to the other. For instance, one of the preparation activities consisted of proposing students to work blindfolded. In the first phase of the activity, each student tried to create recognizable silhouettes with clippings of materials with different tactile characteristics, and in the second phase each student was challenged to identify the clippings produced by their colleagues. This activity allowed them to reflect on the shapes they thought to be producing and the ones they did in fact produce, on specific characteristics of materials (colours, textures, thicknesses), on the recognition of shapes, expressiveness and possibilities in joining the shapes and materials in favour of a visual and tactile communication.

Taking into account that “Most tactile images are thought out by sighted people who try to put themselves in the place of someone who doesn’t see, seeking to imagine how the blind can ‘read’ with their hands.” [9, p.81], the amplitude and contribution of this activity comes framed as “a vague idea of experiencing the world by a blind person” (*ibidem*), as a way to lead students to question what to really build, so that a child with a visual disability may benefit from these books. We sought to encourage a research and production that led them to want to test their creations, putting themselves in the role of someone who is going to use the materials, so that this reflection could lead to criticism and new productions, a reflection in the doing. An activity proposed to another group of students, which also started from a set of constraints was the creation of visual and tactile illustrations from printing using techniques of serigraphy and engraving. Reflecting on the simple image communication, using only two colours and a embossing, they were asked to develop crossings of visual information and haptic information in a story, seeking the expressiveness and creation of points of interest. The group that developed this activity had the particularity of including a blind student as an active participant in the search for solutions. This activity allowed us to reflect on: the communication process through simplicity, the production of accessible images, the inclusion of Braille, the legibility of letters and typographic fonts, the production phases and the workshop processes for the production of multi format books. Placing students in the role of producers and performers has led to a gain of awareness and appreciation of the practical processes, leading them to perceive the continuum that goes from the conception of a graphic object of communication to the final printed object. Giving the students the role of producers and executers led to a gain of awareness and appreciation of the practical processes, allowing them to understand the continuum that goes from the conception of a graphic object of communication to the final printed object. In the final object, the validity of the productions was observed through tests on the images and embossing in the books.

As a way to raise awareness and produce, other activities were proposed to the students, such as the creation of products accessible to children with motor, hearing and intellectual disability. Concerning the first, the fact that one of the participating students had significant motor limitations was of great relevance.

The activities resulted in prototypes, which were analysed by the team of researchers, and used as intermediate results in the process of developing accessible books. While analysing all the work developed with the students, from the texts that served as a basis for the creation of characters and illustrations to the graphic prototypes, the researchers selected the options which they thought to be the best exploring and learning opportunities. Options were combined and directed to children with disability, their peers and the adults with whom they interact, so that the same product could be enjoyed by all children, avoiding that some would feel, due to their characteristics, excluded from the class.

In this sense, it was sought that books contained different formats and languages, namely: text in black, bold, text in Braille, pictograms, videos in Portuguese Sign Language, clear illustrations (with a reduced number of colours, lines and simple figure-background relationships), textures (rough, smooth, soft, hard, warm and cold) and three-dimensional solutions (such as the pop-up), assuming that “children are more interested in the tactile exploration of multisensory figures and three-dimensional figures rather than figures glued onto the pages.” [2, p. 79].

Apart from the described elements, the characters in the books were created so that the ethnical diversity could also be represented.

4. Final reflections

The creation of accessible and inclusive pedagogical books depends largely on their mentors, in other words, aesthetic sensibility combined with idealization and creation options and strategies, receptive to the possibility for continuous improvement of the creation process of these resources. Those reflections, produced during and after several stages of exploration and production, allowed for a constant process of validation and exclusion of solutions.

Aware of the limitations of any pedagogical resource, in what concerns an effective usage by ALL users, it is recognized that it is possible to improve the product options according to the necessities of the different profiles, through various languages which complement each other creating one single message.

The reflection throughout the book production allowed the analysis of the choices and performed tests, the prototypes arising as a means to establish hypotheses that provided answers in the search for communication.

The books created in the project are understood as ludic objects which will optimise the processes of finding different types of information and the characteristics of disability and diversity, allowing the children to reflect on the fact that communicating will also have to do with knowing how to see the world through different perspectives.

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Science Teachers Professional Development

Digital Story-telling to Improve 21st Century Skills: Pre-service Science Teachers' Reflections

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Abstract

In recent years, new methods and techniques have been widely used in education in order to increase the effectiveness of learning in various countries. The use of digital technologies in implementing these methods is also an important approach in terms of developing 21st century skills and adapting to technological developments. In this context, science education is one of the main areas where the use of technology is crucial. It is important that pre-service teachers who will be educate future generations to have 21st century skills. It is also important that they gain experience to synthesize these technology skills with their field knowledge. For this study, third-year pre-service science teachers developed digital stories on the striking scenes of scientists' lives, which allowed them using their field knowledge and apply their technology skills that they gained throughout undergraduate education. The aim of this study is to examine the experiences of science pre-service teachers in terms of 21st century skills. This study is designed as a phenomenology research. The criterion sampling was used from the purposeful sampling methods to determine the participants. The research was carried out with forty 3-year pre-service teachers from Science Teaching Department of a public university in Turkey during the fall semester of 2018-2019 academic years. Digital stories have been prepared in relation to a striking part of the life stories of scientists who had research on subjects from the secondary school science curriculum. The study was completed in a period of approximately 3 months. In this study, digital dairies were used as the data collection tool. Dairies were analyzed using content analysis technique. Reflections of pre-service teachers that they were provided in dairies were examined in terms of 21st century skills. Three main categories given by P21 (2008) were used as themes: learning and innovation skills, information, media, and technology skills, and life and career skills. The preliminary analysis revealed that digital story-telling process contributed all three main categories under the following sub-categories: critical thinking and problem-solving, collaboration, information-media-ICT literacy, flexibility, productivity.

Keywords: Digital story-telling, science pre-service teachers, digital dairies

1. Introduction

Skills that are expected and desirable from today's generation are generally called as 21st century skills.

The P21 (2008) lists these skills under three main categories: learning and innovation skills (creativity and innovation, critical thinking and problem solving, communication and collaboration), information, media, and technology skills (information literacy, media literacy and ICT – information and communications technology literacy) and life and career skills (flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, leadership and responsibility) [10, p. 13]. These skills are also emphasized in today's educational environments and are required by the learners. The digital story approach is a current practice in developing most of the mentioned skills [8].

Nowadays, with the increase in the access to technology and the development of Web 2.0 tools, educators who do not have programming or advanced technology skills can also produce their own educational contents by using these tools [4]. Use of digital story-telling, which is created by bringing video, picture, written or oral narratives or dialogues, and music together in a story-building framework, has accelerated as a means of expression in different areas with the emergence of Web 2.0 technologies [12].

What distinguishes the digital story method from traditional storytelling is that it is supported by digital media, visual and audio materials. Digital story use in teaching is an educational technology that promotes several 21st century skills such as technology literacy, creative thinking, effective communication and productivity [6].

The process of creating a digital story includes creative skills such as determining a topic, researching the subject and creating scripts [7]. Those who prepare a digital story, not only have a unique experience, it is also revealed that this experience contributes to the person's various skills such as research, organization, expression, communication, technology, presentation, cooperation, creativity and imagination [5, 11, 14]. The usability of digital storytelling in schools has been supported in various studies [e.g., 1]. Furthermore, the method of preparing digital stories is seen as an effective pedagogical approach that has been used for a long time in different countries [13].

Like different areas, the use of digital technologies in education has become a necessity. New methods and techniques have been widely used in education in order to increase the effectiveness of learning. One of the new methods that is widely used in education is the digital story-telling. In many studies on digital storytelling, it is emphasized that this approach is a powerful and effective tool that can be used in educational environments [2, 9].

Studies investigating the effect of digital storytelling on educational outcomes present that this method supports students' creative thinking and imagination skills, increases academic achievement and motivation [3, 7, 16]. In addition, digital storytelling contributes to digital literacy skills [7]. Digital storytelling offers opportunities such as providing diversity in classroom practices, personalizing the learning experience, supporting student-centered teaching, helping to explain complex issues, and creating easy and inexpensive learning environments [17, 18]. For this reason, it is important to use digital storytelling in classroom applications. However, when the studies in science education are examined, there are not many studies available about digital story-telling [15]. It is believed that this research will contribute to the field in terms of using this method for science teaching, since it is a relatively new application for science education.

In this research, pre-service science teachers created digital stories on the striking scenes of scientists' lives. This method was used to support pre-service teachers better conceptualizing scientific concepts and understand the nature of science better.

Participants' reflections about the process of preparing digital stories were analyzed to determine which 21st century skills of pre-service teachers are supported by this method.

2. Methods

2.1 Study Design

Phenomenology provides an in-depth understanding of the meaning and nature of our daily experiences (Patton, 2014). This method was preferred, since in depth investigation of pre-service teachers' digital story creation experiences is aimed.

2.2 Participants

The research was carried out with forty third year pre-service teachers from Science Teaching Department of a public university in Turkey during the fall semester of 2018-2019 academic years. The criterion sampling was used from the purposeful sampling methods to determine the participants. The primary criterion is that pre-service teachers have taken the Computer II course and are taking Special Teaching Methods I course.

2.3 Process

Digital stories have been prepared in relation to a striking part of the life stories of scientists who had research on subjects from the secondary school science curriculum. Initial training has been provided about nature of science, the properties of scientific knowledge, technology and preparing digital stories by two experts and feedback was provided throughout the process. The study was completed in a period of approximately 3 months.

2.4 Data Collection Tool

In this study, digital dairies were used as the data collection tool. Nine probes regarding research process about the scientists' life, writing scenarios, creating the digital story, problems encountered in this process and their suggestions to improve this process of preparing the digital story were given in the dairies for participants to fill. Dairies were collected after their experience of preparing a digital story.

2.5 Data Analysis

Dairies were analyzed by content analysis technique. Reflections of pre-service teacher that they provided in dairies were examined in terms of 21st century skills.

First, one of the researchers read through participants' responses and coded under the pre-determined themes, which are the three main categories provided by P21 (2008). Then, two researchers worked on participant quotes to decide sub-categories and finalized codes based on participants' explanations.

3. Findings

Three main categories given by P21 (2008) were used as themes: learning and innovation skills, information, media, and technology skills, and life and career skills.

The preliminary analysis revealed that digital story-telling process contributed all three main categories under the following sub-categories: critical thinking and problem-solving, collaboration, information-media-ICT literacy, flexibility, productivity. Some of exemplar codes and quotes from participants are given in Table …

Themes (categories)	Sub-categories	Exemplar Codes	Quotes
learning and innovation skills	collaboration	support	After finishing the pitching and voice-over, I asked my classmates for the suitability for the grade level. *Participant 1*
information, media, and technology skills	media literacy	visuals	Since our script was starting with the time the scientist was born, we uploaded photographs of that period and tried to create scenes reflecting that period. Since the subject is more related to space, sky and solar system, we used photographs and gifts related to these concepts. *Participant 3*
life and career skills	productivity	Video creation	I have both learned working with different technologies and created an educational digital story. In my teaching life, I would like to give more space to these types of materials. *Participant 12*

4. Discussion and Future Directions

The findings of this study align with the existing literature in terms of supporting development of 21st century skills [7, 11, 14]. Future studies can be conducted on using digital stories produced by pre-service teacher in actual classroom settings and student outcomes could be investigated.

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STEM Education: Future and Current Challenges for the Preparation of STEM Educators

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Abstract

Several studies have shown that the combined education in Science, Technology, Engineering, and Mathematics (collectively known as STEM) is fundamental in preparing knowledgeable and technology savvy individuals who will become active citizens. As a result, STEM education is receiving increased attention and interest in recent years and the interest in STEM design models is literally exploding across the education landscape, leading to curriculum reorganization through STEM initiatives. In these models, the role of teachers is one of the most important factors in ensuring excellence in STEM education. A STEM savvy educator needs to show both deep content knowledge in STEM subjects and mastery of all the required skills and competences to teach these subjects well. As a result, professional development of educators is critical for designing and implementing STEM education concepts and programs. In this paper, the current trends in Teachers Professional Development for STEM education are identified and a brief overview of the state-of-the-art is given. In addition, challenges and potential future areas of research are identified, proposing a research methodology, which aims to identify skills and competencies for STEM educators, while taking advantage of the European Framework for the Digital Competence of Educators (DigCompEdu).

Keywords: STEM education, teacher professional development, skills and competences, DigCompEdu

1. Introduction

STEM (Science, Technology, Engineering, and Mathematics) education constitutes a learning approach, which integrates the content and skills of different disciplines, aiming to introduce into the teaching of Mathematics and Natural Sciences, which are vital for a basic understanding of the universe, Technologies and Engineering Sciences, which are the means of interaction for human with the universe. This interdisciplinary approach promotes a learning environment for individuals to acquire not only 21st century skills, but also to have the opportunity to create new skills, using real problems and situations in order to address global challenges that citizens must understand [1].

Over the past years, there has been a growing interest in STEM education, due to the lack of student achievement in STEM subjects [2] and thanks to innovations on economic growth of nations and the importance of individual preparation to work in the technologically advanced world [1]. As a result, interest in STEM design models is literally exploding across the school-based landscape, supporting curriculum reorganization through STEM initiatives [3]. These initiatives include a shift from teaching students to remember and execute isolated facts and skills, to learning students to experiment as scientists, engineers and mathematicians [4].

However, these kind of educational reform movements require remodeling of the educational process. Based on the innovations that the STEM approach promotes, several challenges have created in order to be supported; educator preparation is one of them [5]. Additionally, since the role of educators (trainers, teachers and tutors) is of strategic importance, especially when it comes to acquiring technical and behavioral skills [6], there is a greater need for well-qualified STEM educators who understand what is needed and how to teach relevant and high-quality STEM courses.

Towards this direction, the purpose of this paper is to present the current trends concerning Teachers Professional Development for STEM education and the emerging research challenges. In addition, a proposed research framework for mapping skills and competencies for STEM educators is presented, aiming to facilitate the design of effective Professional Development Programs for STEM education.

2. Professional Development for STEM Educators

Over the past years, Teacher Professional Development has emerged a recognised area of research, due to its importance for the learning process and its influence on student achievement [7]. In the professional development literature that is specific to science, inquiry-based approaches that emphasize on subject-matter content knowledge to deepen educators' content skills are suggested for high quality teacher professional development [4], [8].

Furthermore, studies have shown that experiences in informal learning environments increased teachers' confidence and positive attitude toward science [9]. In addition, although student achievement in STEM teaching is more effective when teacher develop learning communities in their schools, in most teacher preparation programs offer limited experiences in such informal settings [10].

In the recent literature, the research efforts that exploit Teacher Professional Development for STEM education focus on different areas based on specific needs.

For example, in [11], a model called s.t.e.m. (support, teaching, efficacy, material) was used, providing useful information for the teachers, focusing on the teaching category, the content knowledge of the teachers. In [4], a professional development program was designed, aiming to improve secondary science and mathematics teachers' competence in using a problem-based approach in the teaching of STEM, while in [5], a professional development program for teachers was developed, focusing on improving teachers' confidence towards knowledge and efficacy for teaching inquiry-based STEM. In iQUEST project [12], which aimed to promote student interest and attitudes toward careers in STEM, a professional development model was also designed and implemented, with the aim to train middle school science teachers the use of the technology as a critical part of student learning through integration of innovative technology experiences in formal science settings. In [13], a professional development series for STEM teachers was also developed focusing on the effective use of technology combined with engineering.

As we mentioned, all the above-mentioned research efforts enlighten different aspects of the topic under consideration. However, as the effective use of technology in education and the development of effective educational learning environment require comprehensive expertise in technology, pedagogy and content knowledge

[14], none of them offer an integrated view of what an educator needs to know in order to be an effective STEM educator. Thus, there is a need for further research and discussion on the knowledge, experiences, attitudes and competences that educators need in order to effectively teach integrated STEM courses [11].

3. Research Challenges

Taking into consideration all the above, as STEM approach is being increasingly used and based on the innovations that promotes, several challenges emerged that require further investigation concerning the preparation of STEM educators. Based on the literature, more integration of content is taking place in teacher education programs in mathematics and science methods courses [11]. Although, the research on teaching integrated mathematics and science provides a good basis for teaching integrated STEM education, the biggest difficulty, is that many educators do not know how engineering skills are used in industry, so they cannot relate them to their students or deploy them properly as part of an effective STEM strategy [15].

In addition, STEM educators may have different academic background; as a result, the prior content knowledge may different. Thus, the curricula of the Professional Development Programs for STEM educators may differ based on the specific needs of the group of educators. Towards this, a creation of a competence profile for STEM educators may facilitate the design and development of such training programs.

Different Competence Frameworks have been developed describing competence profile for educators, such as the European Framework for the Digital Competence of Educators (DigCompEdu) [16], which describe a set of digital competences specific to educators' needs. However, the focus is on digital competences, aiming to make an educator able to exploit the digital technologies for enhancing and innovating education, without focusing on technical skills, which is an important factor for a STEM educator.

In contrast, studies have shown that educators lack confidence in delivering science materials and encounter difficulty in gaining students' interest to study science subjects; there is also evidence for a similar association between confidence, anxiety, and efficacy with teacher effectiveness [5]. Thus, there is also the question of the use of STEM approach in educational practice and the appropriate preparation of educators not only for the required technical knowledge and skills, but also for the design of appropriate educational activities that take advantage and feel confident with the STEM integrated approach.

Studies have shown that educators who work in strong learning communities are more satisfied with their careers and are more likely to remain in teaching long enough to become accomplished educators [17]. Additionally, since many studies refer to active interaction and engagement within informal settings as a positive impact for STEM educators effectiveness [9], [18], the research on how active interaction and engagement within communities or online communities may enhance STEM educators' professional development could be an interesting research topic and could bring innovative pedagogical approaches for Professional Development for STEM educators. Thus, future research areas concerning Professional Development of STEM educators should focus on both critical and practical questions. Such questions could be the following: *What are the skills and competencies influencing educator effectiveness? What difficulties does an educator face in his/her attempt to teach STEM related courses? In what ways do educators develop their skills and competences? How does a community of practice affect the educator's competence development?.*

4. Research Approach

Based on the aforementioned sections, there is an interest in the educational community towards STEM approaches and as a result the effective preparation of educators is a core issue. Thus, there is a need for systematic research in order to answer the emerged research questions, such as:

"What are the specific skills and competences, which are needed in order for someone to be an effective educator of STEM related courses and how individuals can acquire these competencies in informal learning environments such as communities of practice?"

Mapping the required skills and competences a STEM educator needs and investigating how he/she may enhance these skills and competences through informal settings, will lead to more structure training programs in the broader aim to enhance scientific and technological dexterity in fighting exclusion in the forthcoming technology-intensive society and to develop technologically savvy citizens.

As this research aims to investigate a new phenomenon, it is necessary to adopt an approach that would allow exploratory research [19], which would improve and extend qualitative findings based on quantitative data through a tool, develop a typology or classification, and identify procedures for experimental intervention from qualitative findings [20]. This is going to be a sequential exploratory design, as it will try to define the variables and qualities of an unknown phenomena and the first phase of the research will be used to build the second stage of the research design.

Moreover, it is worth mentioning that the European Competence Framework of Educators (DigCompEdu) will be exploited, aiming at commonly recognizable research results and developing a competence profile of STEM educators alongside with a training outline. Participants will be STEM tutors and as ethical issues may arise and need to be addressed during all steps of the research process, participants will be will be informed for the purpose of this research and how they will be involved in the research data [21].

The data analysis process includes three stages. The first stage is the primary qualitative stage, where semi-structured interviews, a concept mapping assignment and document analysis will be used. The next stage is the secondary quantitative stage, where a survey and statistical qualitative analysis will be performed. Finally, there will be the integration phase, in which the two strands of data will be connected and will extend the initial qualitative exploratory findings. The final joint display will be included to integrate data focused on the main research question. Fig.1 illustrates the two phases of the research, describing the methods and the data collection for each phase.

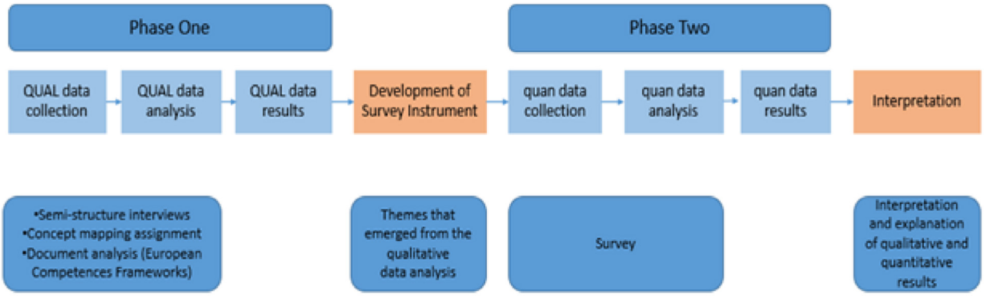

Fig. 1. Exploratory sequential mixed methods design

5. Conclusions

In this paper a brief overview concerning Professional Development for STEM educators was presented, in order at first, to identify the current and future research challenges within this topic and then to provide an research framework regarding the required skills and competences of a STEM educator. This framework included the research questions, the research methodology and the proposed method of data collection and analysis. Finally, we believe that the results of this research are intended to contribute the research and educational community.

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Teachers and Technology – Be Aware or Beware?

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Abstract

Today, in the digital age, the emerging information and communication technologies (ICTs) reshape human life significantly. Fundamental changes reflect in humans' behavior and worldviews. In the field of education, the impact of ICTs manifests on the four components of education: teacher, learning environment, student and curriculum. Each of these components is affected by the digital age. The teachers' identity is a critical component, that can throw light and explain why the field of education is still far behind when it comes to digitization and reshaping education. In this paper, we apply a known SAMR (Substitution, Augmentation, Modification and Redefinition) model in order to assess the above components of education in the context of digitization. Teachers' testimonies are used to place each of the mentioned components at its specific SAMR level. The teachers' testimonies verify the major differences between the way the teachers adjust to the digital age and the way their students do. The criteria found to be the main implication in the interviews resonates why each of the mentioned components is in a different SAMR level. To succeed in reshaping education to fit the digital age, and reach digitalization, all the components described should reach the highest level of SAMR – redefinition. The difficulty lies within the contingent relations between the components. When one independently progresses, others are still behind blocking other components' progress as well.

Keywords: Teachers' Identity, Teachers' Worldview, Digital Age, SAMR Model, Science Teachers

1. Introduction

The emerging of information and communication technologies (ICTs) reshape human behavior [1]. We live on the age of the digital revolution [2], which nature is not completely clear yet. Scientific revolutions yielded a substantial impact on human history; they involve the human consciousness and result in fundamental changes to peoples' worldviews [3]. The development of ICTs brings to blurred lines between the physical and digital worlds, which has an impact on the personal identity of individuals [4]. Education is going through a massive transformation because of the digital revolution [5]. Unfortunately, the transformation in education, as opposed to other fields that were affected by the digital revolution, is still far behind and education remains closer to its irrelevant, traditional form. Teachers' identities and worldviews are the key to understand how to reach the desired transformation in education [6].

Their experiences and skill sets are used by their students to prepare them for the real-world. New perceptions of the teacher's role are being consolidated [7], when teachers required to adjust to a new role [8]. The teacher has received an important mission, as the one who leads the transformation in education, therefore, teacher's readiness to this sort of shift is a crucial aspect to examine.

The technological enhancements change the way we learn; thus, education should refer to as a lifelong process, that happens inside and outside of the classroom, constantly, from anywhere at anytime. [5]. Seamless learning, which expresses this type of learning, is being acknowledged and supported as a successful approach for learning [9]. This phenomenon has a great impact on teachers, which should now be considered partners of learning outside of school; they are met on videos and social networks and contacted via text messages. The distance between them and their students changes and so does their professional identity that is going through a major transformation [10]. As partners of the process of learning, the teachers should be aware of the state of all involved components; the learning environment, the students and the curriculum.

The SAMR model states the four stages – Substitution, Augmentation, Modification and Redefinition – to achieve ICT integration [11, 12]. Digitization in education will be achieved through the implementation of the fourth and highest level of the SAMR model – Redefinition. Using the reflection provided by the teachers on themselves, on their students, on the learning environment and on the curriculum, we analyzed the current level of the four involved components and suggest a new aspect of the SAMR model levels to understand how redefinition in education can be achieved.

The purpose of the study was to (1) understand teachers' technology perception, (2) identify the differences between the teacher, student, environment and curriculum proposed by the teachers', and (3) identify the teachers propositions on how to reconcile the differences.

2. Research Design and Methods

To understand the way teachers perceive technology, semi-structured interviews were conducted. The data collected in the semi structured interviews was analyzed using the SAMR model levels [11]. The research was conducted in Israel. Participants included 15 school science teachers, who participated in interviews, using a semi-structured protocol, with most interviews conducted over the phone and Skype calls.

After conducting the interviews, we shifted to analyze the data using conceptual categories and to design a new aspect of the SAMR model levels.

3. Results

In table 1, two categories that were found to be the main characteristics of the teachers' technology perception are presented. The first category, "No better option but to fit in" characterizes teachers that have not happily accepted the technological transformation and described it as a change they are willing to accept; they describe it as a need, or an obligation. The second category "A will to fit in", characterizes teachers that demonstrated a desire to adjust and cannot imagine a situation in which they are not a part of the digital society.

	No better option but to fit in	A will to fit in
The individual in the digital era	*"I feel there are more minuses than pluses to it, but there is a sense of inevitability to fit and use it (technology)"*	*"Can not see life today without the digital society."*
	"I appreciate the donation of it (technology) to our lives as an individual and as a society, and along with that, I find that we need to limit it so we will not degenerate as individuals."	*"The 21 century is the digital century, and one who will not be technological, will be irrelevant."*
The teacher in the digital era	*"The teacher's role has changed and therefore, he has to adjust to the changes.*	*"The school must not be disconnected of real life"*
	"The teacher does not have the privilege to ignore the world around him, as I see it, and it is true for any educator."	*"You cannot challenge students in face to face lessons only."*

Table 1. Teacher perceptions of technology

Table 2 describes the differences in digitalization as described by the teachers between themselves, their students, the learning environment, and the curriculum.

Teachers claim that students learn outside of school, they claim that they are constantly connected and use technology more than they do. Most of them considered the classroom as the main, if not the only, learning environment.

Student foucued	Role focused	Environment focused	Curriculum focused
"They do not learn it in school, there are workshops in school, but their effect is minor compared to reality, when the experience it themselves."	*"In an era where there are phones and I cannot get the students attention, I cannot teach them."*	*"The change should be human, not technological."*	*"We are under the pressure of the curriculum and the timetables to complete transferring all the content"*
"Each student progresses in his own pace, not everyone at the same level. therefore, the teacher should be very flexiable"	*"If the teacher does not prepare a visual, virtual lesson, it is not working."*	*"There is a slide projector and speakers in every classroom."*	*"Eventually we need to align with the Minister of Education's curriculum"*
"They are all the time on the phone, playing games, play and talk to their friend about the game, they use technologies more than me."	*"The teacher today is not a character that the students are intimidated of like it used to be, and on the other hand, the limits are blurring. Sometimes it is hard to take over the class like that."*	*"Today we push a button and we are all connected to all of the videos etc."*	*"As teachers, we squeeze to align with the restrictions. It seems like there's this attempt to keep pushing more and more content, but what is the purpose?"*

Table 2. Differences between teacher, student, environment and curriculum

They did not consider other locations or spaces as an environment where they have an influence. The teachers claim that they teach the curriculum that is provided to them by the Minister of Education; they have minor influence on the class plan.

The two major concerns described by the teachers were their role, which is unclear to them and their students, who do not pay much attention during the lesson.

Student Habbits Change	Role Change	Environmental Change	Curriculum Change
"We should listen to the students, they have a lot to say and they are bright, they are not deserve to be asked?	*"We cannot continue to complain that the student are not suitable for us. It is the teaching and the content that we teach should change."*	*"The availability of computers. Every classroom should contain working computers, with WIFI connection which I can use when ever I want.*	*"The time to teach languages is now, when they are young. Languages like Chinese develop and we should teach them those languages. It is something we are missing."*
"Talking from experience, I believe that books help students, it is more focused. The Internet distracts them."	*"Today I understand that I must accept it (digital technology)"*	*"There are still not enough Internet, not enough working computers."*	*"We should consult more with the students about the curriculum, they have so much to say."*
"Some kids sits with a laptop or a computer, kids who are more connected to their phones. You need to know how to learn how to deal with it."	*"I think that it is a matter of time until all subjects will be more about facilitating and less on granting knowledge."*	*"Schools should regulate the use of technology. Because we (teachers) have no control over it during the class."*	*"Teachers should start using all the available content there's on the web. There are many reliable content suppliers."*

Table 3. Teachers propositions on how to reconcile the differences

Table 3 demonstrates how teachers suggest reconciling the differences in digital progression between themselves, their students, the environment and the curriculum.

They focus on equipping the classroom with more technological elements such as computers. They understand the need in role change and suggest connecting to their students via digital technology.

4. Conclusion

The study aimed to understand teachers' technological perception in order to identify the differences in the level of SAMR model among the four components of education: teacher, student, environment and curriculum. From looking into teachers answers and experiences, two dominant groups of teachers were recognized. The teachers attributed to the first category accept technology as a "no-other-choice" perception and present a state of acceptance, unwillingly. The teachers attributed to the second category showed a desire to accept technology, relate to it and presented a generally positive approach towards it; they believe that the world should adjust to technology. One major finding of this study is that both groups of teachers think that technology should be accepted and practiced which throws light on the way technology is perceived.

Additional finding of the study is that the education components varies in their level of SAMR model. From the way that the teachers reflect on the relationship between the four components, it appears that there are almost no interface points between them. The teachers are concerned mostly about the new problems they deal with regarding students, describe their students as digital, connected individuals and even imply that learning happens outside of school, but do not identify themselves with those symptoms of digitization. Most of the teachers still limit their teaching to the classroom, while describing it as lacking in resources; their major concern is how to add more technology to their lessons, even though they cannot implement it in the curriculum. It is clear that teachers are more focused on transferring the content of the lesson as planned, rather than on the learning process, and do not take into consideration all the components as a whole. Their attempt to "hit" as many targets as possible, such as technology integration, student's satisfaction and completion of the material in time for exams is recognized; deep learning approach and attempt to act toward learning redefinition does not. When the teachers describe their students, they bring up their concerns regarding the use of smartphones in class and the students' lack of attention. Only a few clarify that they do not wish to fight the phenomenon but do not know which adjustments are needed to succeed in teaching the students in the current situation. The study identified the teachers propositions on how to reconcile the differences between themselves, their students, the environment and the curriculum. The majority of teachers suggested to listen to students, to change the school environment and curriculum, and redefine the teacher's role as a facilitator.

In order to handle the main issue that should be addressed, we propose to use the SAMR model. As presented in Figure 1, all the components are behind the desired level of SAMR – redefinition, while each component is at a different level.

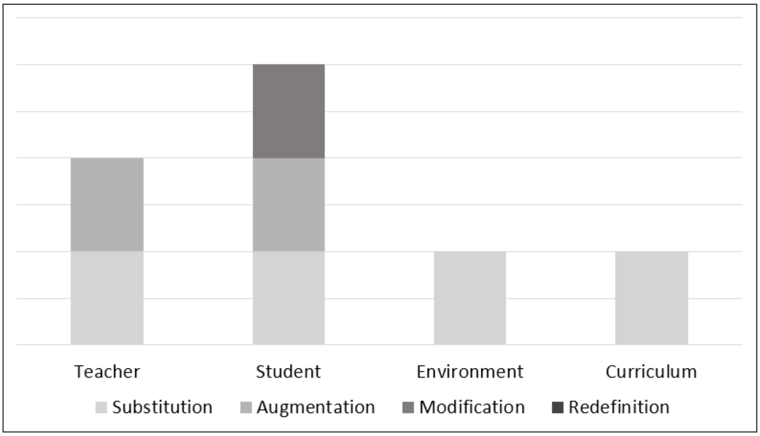

Figure 1. The level of SAMR model of each of the four education components

The main contribution of the paper is our conclusion that in order to achieve the digitization of education, all components should meet at the same SAMR level, the level of redefinition. We believe that the proposed approach has both theoretical and practical significance on the way of the digitization of education.

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The QUAL4T2 Method – Improving Quality in Teacher Teams

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Abstract

No matter which sector of education you're involved in, no matter the discipline you teach, undoubtedly like every educator you strive to achieve ever better results and to contribute to a culture of quality improvement. Why? Because like every educator you want the best quality education for your pupils, students or trainees.
*The QUAL4T2 project aims to address this objective. The full name of the Erasmus+ funded project is: '**Further Quality Improvement for Vocational Education and training: Guiding Teacher Teams in Europe in strategy planning**'. It aims to introduce a bottom-up approach to the development of a solid team culture and the design and implementation of strategic planning by teacher teams.*
A method for monitoring the teams and the provision of simple quality tools helps teacher teams create a culture of continuous improvement and raise the quality of their educational program [1]
The Qual4T2 project is now in the final phase. This paper summarizes the outcomes of two and a half years' work, including the one-year pilot experience in five VET organizations in Denmark, Greece, Italy, the Netherlands and Spain. A Toolkit providing a range of tools for quality improvement in teams, a Quality Guide for Teams and a Story book about the one-year pilot have been developed. The tools and Guide have all been piloted; the final versions of each are based on valuable teacher/trainer feedback gathered in two reports: a research report and a pilot report. The pilot report shows the progress that all pilot teams have made. [2] The tools in the Toolkit are centered around three main areas: A – Working on Quality Culture; B – Design your Team Plan and C – Various Team Plan Models. All tools can be downloaded for free from the website www.qual4t-project.org [3]

Keywords: Education, team, quality, quality improvement, planning, quality culture, research, pilot, professional training

1. QUAL4T2 Project aims

Teachers/trainers have multiple tasks to carry out: teaching, coaching, visiting companies, preparing lessons, attending team-meetings to evaluate learning outcomes etc… Thus teachers have to prioritize the best way to spend their work days. In addition, teams have to connect short-term actions on the job with the long-term strategy and policies of the institute/organization.

According to the project partners, supporting teams in their choice and use of quality mechanisms and implementing a bottom-up approach to the design of strategic planning is effective. By investing in professionalization, the project partners planned to contribute to the development of educators' competences, hence to reinforce quality culture and improve performance and efficiency in education [1]

1.1 Target groups

The QUAL4T2 target groups are teacher teams, quality staff members and managers. Targetted team topics are: Quality awareness, evaluation and feedback, competences needed to develop a year plan and models for a year/team plan.

Materials to work on these topics are:

- a Quality guide for teams;
- a Quality toolkit for teams;
- a Story book with best practices.

European school teams that are interested in quality improvement can use the QUAL4T2 toolkit in seven languages (English, Spanish, Italian, Danish, Dutch, Greek and German). Products are available on the website. [1]

2. Pilot year

"Increased trust in each other and involvement in the goals that we set as a team" were some of the valuable outcomes of the pilot year. About 13 teams and over 285 teachers/trainers from the partners' organizations were directly engaged, providing the opportunity to test quality improvement materials, share experiences and learn with and from each other. This is shown in the international pilot report of this Erasmus+ KA2 project, funded by the EC. The international pilot report is available on the project website [1] and aims to summarise the piloting activities implemented in the partner organizations: Landstede groep (coordinator, NL), Politeknika Ikastegia Txorierri (ES), CIOFS-FP (IT), Køge Handelsskole (DK) and IDEC (EL). They all tested the quality tools within their own organizations and, sometimes also further afield. [2]

2.1 Feedback and impact

Five chapters describe the application, the methods used, the difficulties met, the adaptations made and the feedback from the direct use of the selected tools in each country. The feedback was used to finalise the products. All tools are flexible and adaptable to any school in different countries which may differ also in terms of size, current culture of quality improvement or experience.

The project is already making a good impact on the teams in the partner institutions, judging by the positive feedback of the professionals (456) who took part in at least one project activity – i.e., not only direct piloting but also dissemination and valorisation ones – and by the fact that many of those directly involved in piloting activities have already decided to exploit or even insert some of the tools they tested in their own QMS. For instance: in the Netherlands the final tools have been integrated into the Quality system of Landstede groep (Kroese, 2018); in Spain the QUAL4T2 Quality Guide for Teams will be offered to the wider community of 24 VET centres in the HETEL association (Menica, 2018); in Italy QUAL4T2 products will be presented to the school system (Di Paolantonio, 2018); in Denmark teams will continue working closely together with the heads of departments spreading tools and finding ways to work better together (Dyrløv, 2018) and in Greece IDEC intends to make exten-sive use of the Qual4T2 outputs in their own training courses (Kazantzidou, 2018). [2]

2.2 Effective education plans

The main interest of the partners was obviously focused on possible changes stemming from effective use of an annual team plan for each team. The main goal of the project aims to support teachers/trainers teams in writing a year plan to empower their performance. In this regard the data gathered from the final questionnaires (we started with a 0-questionnaire) tell us that:

- The use of the annual team plan has grown, reaching a general increase of 26%
- The involvement of individual members in each team in writing a year plan increased by 54%, (almost doubled in the Netherlands and tripled in Spain)
- The task of the individual members in each team also increased 68%, almost tripling in Italy
- The importance of collecting and analysing students feedback has been confirmed which proves the “client-oriented” attitude of the partner organizations;
- The perception of Q-culture within the teams shifted from a behavioural oriented Q-Culture (-23%) towards a people oriented one (122%) thus proving the evolution of the Q-culture *towards the mutual striving of a group towards a quality awareness based on its own values and intentions, which are decisive for the behavior of the persons involved*
- The team members feel more ready and confident in managing an annual team plan, although a greater awareness also increases the sensation of needing more training; as Socrates said: ‘*I know I do not know’.*

In conclusion, the pilot report highlights ideas and reccomendations on how to improve the piloted products which will be revised by the partners in a final version for wider use and exploitation within a larger numbers of organizations in the short and mid term future. During the latest project meeting in Køge (DK), the steering board identified common elements, concluding that the positive results are visible and that it is therefore desirable to spread the quality products to a wider audience. [2]

2.3 SWOT matrix

For the piloting the project partners also used a SWOT-matrix to verify the effectiveness of the products or the need to modify them with the ultimate aim of better supporting teaching teams in preparing an effective team plan.

Each partner evaluated the elements, that have influenced their experimentation.

During the fifth project-meeting, the steering board looked at those matrices and identified the common elements, concluding that it is desirable to spread the project’s products to a wider audience.

All the changes that have been made to the piloted tools have been decided jointly by the partners with a view to making them more flexible and therefore adaptable to different organizations, both in terms of size and quality culture and experience in quality management.

3. Experiences of teacher teams

From May 2017 the five pilots took place in QUAL4T2 partner institutions. The feedback from the teacher teams involved, combined with the facilitators’ meetings have led to this collection of good practices, tips and surprises. Feedback also shows the impact of the project on the participating organisations. [3]

3.1 Storybook

The pilot practices were used to write a QUAL4T2 Storybook. In this book, readers can follow five Vocational Education and Training organizations in the Netherlands, Spain, Italy, Denmark and Greece and enjoy the stories gained from teacher teams.

The book shows the frustrations when something did not go as expected, as well as the euphoria when a success was reached. Readers can enjoy these precious stories in which teams really move forward to greater excellence in Vocational Education and Training! Each chapter ends with a summary of the successes and pitfalls. An epilogue can be found on the last page. In October 2018 the storybook was presented at the EfVET Conference, where about 250 European vocational education and training centers are represented each year. [2]

3.2 Impact

An example of the impact of the project method can be found in the Dutch chapter of the Storybook; the facilitator monitored the participants in reducing the number of team objectives to 3 from an initial 6, depending on the duration of the plan (having a maximum of 6 objectives for a two year plan). Attempts were also made to help teams understand the importance of analysing data, formulating a goal and describing detailed SMART activities related to each the goals. Questions asked were: '*I am proud of..., What could go better, What needs to be improved, My ambition for the team is, What effect will our actions have on the students…*' In May 2018 this resulted in: a) three models for a year plan for the Dutch organization, from which all 52 teams may choose, depending on their culture and development phase; b) reducing the maximum number of goals; c) educational leadership steering the involvement of teams instead of individuals and d) an integral vision for the organization, the school and the team. [4]

4. Conclusions

QUAL4T2 has so far proven to be a project that can offer professionally designed and carefully revised materials, translated into partner languages as well as being available in English and German. The teams that piloted Theme A tools have realized that beyond technically perfect quality tools there are human relationships which can create shared objectives. They have learned to be a team and not a group, to listen to each other and to confront each other to achieve common goals. The most significant improvement in piloting the Theme B tools has been the ability to set a team mission/ vision consistent with the training organization's vision and mission.

The most important improvement in piloting the Theme C tools has been that all teams chose the model of annual team plan that best suited the culture and needs of their organization and team, and are still using it. Designing a team-plan also encourages collaborative working; it promotes broadmindedness, understanding, respect and empathy for other people; develops the personal skills and individual responsibility of the professionals as they are encouraged and supported by the team itself in accomplishing the tasks agreed. The Quality guide, tools and storybook are published on the website. [5]

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Science Teaching in Primary and Middle School

Conceptual Maps as the Lucrative Way Showing Integrate Characteristic of the Energy Concept In School Environment

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Abstract

Energy as an integrating concept is currently a widely discussed subject in didactics of physics among its representatives. Many theoretical works and book publications related issues have been published in various didactic teaching approaches. Our work also concerns the same subject. We are focusing on an innovative, however not frequently used, method in evaluating teaching process, which uses graphical depiction-conceptual mapping. The conceptual mapping belongs to strategies leading to meaningful learning. Based on conceptual maps, it is possible to look into the pupils' minds, in which they create their own structure, made up of familiar as well as new concepts. Comparison of complex conceptual maps of related concepts can provide an image of their hierarchical structure. Conceptual maps are investigated using the methods of analysis of semantic networks. Using this method, we were detecting whether a selected group of pupils from elementary school perceived terms related to energy from its integrative point of view, or primarily from one perspective, only within the subject of physics. The aim was to find out whether pupils are able to connect meaning of the terms related to energy in science (physics, biology, chemistry) and also in technology. The integrating role of the concept of energy have to be reflected in the hierarchical structure of the conceptual maps.

Keywords: Energy concept, Concept maps, Energy integration characteristic

1. Introduction

The concept mapping is one of the modern teaching methods. Its main task is to guide pupils to improve memorisation skills as well as lead to make connections and relations between already created knowledge. Student is led to higher cognitive form of learning than the level of memorising by Bloom's taxonomy of educational objectives. The concept maps are an interesting method in didactics, which shows an interdisciplinary character of the particular topic in physics. Some topics have an interdisciplinary attribute. This attribute shows integrate character of the some significant and fundamental concepts. Those concepts are for instance matter, energy, particle, mass, amount of substance, electric charge, motion. In this article we are focusing to the concept of energy and its extent of integration in the mind of students. In the past, the science has been divided into definite subjects. That caused separation of concepts of knowledge and resulted in the deficiency of the understanding of the meaning of some of the integrating elements of topics such as the concept of energy. That is the reason why we focused our research on finding out the rate of the integration of this concept.

Energy is the concept blending within the science spheres such as chemistry, biology, physics, technics. It appears in the common themes like photosynthesis, respiration, the source of energy, renewable and unrenewable sources, consumption of energy, transformation energy etc.

Therefore it is important to mediate the concept of energy from various points of view, which enables students to acquire comprehensive perspective. We cannot consider energy to be exclusively matter of physics. Energy characterizes both inanimate systems as well as animate systems. Therefore it is relevant also in sciences concerned with animate systems (biology, chemistry). One of the goals of our research was to find out to what extent can students interconnect the knowledge of concept of energy from various subjects. Another goal was to find out whether students perceive the hierarchical organization of the concepts.

2. Research methodology

By realization of the research we aimed to find the answers to following questions:

1) How many concepts and in what quantity of the physics, biology, chemistry and common experience have been used by how many students?
2) Can students hierarchically organize the concepts of energy (students of 6th year of study)?

We focused the research on the students of the elementary school, specifically of the 6th year of their study. Thirty-six students in total took part in our research work. Students have been divided into smaller groups, one group constituting of approximately twelve students.

In Slovak schools, the students of this age category have the knowledge of these subjects: technology, biology and introduction to physics.

Currently all the knowledge about energy that they acquired comes not only from their own experience and observation of the surrounding life. The learning structure is apart from the mentioned subjects influenced by the subject – natural science, which is taught in the first grades of elementary school. We wanted to find out what vocabulary bank related to the content of the concept of energy students have.

We have identified which specific concepts will occur to students according to their previous knowledge of energy. After that, they created concept map describing the connections and coupling amongst the concepts. Since we worked with students who had no previous experience with concept mapping, it was necessary to instruct them how to create concept maps at first. That is why we spent one lesson with students, where we informed them about this learning method. We started with concept, which is well known and frequently used among students within their everyday vocabulary – applications see Fig. 1. Firstly, students themselves wrote down on the paper concepts that came to their mind. Next task was to use circles and different colours to separate those having the same particular attribute. After that, they determined hierarchical organisation to arrange them by numbers according to their importance.

This method was chosen because we wanted to lead the students to become conscious of connecting the relations behind concepts such as hierarchical structure too. In third step, we prepared a picture on the board, where we together created the concept map. We went through the terms of biology, after that the terms of physics and the end we let the students create concept maps by themselves, which was oriented to the concept of energy. At the end students presented their results. We divided the concepts that students stated in their concepts maps into following groups:

physics concepts, technical concepts, biological concepts, chemical concepts and common concepts. A lot of mentioned concepts have interdisciplinary character. That was the reason to consider how to assign it to the correct group. We proceeded with studying the concepts by their classification in the specific scholarly dictionaries [1, 2] and books for elementary school [3, 4, 5] and methodical guides [6, 7].

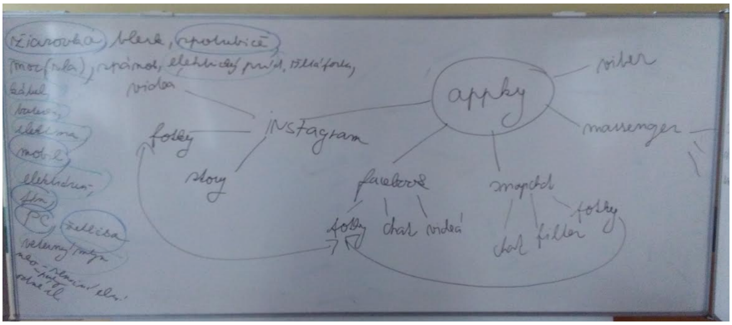


Fig. 1. Concept map (mobile application)

3. Results

In this part we introduce the concepts, which students used in their created concept maps. The students used these physics concepts: electricity, power station, current, hydroelectric power plant, solar station, heat station, wire, force, power, lighting conductor, lighting, heat, motion, wind power plant, light, physics, physical inventors, core of atom, flowing of water, speed, Sun, universe, planets, solar energy, Volt, source, windy energy, flowing electricity, discharge, water energy, electric energy, temperature.

The students used these technical concepts: Wind mill, wall plug, battery, bulb, appliance, Tesla, Edison, solar panels, electronics, charger, artificially energetic supply, propeller, dam, production, gaining energy, car, tablet, device, factory, X – box, playstation, iron, radiator, reproducer, train, television, mobile, PC, PS 4, hair dryer, charging.

The biological concepts: energy of human, human, life, colony, air, water, wind.

The chemical concepts: ion, atom, molecule, sugar, chemistry, chemical experiment.

The students used these common concepts: sleep, control, yellow colour, Victory Royal, film, good mood, good feeling, bad feeling, hyperactivity, football, basketball, sport, supernatural things, dimension, turistic, temperament, drink, chocolade, redbull, coca-cola, positive energy, negative energy, religion, hockey, dance, social networks, application, games, home, Peter, David, sweets, candys, energetic bars, food, household, fruits, vegetables, tolerate, energetic drinks.

The Graph 1. shows how many concepts of physics, chemistry, biology, technics and how many common concepts have been used by one student. Given data are in table 1. and table 2.

Graph 1. The count used concepts (physics, technology, common, biology, chemistry) by students

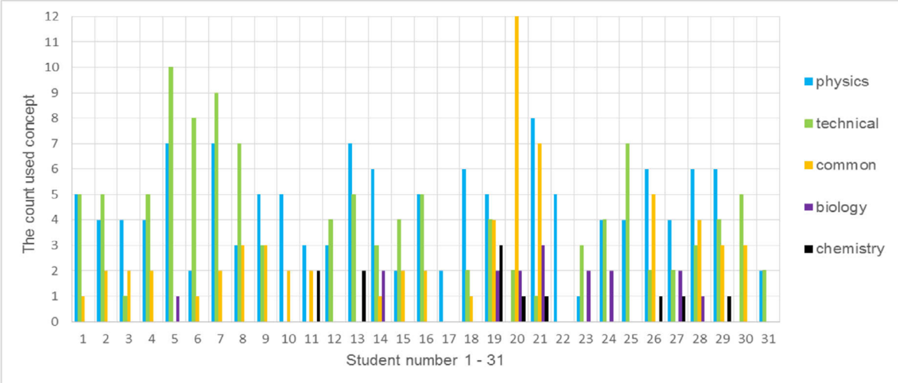


Table 1. Types of concepts used by students number 1-15

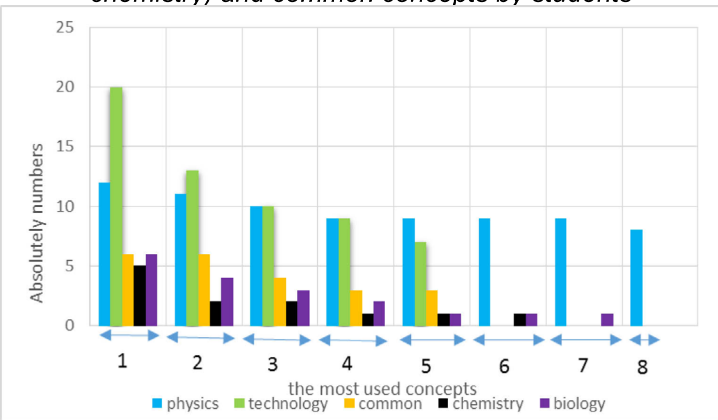
	Student number														
concept	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
physics	5	4	4	4	7	2	7	3	5	5	3	3	7	6	2
technology	5	5	1	5	1	8	9	7	3	0	0	4	5	3	4
common	1	2	2	2	0	1	2	3	3	2	2	0	0	1	2
biology	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0
chemistry	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0

Table 2. Types of concepts used by students number 16-31

	Student number															
concept	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
physics	5	2	6	5	0	8	5	1	4	4	6	4	6	6	0	2
technology	5	0	2	4	2	1	0	3	4	7	2	2	3	4	5	2
common	2	0	1	4	12	7	0	0	0	0	5	0	4	3	3	0
biology	0	0	0	2	2	3	0	2	2	0	0	2	1	0	0	0
chemistry	0	0	0	3	1	1	0	0	0	0	1	1	0	1	0	0

The graph 2. shows the most frequently used concepts of the specific subjects by the students. We marked physics concept by the blue colour, technology concepts by green colour, common concepts by orange colour, biological concepts by violet colour and chemical concepts by black colour. The amount of students who used the concepts is stated in the brackets. There are eight groups in the graph 2. The first group contains the most used concept of physics by students – power station (12), technology – mobile (20), biology – water (6), chemistry – saccharide (5) and common concept – sleep (6). The second group contain concepts, which used like second frequent: physics – electricity (11), technology – battery (13), common – sport (6), biological – life (4), chemical – chemistry (2). The third group contains concepts, which are used like third frequent in the specific sphere: physics – light (10), technology – computer (10), common – chocolate (4), biological – air (3), chemical – chemical experiment (2). Fourth to seventh group contain physics concepts, which have been used with the same amount of students (9). Fourth, fifth and sixth group contains the same amount in biological concept (1) and fifth, sixth and seventh group contains the same amount of chemical concepts (1). The fourth group: physics – electric power (9), technology – bulb (9), common- sweets (3), biological– colony (2), chemical – molecules (1). The fifth group: physics – wire (9), technical – car (7), common – power (3), biological – human energy (1), chemical – atoms (1). The sixth group: physics – force (9), biological – wind (1), chemical – ion (1). The seventh group: physics – motion (9), biological – human (1). The eight group: physics- hydroelectric power plant (8).

Graph 2. The most used concepts of subjects (physics, technology, biology, chemistry) and common concepts by students



4. Discussion and conclusion

The students of the 6th year of the elementary school have the most frequent occurrence of the concepts of commonly used vocabulary. They listed overall 40 examples from the common life. They connected energy with specific meal, drink, feeling, religion. The concepts of physics occur more frequently (33 concepts), technology (31 concepts), biology (7 concepts) and chemistry (6 concepts). The physics concepts are connected with the electric energy, renewable source of energy, universe. Students listed technology concepts according to household appliances or sources of energy in the house. Biological concepts were listed as geological factor, energy of human. None of them wrote concept like photosynthesis or respiration.

Despite of the fact that they were taught them on the biology class. One of the students during her concept map presentation said, that energy is connected with yellow colour. When we asked her: *"Why do you think that?"* " She said: *"...sun is yellow, that's the reason."* Interesting is, that she did not write sun to her concept map.

The students wrote the chemical concepts as the particle structure of the matter and saccharide. They connected saccharide with the source of energy, which humans get from the food intake. Students could not comprehend this concept as building particle biogenic structure, which is understandable according to the degree of their study. The students did not create concepts structure of the energy connected with chemistry. The reason is that the students of 6th year of the elementary school did not pass the subject-chemistry.

We can say that the students of sixth grade of the elementary school did not fully comprehend the phenomenon of integration. The concepts like photosynthesis, respiration, unrenewable sources of energy should have been listed in their concept maps. The students knew how to hierarchically organise the concepts, to the centre they wrote energy and marked it as the level one. They determined concepts of the central concept energy like level two. Specific concepts were considered as subordinate to level two, therefore determined like level three. Research shows that 32 students of the 6th year of the elementary school can hierarchically organize. Four students had a problem with hierarchical organisation.

The result of the research shows the need to introduce the concept of energy by teachers from the chemical point of view and its significance for life and surrounding environment. That is why we would recommend to chemistry and biology teachers to further emphasize the meaning and content of the concept of energy in their lessons.

Acknowledgement

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Grassroots Green Schools: A Model Program for Increased Local Participation

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Abstract

The international Green Schools movement continues to grow, but it takes root locally, one school at a time. Learn how one US based county-level program increased local Green School participation in two years with the help of an innovative Ambassador program to mentor new schools. In 2016, the Green Schools Recognition Program at Florida Atlantic University's Pine Jog Environmental Education Center initiated a "program-within-a-program" to help new schools go green: the Green Schools Ambassador Program (GSAP). The purpose of this program was to grow more Green Schools in the two counties Pine Jog serves by providing new participants with experienced mentors to help them navigate the challenges of their first year: to develop green initiatives, find resources, make community connections, and successfully apply for recognition. The GSRP implemented the GSAP for the 2016-17 and 2017-18 school years, providing each school with a trained mentor who had prior experience with the GSRP. This initiative resulted in 36 new schools successfully joining the program, raising the total number of schools to 122, and contributing to ~40% increase in overall program participation from the previous years. This presentation will share strategies and successes of the GSRP's Ambassador Program.

Keywords: Green Schools; K-12 education; sustainability education

1. Introduction

Throughout a student's developmental years, they will spend a large proportion of their time in school. Many studies have shown that a robust environmental education program during these pivotal years of intense learning have numerous benefits [1, 2, 3, 4]. Across the globe, schools are embracing a culture of sustainability [5]. These programs (i.e. green schools, sustainable schools, enviroschools or eco-schools) play an important role in shaping our students into environmentally responsible citizens [5].

The U.S. Green Building Council [6] defines a green school as a school that "creates a healthy environment that is conducive to learning while saving energy, resources, and money." According to Hoffman [7], the key unifying feature in the green schools movement is to take action in three main areas: the school building, the school grounds and the curriculum. Many of these programs refer to the integration of these features as a "green school culture". Culture includes aspects such as core values, tradition, organization, leadership, roles, programs and curriculum [8]. Palm Beach County School District [9] defines a green school culture as: "the sum of the values, beliefs, norms, priorities, expectations, and organizational structures within a school that cause it to function and react in a way that engenders a overall sense of environmental stewardship in the staff, students, parents, and community."

1.1 Palm Beach County Green School Recognition Program (GSRP) Overview

In 2008, Florida Atlantic University's Pine Jog Environmental Education Center (FAU Pine Jog) initiated the Green Schools Recognition Program (GSRP) to recognize schools for taking a holistic approach to going "green" with a school-wide commitment to sustainability and environmental stewardship as part of their school culture. The GSRP's aim is to recognize public and private schools that "encourage cultures of sustainability within their school environments." Schools document their attempts in an application that is then judged by community leaders according to guidelines outlined in a rubric. The GSRP is a partnership between the South Florida school districts of Martin and Palm Beach counties and FAU Pine Jog.

Schools are awarded one of three designations: a School of Promise is a school that is beginning its green school efforts, a School of Quality is a school that is making great strides in its efforts, and a School of Excellence is one that is succeeding in integrating sustainability education throughout its school culture. FAU Pine Jog, the administers of the program, supports schools along their pathway with professional development workshops, providing information on available resources (lesson plans and funding opportunities) and by providing "green seed money", or small grants up to $250 to help fund projects. School applicants are evaluated based on their performance in the following areas:

- School grounds enhancement
- School sustainability
- Curriculum integration
- Community involvement
- Administrative support
- Innovative practices

Over $30,000 in cash prizes are awarded to schools annually in the form of "Judges Choice Awards", for awards within a specific category on the rubric.

Since its inception, the GSRP program has grown from 10 schools to 122 schools in 2018, representing 35% of potential schools in these counties. Although that is a significant number, there is still much work to be done. We have identified several barriers that schools face in becoming a Green School, including insufficient funding, lack of administrative support and a detailed application process.

In an effort to mitigate these barriers and support the GSRP Program, in 2017 FAU Pine Jog created the Green Schools Ambassadors Program, which is designed to support schools during their first critical year of "going green," while helping them develop the knowledge and skills to continue their green efforts on their own.

2. The Green Schools Ambassadors Program

The Green Schools Ambassadors Program (GSAP) is a program-within-a-program that provides experienced 'green' mentors and resources to new schools to help them achieve their green goals. This program aims to grow the quantity, quality and retention of Green Schools by helping to overcome barriers. Through this program, experienced mentors are provided to novice schools to guide them through researching, planning, and documenting green activities, assisting with the application process, and identifying funding sources.

Program mentors are recruited from our vast network of community members, including retired and active teachers, parents, community organizations (such as members of local garden clubs and environmental groups), local municipality sustainability officers and representatives at the two school districts. Mentors work with 1-2 schools to do the following: visit schools a minimum of 4 times, consult with the school regularly via email and phone, submit a quarterly communication log, and provide ongoing feedback to the FAU Pine Jog team. Mentors attend an initial training, as well as mid-year and final debriefing meeting wherein they complete a final evaluation reviewing the success of the program. Each mentor receives $300 and travel reimbursement for each school that they assist.

Schools participating in the program are required to complete a letter of commitment, signed and submitted by their school's principal or assistant principal. In addition, schools are required to attend an introductory workshop, assemble a Green Team, designate a GSAP Liason, meet with their GSAP mentor 4 times during the school year and, finally, prepare and submit their application for the GSRP.

Each school is provided with a "starter kit" which includes numerous resources to support the schools in their journey toward becoming "green." These resources include a planning guide, a timeline for implementation, a 1-year subscription to *Green Teacher Magazine*, a school gardening guide, and example lesson plans for curriculum integration.

3. Results

Success of the GSAP can be measured by comparing the quantity, quality and retention of new schools in previous years with news schools in 2017 and 2018 that included the GSAP.

3.1 Quantity

In year one, 29 new schools successfully applied for and earned Green Schools recognition of which 19 were due to participation in the GSAP. In year 2, 24 new schools applied and earned recognition, of which 17 were due to participation in the GSAP. Prior to this, the GSRP averaged approximately 16 new schools per year.

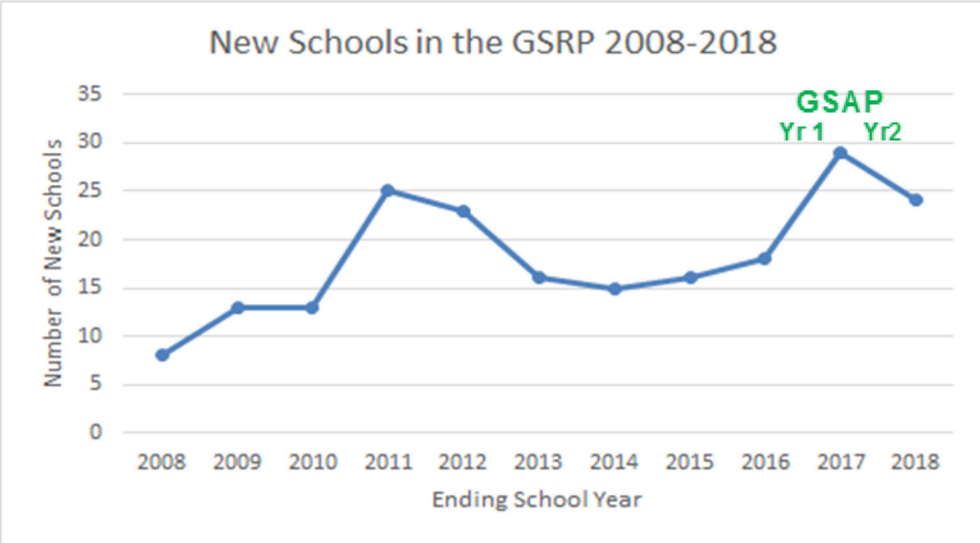

Fig. 1. Yearly Number of New Schools entering the GSRP 2008-2018

3.2 Quality

Of the 19 schools in year 1, one earned a designation of Excellence, 12 earned Quality, and 6 earned Promise (Table 1). Of the 17 schools in year 2, 9 earned a designation of Quality and 8 earned Promise. Historically, less than half of all new schools entering the program earn the designation or Quality or Excellence. Through the GSAP, greater than 60% earned those designations, representing a 10% increase.

Another measure of success of the program was the improvement in the quality of the Ambassador Schools applications in their second year. Typically, approximately 35% of new schools increase a level from their first year to the next. However, 57% of the Ambassador schools increased a level the second year in the program (Table 2), with almost half of those schools achieving Excellence their second year.

Table 1. GSAP Quality Data

Year	**Number of Schools**	**GSRP Levels**		
		Excellence	**Quality**	**Promise**
Year 1	19	1	12	6
Year 2	17	0	9	8

Table 2. The percentage of new schools that increase a recognition level from one year to the next

	2013 to 2014	2014 to 2015	2015 to 2016	2016 to 2017	2017 to 2018 - Not Ambassadors	2017 to 2018 - Ambassadors
Percentage	13%	53%	29%	39%	29%	57%

3.3 Retention

Another clear sign of our success was evident when we tracked our first-year cohort of GSAP participants their second year in the program. Historically, approximately 23% of new schools entering the GSRP would not return the following year. Of the 19 schools that participated in Year 1 of the GSAP, 89% returned in the 2017-18 school year. While we haven't yet received applications for 2018-2019 cycle, all Ambassador Schools that were in Year 2 of the GSAP have submitted an "intent to apply", indicating that they are on track to complete applications this Spring.

3.4 Evaluation Results

All participants in the program provided feedback in the form of a survey. Success stories of the program are reflected in the comments of some of our participants:

- "The best part [of the program] was having one-on-one time and advice from our mentor. The process was daunting at first and [she] really helped us to see that we could do it!! Please continue to help new schools with this program. We could not have achieved as much as we did without our mentor. Thank you for everything! So proud to be a new Green School of Promise!"
- "This was an amazing experience! There is no one like [our Ambassador]. We couldn't have come this far without her incredible encouragement."
- "I think that everyone should have the opportunity to have an Ambassador or at least a copy of the guidebook. It was soooo very helpful! I really cannot say enough good things about this program... Thank you for inviting [our school] to participate!"
- "[Our school] is really looking forward to the next school year and can't wait to see how green our school becomes."

4. Discussion and Conclusion

Schools have been increasingly called upon to serve as a conduit for training the next generations of environmental stewards, and also to act as a model of sustainability for their communities. The FAU Pine Jog Ambassador Program is a highly replicable program, designed to support schools during their first critical year of "going green," while helping them develop the knowledge and skills to continue their green efforts on their own.

The increases in the quantity of new schools as a result of the GSAP appear to have generated a new interest in the program. With 35% of the schools in these counties participating already, the GSAP provided the extra support needed to bring in new schools. This support provided schools with a solid foundation to continue to "green" their school culture and practices from which they were able to build and jump to the next quality level and the confidence to remain in the program.

The success demonstrated in the first two years of this program indicate that it can be a model that can be utilized in other green schools programs globally, to assist in the growth of the quantity and quality of their green schools efforts and their retention in the program.

Acknowledgements

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Misconceptions in Quantum Mechanics through Double Slit Experiment

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Abstract

The best-known early experiments in quantum theory include a double slit experiment. *This experiment points to the wave-corpuscular dualism of microparticles, their wave and particle properties. For its simplicity and unexpected behavior, it is mentioned in many introductory quantum physics courses as well as in the curricula of some technical secondary schools. Despite the frugality of this experiment, many students have difficulty understanding certain parts of the behavior of micro-objects, resulting in many misunderstandings and misconceptions. For this reason, our work aims to reveal some misconceptions regarding the behavior of objects in microworld in connection with the use of a double slit experiment and its modifications. Misconceptions that we focus on will be primarily concerned with the state of the physical system in quantum mechanics. To achieve the goal, the research method was chosen in the form of a test, which consisted of a set of nine test questions focused towards the behavior of particles – electrons – in* double slit experiment. *Testing of students took place over a more extended period from a professional interpretation of a double slit experiment. A random group of university students was selected as a test sample. The collected data from the tests were analyzed and evaluated by the analytical-synthetic method, out of wrong answers there were set up misconceptions, created by misunderstanding or incorrect understanding of behavior in the world of microparticles when explaining double slit experiment. Identification of misconceptions and their subsequent analysis is of great importance in the educational process itself, as such findings can be the subject of further lectures to remove misconceptions from student awareness and subsequent correct understanding of the theory of microparticles.*

Keywords: Double slit experiment, wave-particle duality, misconception

1. Introduction

The teaching of quantum mechanics theory comes along with some paradoxes.

One of them is also a well-known fact in the pedagogical practice that despite the enormous effort of pedagogues using the most current methods and forms of teaching, there is a misunderstanding of the presented topics and concepts. This knowledge, based on pedagogical practice has been and continues to be the subject of several studies. As per findings, this is caused by the students' attempt to understand and explain the elements of surrounding objective reality, using the theoretical knowledge, tools, and experience gained from previous studies of classical physics, creating their misconceptions and informal theories that we can name by a term of preconception.

Early non-identification and subsequent non-removal of the preconceptions thus formed with students later the misconceptions of the world of behavioral microparticles in quantum physics, resulting in various misconceptions. Misconceptions manifest themselves as unrelated or mistaken knowledge, so we can simply define them as deformed thought structures that lead to incorrect predictions, interpretations, explanations, or solutions to science issues [1]. Based on this simplified definition there is a definite negative impact of misconceptions not only on science and research but also on the quantum physics teaching process. As discussed above to eliminate misconceptions, it is essential to identify these and define their nature. The aim of our work was, therefore, to discover some misconceptions concerning the behavior of objects in microworld in connection with the use of a double-slit experiment and its modifications, since this experiment belongs among the basic experiments of the introductory courses in quantum mechanics, to be found for example in [2]. More about double-slit experiments can be found in [3].

2. Theory

As a core of our research aimed at identifying and defining the misconceptions arising from the study of the world of microparticles, double slit experiment was used as a tool that was divided conceptually in three different ways into research questions. By double-slit, we sent not only bunches of electrons, but also electrons one after another-individual, when the electron interfered with itself. The first variant was a standard double-slit experiment, consisting of a particle source, in our case, electrons, double-slit, and a detection device. In the second experiment variant, one of the slits was covered in the experimental apparatus. This variation of the double-slit experiment is often cited as an example in quantum physics introductory textbooks to compare the results with classical particles and classical wave [2]. In the third variation of the double-slit experiment, a modification was made in when a detection device was located for one slot of the apparatus to allow us to identify which slot the particle went through (the so called “which way experiment”). The electron passage is only registered by the connected recording device. Registering the electron passage by the slot breaks the resultant interference pattern. In this case, the electron behaves as a classical particle. Such a modification of the double-slit experimentation apparatus is not so popularized and published in textbooks, and it is, therefore, possible to expect the most frequent occurrence of misconceptions in the theory of electron comprehension behavioral theory in this type of experiment.

3. Data and methods

The research itself was carried out on a sample of 54 students of the first year of the Technical University without a previous university course in quantum mechanics.

The knowledge gained by students was exclusively from their previous studies at secondary or high schools. To achieve the goal, the research method was chosen in the form of a test which consisted of a set of nine test questions focusing on the behavior of particles-electrons in the double-slit experiment. The data were collected by the questionnaire method. The questionnaire consisted of nine closed questions with the choice of one correct answer. The respondent was presented with a variant of the double-slit experiment and its two different modifications in the questionnaire, with the respondent choosing one of the five options offered. In the first part of the questionnaire, the respondent was provided with the description of the device for the study of the electron passage through two parallel narrow slits at a small distance - a double-slit with a backlight in the background. In case I. the two slits are open, in case II. the right slit is closed, and in case III. both slits are open, but close to the right slit there is a sensor that registers when the electron passes through this slit. Subsequently, the types of shapes or figures were presented to the respondent that could, in given cases, create a trace of electron impact, i.e., five possibilities of determining the correct resultant interference pattern marked by letters A through E. (Fig. 1)

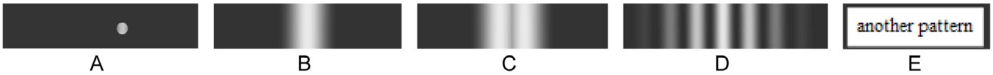

Fig. 1. Possibilities of interference patterns from which the student should choose the right option as per the question

The test questions were divided into three interrelated parts according to the type of apparatus described above, i.e., a conventional double-slit with a detector, an apparatus with a right slit covered, and an apparatus with a path sensor. Each part consisted of three questions, the answer being the correct interference pattern from the choice of options, if the electron passes through the apparatus, a large number of electrons in the form of one after another electron, and the flow of many electrons. The respondent should have realized the fact that, if we have information about which slit was crossed by microworld object, the interference pattern disappears. More about conceptual testing can be found in [4] and [5].

4. Results and discussion

On the first test question, what pattern appears when the electron passes through a double slit experiment when both slits are open, 62.5 percent of respondents answered correctly. The achieved result shows that more than half of the students have a clear idea of the behavior of alone electron passing through a double slit experiment.

However, students are already facing issues when we start asking questions when the electron beam is sent through the apparatus individually or in the group, parallel.

Despite the high success rate of answers to the first question, up to 37.5 percent of students are unaware of the composite of partial interference structure of points. The most common failure was the occurrence of an interfering pattern of options B and C, indicating the existence of misconception that already one particle that has passed through the double slit creates a complete interference pattern. In the second question, we asked what kind of interference pattern occurs when the two-slit apparatus is passed by a large number of electrons, but one electron sequentially, so that at one point only one electron was in the apparatus. Only 12.5% of the students answered correctly. A third of students in the second question assumed that the detector would have a single stripe (option B) of an interference pattern, by that they did not realize that the particular electrons interfere together and with interference pattern is created, as shown in option D. In this question, there is a misconceptual assumption that, if we do not know the information where the electron passed (the two slits are open), there is no interference pattern. Students do not realize the superposition principle at all with this question. In the third question, the flow of electrons passed through both slits, with 51.97 percent of respondents correctly answering. An incorrect answer to the C pattern was noted in 37.5 percent of students. A high degree of failure results in students not realizing an interference pattern. Interestingly, none of the respondents indicated a correct answer for a spotted image, that is, the possibility of a final option of A. In the fourth and fifth question there was a modification that one slit was closed.

Even though this is a classic textbook example in the fourth question, half of the respondents answered incorrectly. In the group of 26.79 percent of the students predominated in the idea that a figure of A would be created, therefore a single point on the detector. This fact suggests that while the student is aware of the disappearance of the superposition of quantum states, they do not realize that a scatter pattern arises from the points of multiple points of hit electrons, resulting in a misconception that supposes that the disappearance of the particle scattering is also extinguished by the disappearance of superposition of quantum states. To the fifth question, half of the students answered correctly. The most common misconception when sending the electrons through one slit was the E response, in which 23.21 percent of the students considered an interference pattern other than the one right one. In the questions six to nine we consider the apparatus when we connect a detection device to one of the slits. This device gives us information about where the electron has passed. In the sixth question, we send one large number of electrons one by one, and it should be realized that the registration device has been connected, hence switched on. Quantum theory also states in this case that there is interference created. The correct answer to the sixth question was provided by only 10.71 percent of the respondents. A group of 35.71 percent of respondents assumed the appearance of a double interference pattern C. On the seventh question, the regulation of the registration device is the same as in the question six, but the only difference is that we sent electrons as a flow.

Only 12.50 percent of respondents correctly answered question 7. This is the same misconception as in the sixth question that if we have information about where the electron passes through the slit, a double interference pattern is created. The origin of the double interference pattern was chosen by half the respondents. Questions 8 and 9 are an analogy of questions 6 and 7; however, the student was aware of the fact that the detection device is disconnected. Question 8, in which the electrons were sent one by one, was answered correctly by 14.29 percent of the students. The most common answer was an E option, therefore a different pattern creation. The students did not realize that if the device is disconnected, i. e., we do not know through which slit the electrons have passed, the interference pattern given in option D is created. In this case, it does not matter if the electrons are emitted one by one or in one as electron flow. The answer to the 9th question was provided correctly by 28.57 respondents.

The answers were unambiguous because also 28.57 respondents replied that after the electron beam crossing, the interference pattern would be different from any of to be selected from the above. Table 1 shows the success rate of individual respondents' answers.

Table 1. Percent evaluation of questions

No. of question	Percentage success rate of correct responses
1	62.50%
2	12.50%
3	51.79%
4	48.21%
5	51.79%
6	10.71%
7	12.50%
8	14.29%
9	28.57%

5. Conclusion

Evaluating the results of our research to identify misconceptions in understanding the behavior of the world of microparticles in quantum physics students, which we made using a double slit experiment on a sample of students, we concluded that the understanding of the fundamental questions of quantum physics theory provides some misconceptions and opinions, leading later to more severe problems in understanding the essence of the functioning of the world of quantum physics. The origin of misconceptions is conditioned by a non-complete understanding of basic theoretical models, or by preconceptions acquired during the previous secondary education, which was also confirmed by this research. Percentage of respondents to individual questions is in Table 1. By evaluating the incorrect answers (including correlations), we were able to identify the resulting misconceptions associated with the state of the physical system and the particle-wave dualism using an example of a double slit experiment. The most common misconceptions that occurred among the respondents of the research sample can be briefly summarized in the following misconceptions:

- Electrons entering individually behave like regular particles.
- The macroscopic flow of electrons acts as a classic wave.
- Path sensor does not affect interference pattern.

Acknowledgment

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Science Teaching Methods

Changes in Working Life Create Challenges to Engineering Education

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Abstract

The changes in working life require new kind of skills from engineers. Alongside the traditional technical knowledge engineers now, need language and communication skills, the ability to negotiate, make connections, work in groups and adapt to changes. Being able to use these so-called meta skills strives for the employees having ability to adapt to constantly changing tasks. This gives engineering educators new challenges. Häme University of applied sciences Electrical and Automation degree programme aimed to improve these skills with a new teaching implementation. First year students were given a development project in which they studied basics of programming. Most important part was the method of implementation: small heterogeneous groups of 3-4 persons were formed. Every group had foreign and native students. Their education background also varied: some had high school degree, and some had graduated from vocational school. Different cultural and educational backgrounds created challenges for the students in their problem-solving situations, but also possibilities for new kind dialogue and learning. Teaching staff mainly acts as supervisor for the process and not as the knowledge sharing party. At the end of the course students were asked with a survey about their opinion how the new teaching implementation had improved their meta skills.

Keywords: Engineering Education, Meta skills, Pedagogy

1. Introduction

The rapidly changing working life needs engineers that know how to utilise so called softs skills, such as teamwork and communication skills and working in multicultural groups. The purpose of this article is to present an example how these skills are being taught in the Häme University of Applied Sciences Electrical and Automation engineering study programme. This article explains the methods that have been used and the feedback collected from the students.

The main question is: Is it possible to develop better meta skills by assigning students to very heterogeneous groups based on their backgrounds and how do students feel about this?

2. Literature review

"What Skills Will You Need to be Employable in 2030?", asks the headline of MIT Technology Reviewer. And what are the answers? Because of the robotization and artificial intelligence, future work needs different kind of skills than today. According to the British innovation foundation Nesta and University of Oxford five most important skills century skills – are judgement and decision making; fluency of ideas; active learning; learning strategies; originality. [3]

Expectations of skills change, because the work changes. There is a need for a new kind of services and functions in the future. The study mentioned before describes trends that will change working life. One of these is technological change, that bring up the often highlighted and even feared automatization. However, interesting is also that, technology can improve people's performance in some occupations and create entirely new professions. According to the study the significance of technology will be large: "Creative, digital, design and engineering occupations have bright outlooks and are strongly complemented by digital technology." But to be succesful, the future expert must also incorporate the previously mentioned so-called 21st century skills.

To reach these, education sector has to be a part of the change and the change is a one-off long time frame. [1]

According to study by Union of Finnish work highlighted qualities in future employees desire to learn and develop yourself (55%); flexibility in working hours and work tasks (48%); readiness and adaptation to changes (45%). Interaction, communication and cooperation skills were also thought as important (11%). Percentages represent answers given by representatives of employers. [6]

The globalization of working life has sped up the expanding of needed skills for professions. This includes engineers.

"One of the most global of professions is engineering", says Douglas Bourn.

When operations of companies become more and more international, engineers are expected to have skills to work in the global market. Engineers need to understand different cultures and their effect on their jobs. In turn, engineers are expected to have similar type of skills all around the world. Basic are build up of technical skills, but teamwork and communication skills are highlighted more and more. Bourn summarizes the industry from literature skills for 'global engineer', which are "a sense of ethical social, moral and civic responsibility; ability to lead and influence, a sense of entrepreneurship, have skills in public speaking and be self-confident; ability to work in teams, be adaptable and have strong project management skills; being able to work with people not only from different cultures, but to be sensitive to different cultural approaches, recognizing the impact this has on one's own cultural outlook; critical thinking and being prepared to re-consider one's own worldviews and approaches to engineering." The concept of 'global engineer' must be expanded and notice must be taken on how globalization changes the engineer profession and how engineers act as agents of change. [2]

What does Finnish Energy registered association say? A summary of surveys concerning the requirements of working life made in 2017 and 2018 brings up following skills that future recruits should have. In addition to skills required by occupation: Ability to network, knowledge of digitalization and robotics; multilingual; negotiation skills; basic knowledge economic indicators; computer skills; sales and customer service skills; teamwork skills; communication and influencing; ability to adapt to changes; ability to integrate previous knowledge to new concepts; ability to realise the added value your skills and knowledge to company and customer. The data is based on Finnish Energy's survey to their member companies. Members represent about 90% of all Finland's energy sector companies. Results bring up a challenge how to upkeep already existing technological knowledge and how to build new at the same time because companies will be needing versatile and more profound knowledge from new areas. There is a rise for a need for the skills mentioned above, that are needed in almost all occupations. [4]

Although the sample is narrow take on all the literature written on the subject, congruent line can be seen. The so called 'soft skills' are needed more and more alongside technical engineering know-how. This transitions to reflecting on how engineering education answers these needs. With what methods can engineering students be developed to be the most employable professionals?

3. HAMK's framework

The vision of Häme University of Applied Sciences (later: HAMK) is to offer the most inspiring higher education and the most customer-oriented applications of research. The students are a central part in all activities. CBE, the competence-based education and student-centered approach are in the focus of pedagogical approach and teaching methods to be developed with the intention that they support the prerequisites of changing working life competencies. [5] Teachers work in teams and the education carried out in modules consisting of 15 credits.

Team teaching reinforces a teacher's ability to cope with constant changes, provided there is trust between the members. In good atmosphere preparedness to try different pedagogical solutions increases. Overcoming challenges together strengthens the feeling of making progress together and that increases the feeling of works relevance and job satisfaction. At its best teaching team and students act together as developers. Teacher is also a learner in addition to being a teacher. [5]

In the Electrical- and Automation Engineering study programme team teaching has a solid foundation. Several methods of operating that have been found good have formed that have continued while making small changes. Good experiences and team spirit have increased readiness to try out and take controlled risks in teaching. Experimental culture has formed.

Learning and wellbeing are closely related with each other. Teachers have a central role creating a trusting relationship with students, the best possible prerequisite for learning. With increased collaboration of teachers a good foundation. [5]

This was seen especially important when designing the implementation described in the article, where some students were known to fall outside their own comfort zone.

This was evident in careful planning of student teams, continuous monitoring for problems, and guidance discussions.

4. Description of implementation

The project to develop meta skills was implement as follows: The programme for both English and Finnish language electrical and automation engineering studies begins once a year. Students may have a high school degree, a vocational degree or both. Traditionally, education for educational programs in different languages has been organized separately. For the student groups that started in the autumn of 2018, a pedagogical experiment was organized in which a joint implementation was organized, integrating an automation project, English, Finnish language teaching for foreign-language students and Finnish communication course for Finnish language programme. The studies were centred around a joint technology project lasting about four months. Students were assigned to groups of 3 to 4 students consisting of different nationalities and educational backgrounds. They were given a challenging project and while completing it they had the possibility for peer learning as well as encounter differences. They were encouraged to find the team's strengths and create a spirit of communion where they help others and learn together.

The aim was that through a joint project they would naturally learn how to work in projects, teamwork, problem solving skills, internationality and reporting, and interaction skills in English and Finnish. A survey conducted for students with the intention to find out about students' experiences about pedagogical experiment.

The survey was conducted about two weeks before the final presentations and the deadline of the reports.

5. The results

The questions were based on the needs to develop engineers' meta-skills mentioned in the article in the literature review. The survey was answered anonymously. Only recognizable was the language of education: 30 answer from Finnish programme, 15 from English. One of students did not want to share background information. Of the 51 students, 46 responded to the survey, so the response rate is 90%. There were 6 questions. Results are seen in figures 1-6.

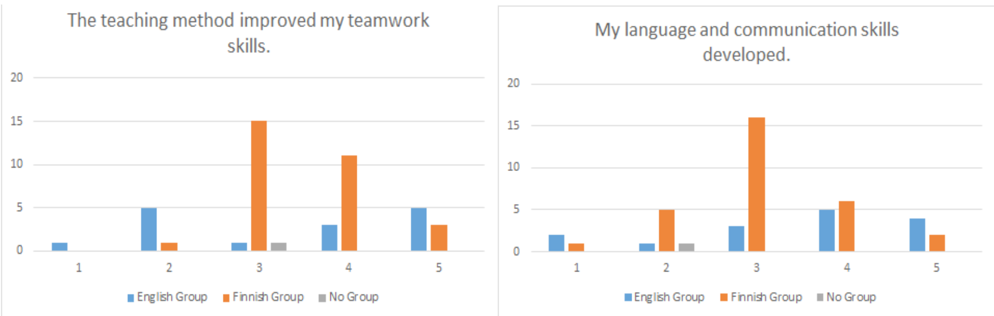


Fig. 1. & 2. Teamwork, language and communication skills development

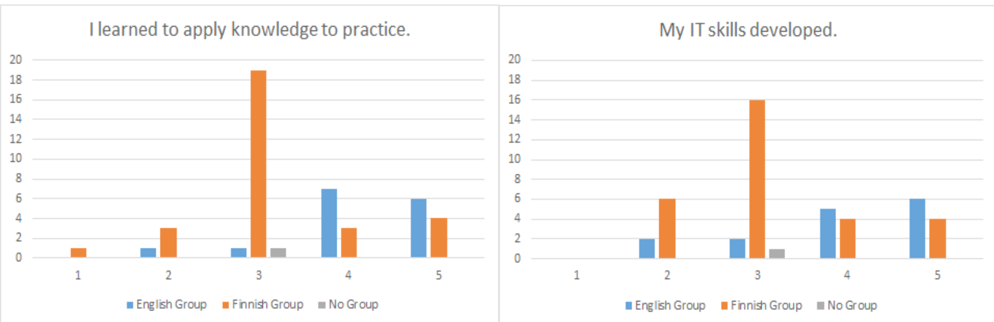
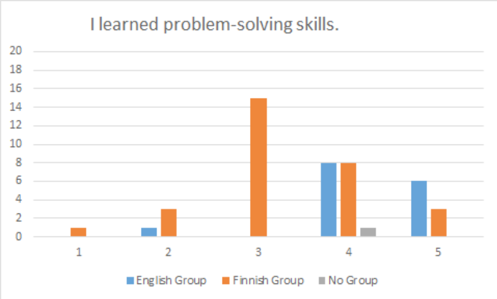


Fig. 3. & 4. IT skills and apply knowldge to practise development



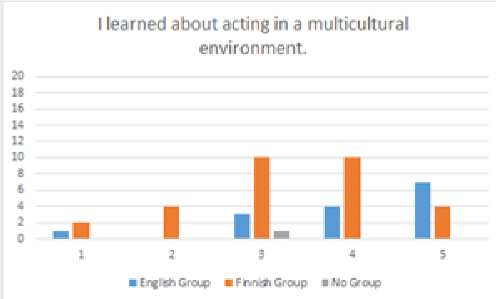


Fig. 4. & 5. Problem-solving skills and acting in multicultural environment development

Based on the results, it is recommendable to organize such implementations in the future as well. The positive feedback can especially be seen in questions 6, 5 and 1.

Attention must be placed on the fact that the responses of English-language education students were more divided into extremes, while the Finnish-speaking group had more reviews of 3 and 4. In free comments, the module received both positive and negative feedback; for some students the module was either "super great!" or "not wise". The majority was positive feedback.

6. Conclusions

The method of implementation proved to be motivating for both students and teachers. For teachers, a new way of implementing means more work than before, because student teams should be closely monitored, and time should be reserved for guidance. Targets of development also exist. The survey may have been carried out too soon after the competition. Later in guidance discussions, it turned out that Finnish students were really anxious about the final presentation, that was held two weeks after the survey. After the presentations, the students seemed to be relieved and happy. If the survey had been held at that time, the results would probably have been even more positive.

The implementation as whole showed that it is possible to develop the meta-skills needed in working life through pedagogical means. Skills cannot be taught by lecturing or reading books. Development requires readiness to move to an area where there are no routines or ready-made responses that have been developed over the years. Above all it needs implementation of experimental culture by the teaching staff.

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Does it really Work then? Practical Work in Undergraduate Science Education

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Abstract

Many find it impossible to think of science education without practical work, stating that it is an essential part for effective teaching. Whilst there is much research in the area of practical work in secondary school there has been little research on how practical work enhances undergraduate students' conceptual knowledge and motivation as part of their science degree syllabus.
This case study research will be conducted at a university in England and will explore the effectiveness of practical work in terms of developing conceptual understanding, and its affective value in terms of motivation and personal interest in biology, chemistry and physics amongst undergraduate students. A presentation of the associated literature is presented along with the rationale behind the research.

Keywords: Practical work, undergraduate, tertiary, sciences, effectiveness, affective value

1. Introduction

A number of educators have directly related the teaching of sciences with the performance of practical tasks, deeming the two as inseparable [1], [2]. Whilst a big part of the literature has been concerned with practical work in secondary education, there has not yet been enough research on the impact of practical work in the teaching of sciences at university level [3]. Moreover, there is a lack of empirical evidence on how practical work contributes to the understanding of science concepts and undergraduates' motivation during their studies. Apart from being financially more expensive that alternative methods of teaching, practical work requires a lot of time and effort. Financial resources invested in equipment and consumables and in appointing trained laboratory staff and going through bureaucratic procedures concerning ethical clearance and health and safety should at least carry advantages that outweigh lecture-based science teaching [4]. In addition, practical work contributes to the increase of tuition fees for international students between science degrees and those in art and social science [5], as practical work is one of the most costly aspects of science education [6]. Despite claims that practical work does motivate and contribute in the understanding of science knowledge [7] ,albeit many of these claims lack research-based evidence, a more critical view has emerged showing no evidence of correlation between practical work and science conceptual understanding [8, 9, 10].

Furthermore, although there have been very few studies into the effectiveness of practical work at university level, none of these provide any support for the suggested purpose of practical work apart from them being an important part of the science syllabus [11], [12].

Taking into consideration that for undergraduate students, science is being studied by choice, in contrast to secondary school students who, in the Untied Kingdom, are compulsory required to study sciences up to the age of 16, it is anticipated that practical work might motivate undergraduates to study science as it has been reported that practical work is one of the most enjoyable aspects of studying science [13].

The purpose of practical work and the arguments concerning conceptual knowledge and affective value are now considered along with the rationale behind the research study being conducted.

1.1 The purpose of practical work

Much of the literature regarding practical work has been concerned with secondary education. However, it has been argued that the findings can be similarly applied to university level education and that the purpose of practical work at university has similar themes with objectives in secondary education [14]. A seminal study by Kerr [15] shed light on the aims of practical work in secondary education by providing teachers' opinions on the importance of objectives concerning practical work in ranked order. The findings in regards to the objectives of practical work by Kerr [15] included:

1. To improve and promote science learning and enhance knowledge to aid comprehension
2. To foster laboratory and scientific skills (e.g. observations, recording, measuring, using the microscope)
3. To develop scientific thinking (e.g., open-mindedness, observing, critical thinking, problem solving)
4. To motivate and enthuse pupils, stimulating enjoyment
5. To promote the understanding of the scientific method.
6. To make theories more real through tangible experiments

With regards to university level education, Reid and Shah [16] discussed the main objectives of practical work presented in thematic categories below:

Skills: Application of different skills in different contexts, understanding data, Getting familiar with equipment

Thinking scientifically: Application of knowledge in different contexts, Critical problem solving, Designing experiments

Affective value: Promoting confidence, Promoting interest, Motivating

Learning: Illustrating material presented in lectures

The main difference between secondary, and undergraduate, level science objectives is that motivation is not prioritised in the latter as, according to a survey asking graduates and practicing scientists to rank objectives based on importance, motivation was ranked the lowest in contrast to the acquisition of practical skills which was ranked among the highest aims [17].

2. The effectiveness of practical work

2.1 The cognitive argument

Based on Kerr's [15] objectives, the cognitive argument is concerned with practical work improving science learning and enhancing knowledge. It is argued that practical work can promote understanding in sciences by allowing students to visualise, in the form of experiments, material taught in class [14]. Admittedly, there is a difference between doing a practical activity and understanding a practical activity, and therefore a practical task done incorrectly can leave students confused. In the absence of guidance, students can leave their practical class with misconceptions that could affect their learning instead of supporting it. Indeed, studies [10] report that when students were tested using pen and paper examinations there was no evidence of conceptual understanding developed by practical work since it would be unrealistic to expect conceptual learning to be directly attributed to solely performing practical tasks. In an experiment, students usually see what they want to see since their pre-conceived ideas are influencing their interpretation [18]. Furthermore, it has been reported that practical work, instead of improving the understanding of science concepts, only allowed students to recall details from experiments involving unusual sounds or visuals [13]. With regards to studies concerned with undergraduate students, results showed that even though open-ended practical work, reflecting real science research, was incorporated into lectures, examination results remained constant despite an increase in the difficulty levels of the examinations [11]. Similarly, results from a study with introductory physics university students showed a correlation between conceptual enhancement and experimentation in comparison to traditional classes [19]. Furthermore, practical work enables students to experience what they have been taught theoretically in class through the subsequent use of hands-on activities. Even though conceptual understanding might not be completely achieved, since practical work has not been reported to have any further advantages compared to other didactic methodologies, there is no evidence suggesting that it should be excluded from a science curriculum [9].

2.2 The Affective argument

According to Kerr [15] practical work promotes students' interest in learning sciences. Consequently, it has been asserted that interested students will be actively involved in practical tasks and will therefore remember information in comparison to traditional taught classes [20]. However, it is unclear whether students' expressions of enjoyment towards practical work is based on its worth as a didactical tool or as an activity that is being run in a more relaxed pace than a traditional lecture [9] where they could possibly be passively copying material from the board. Students have previously expressed their enjoyment for practical work since it promotes collaborative work and allows them to work in their own pace [9]. Confirming this, it has been reported that one of the reasons students felt motivated was that they had a sense of control while doing experiments [10], something that can be counterproductive if students start concentrating on non-substantial issues. However, students reported to be excited when they were doing experiments that were confirming previously stated theories, contradicting the true nature of being a scientist [21]. In this respect it should be acknowledged that the way students perceive practical work is different from the affective value practical work provides *per* se, since students' perception might be influenced by factors including the style of a practical lesson or their ability to understand and relate concepts learned, to their everyday life [9]. In support of this view, undergraduates' motivation was found to be highly affected by the style of the practical work which influenced their perceptions of the lecture [11]. However, students' satisfaction did not increase when more time was spent in practical activities [8].

This was explained [10] in terms of practical work primarily only developing short-term, non-eduring, situational interest, rather than motivation which was the term teachers mistakenly used when explaining what they saw as the affective value practical work on their students.

3. The research

As a result of the aforementioned findings deriving from previous research and the gaps identified in our understanding of the value of practical work at university level, a study will be conducted exploring the effectiveness of practical work in terms of developing conceptual understanding and its affective value in biology, chemistry and physics, the three pure sciences, amongst undergraduate students. The main objective of the research is to focus on finding answers to the main research questions being:

1. Is practical work effective in enabling undergraduates to learn science concepts?
2. Does practical work have an affective value?

Only with more comprehensive research will a clearer picture be formed as to the effectiveness and affective value of practical work in university education, where undergraduates are attending by choice. The results of this study will enable the use of practical work to be adjusted so as to maximise the support in provides to students in terms of learning conceptual material and in developing enduring motivation towards science.

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Evaluation of Educational Digital Stories Prepared by Science Pre-service Teachers

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Abstract

The use of digital technologies in education has become essential and unavoidable similar to many areas of life. In order to increase the effectiveness of learning, new methods and techniques have been widely used in educational settings. One of the new methods that is widely used in education is digital storytelling. The aim of this study is to investigate the quality of digital stories developed by pre-service science teachers in terms of different dimensions. Phenomenology from qualitative research methods is used for study design. The criterion sampling was used from the purposeful sampling methods to determine the participants. The study was carried out in the spring semester of 2018-2019 academic years with 40 pre-service teachers from Eskisehir Osmangazi University. At the beginning of the process, a total of 4 hours of training was given to the prospective teachers about nature of science, characteristics of scientific knowledge, approaches to teaching nature of science, and digital story creation process. Throughout the process, pre-service teachers were provided help and feedback by two researchers. The implementation period of the project is approximately 3 months. Pre-service teachers worked in groups and developed digital stories about lives of scientists. These digital stories (N=19) were evaluated using the Digital Storytelling Rubric in Educational Context. Digital stories were scored by two independent evaluators, and the weighted kappa coefficients were calculated and it was determined that very good and good agreement between the two evaluators for majority of dimensions. When the digital stories are examined in terms of product quality, it is concluded that the vast majority of digital products prepared by science are of high quality. Experimental studies can be conducted in which the digital stories prepared by pre-service science teachers are applied in actual classroom settings and at different grade levels, and the effects of these applications on various variables are examined.

Keywords: Digital storytelling, science pre-service teachers, Educational Digital Storytelling, Evaluation Rubric

1. Introduction

The new generation faces technological devices such as iPods, iPads, tablets, mobile phones and smartphones from the moment they were born. Skills that are expected and desirable from today's generation are re-generated by new millennium (Dede, 2010). Digital skills that are an integral part of 21st century skills are determined under seven core skills: technical, information management, communication, collaboration, creativity, critical thinking and problem solving (Laar, Deursen, Haan, 2017). These skills are also emphasized in today's educational environments and teachers are required to have those professional skills in their classroom activities (James & McCormick, 2009; Leonard, Elizabeth and Marta, 2007). Educators apply contemporary methods and techniques for increasing the effectiveness of learning.

The use of digital technologies in implementing these methods is also an important approach in terms of developing 21st century skills and adapting to technological developments.

The digital story approach is a current practice in developing the mentioned skills (Malita and Martin, 2010).

Studies in science education and science related fields posit that new, creative, contemporary methods to engage students with science content are needed in science teaching and learning (Feinstein, Allen, & Jenkins, 2013; Wieman, 2012).

These new methods should employ educational technologies and promote a deep interest for learning in science concepts (Hoban, Nielsen, Shepherd, 2016; Swarat, Ortony, Revelle, 2012). Digital story method, which allows to use many different media elements such as sound, image and written text at the same time in the framework of a certain plan, is seen as an up-to-date teaching method in the field of education.

The process of creating a digital story includes creative skills such as setting a topic, researching the subject and creating scripts; it is a teaching method that supports collaboration and production skills (Karataş, Bozkurt, Hava, 2016; Sadik, 2008). Enrich the learning experiences by maximizing the interaction with the content (Karataş, Bozkurt, Hava, 2016). In this research, pre-service teachers were asked to digitize scientists' life stories to enable them to be educated as a science literate, to be able to learn the stages of science, the characteristics of scientific knowledge, how scientific knowledge changes over time and the ways in which scientific knowledge can be reached. At the same time, using various media forms to increase their technology skills, increasing collaborative working skills by working in groups. The aim of this study was to investigate the quality of digital stories developed by prospective science teachers in terms of different dimensions.

2. Methods

2.1 Study Design

This study was designed as phenomenological study from qualitative research methods. Phenomenology aims at gaining a deeper understanding of the nature or meaning of our everyday experiences (Patton, 2002). In this study, this method was preferred to examine the experiences of pre-service science teachers while developing digital stories on life stories of scientists.

2.2 Participants

The study was carried out in the spring semester of 2018-2019 academic year with 40 pre-service teachers at a public university in Turkey. In this research, criterion sampling was used from purposeful sampling methods. The main criterion was taking Special Teaching Methods I and have taken Computer II course. Thirty-three of the participants were female and three of them were male.

2.3 Process

At the beginning of the project, about 4-hour training was given to pre-service teachers, including science, the characteristics of scientific knowledge, and approaches to teach the nature of science. In addition, about 4 hours of training was provided on digital story creation process. Pre-service science teachers worked in groups, 19 stories were developed. First, they researched the life stories of scientists.

Then, they have adapted the dramatic parts of life stories into scenarios and digitalized them. Scientists who worked on the subjects included in the middle school science curriculum were chosen for this assignment. 21 digital stories have been developed. Throughout the process, pre-service teachers were provided help and feedback from two researchers. The implementation period of the project is approximately 3 months.

2.4 Data Collection and Analysis

For the evaluation of digital stories, *digital story* section of Digital Storytelling in Educational Context Rubric developed by Sarica and Usluel (2016) was used. The *digital story* section consists of 18 criteria. Digital stories (N=19) produced within the scope of the study were evaluated according to 17 categories (copyright category was not scored) of *digital story* section of the rubric. The validity study of the developed rubric was conducted by experts in terms of content, structure and criteria dimensions.

For the reliability of the rubric, Evaluation was conducted by two independent evaluators and the weighted kappa coefficients were calculated. Cohen's Kappa index was calculated using interrater reliability coefficient=number of agreements/ (total number of agreements + disagreements) (Miles & Huberman, 1994). If the evaluators gave the same score for one item it has accepted as *agreement* and accepted as *disagreement*, if they gave different scores. The values obtained from the Kappa coefficient are interpreted as: strength of agreement is slight for 0.00-0.20, fair for 0.21-0.40, moderate for 0.41-0.60, substantial 0.61-0.80, and almost perfect 0.81-1.00 (Cohen, 1960; Landis and Koch, 1977). It is stated that a minimum of .60 value should be searched for reliability (Cohen, 1960). Among the two evaluators, it was determined that the majority of the criteria showed *substantial* or *almost perfect* agreement. Kappa coefficients between two evaluators' scores were given in Table 1, it can be seen that there was almost perfect agreement for five criteria, substantial agreement for five criteria, moderate agreement for six criteria, and fair (acceptable) agreement for one criteria.

Table 1. Kappa Statistics for Rubric Categories

Rubric categories	Purpose	Language	Clarity	Length	Originality	Affect	Plainness	Proper visuals	Effective visuals
Kappa coefficient	0.947	0.947	0.894	0.684	0.473	0.473	0.947	0.526	0.578
Rubric categories	Proper audio	Audio speed	Audio quality	Proper music	Music speed	Music level	Integrity	Fluency	
Kappa coefficient	0.526	0.684	0.631	0.736	0.842	0.736	0.316	0.421	

3. Findings

Digital stories (N=19) were evaluated independently by the two raters. The categories for the digital stories were rated in three level (weak, medium, good). The frequency information for each category is presented in Table 2.

Table 2. Frequencies of mean of ratings for digital story quality (N=19)

Rubric categories	**Weak**	**Medium**	**Good**
Purpose	0	100	0
Language	0	0	100
Clarity	0	11	89
Length	0	11	89
Originality	0	5	95
Affect	0	0	100
Plainness	0	5	95
Proper visuals	0	26	74
Effective visuals	0	32	68
Proper audio	0	5	95
Audio speed	0	16	84
Audio quality	0	5	95
Proper music	0	37	63
Music speed	0	37	63
Music level	0	42	58
Integrity	0	21	89
Fluency	0	26	74

In Table 2, it can be seen that all 19 digital stories at least at *medium* level. For the "purpose" item, all of the stories were at *medium* level. For fourteen categories, stories were at *medium* level, frequencies ranging from 5% to 42%, and at *good* level frequencies ranging from 58% to 100%.

4. Discussion and Future Directions

When the weighted kappa coefficients related to the categories developed by Sarica and Usluel (2016) were examined, majority of the criteria showed *substantial* or *almost perfect* agreement between two raters. According to this result, it can be said that product evaluation results are valid and reliable. It has been found that the majority of digital stories prepared by pre-service science teachers were at high quality level.

Similar studies can be conducted with different samples and compared with this study. Experimental studies can be carried out on use of digital stories prepared by pre-service teachers in actual classroom settings in science courses and the effects of using digital stories for instructional purposes could be examined.

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Feltballs Arithmetic Study – Feel and Imagine Arithmetic with their Ears and Hands

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Abstract

The goal of arithmetic learning so far has been to cultivate the ability to think by teaching arithmetic step by step to learners, and solve problems on their own. But learners who are not good at rocognizing arithmetical sign got stuck in the early stage, and ended their lives without meeting advanced arithmetic thought .So we thought of a method that could experience advanced arithmetic thinking simply by moving felt balls according to voice instructions for them five years ago. In this case, felt balls are numerical entities and the movement corresponds to a calculation formula. An adult who practiced this method said, "why does arithmetic that could not be understood at the head understood by just moving the felt balls?" A child who practiced this method said, "Arithmetic is free and so fun." The arithmetic experience gained through ear and hand will become established as arithmetical power linked with logic in mind some days. In this paper, we will do a practical report of experimenting this EAR-HAND-MATH method from a child to an adult.

Keywords: arithmetic method, ears, hands

1. Introduction

When I was presiding over a high school mathematics cram school, I suddenly had doubts, "why does the degree of comprehension differ from one student to another in spite of getting the same classes?" For example, a student has a flash of graphics problems even though he cannot do any analysis field at all. On the contrary, although the field of analysis can be improved, he took zero points in graphics test as he cannot imagine the spatial figure being questioned. In order to find out where this difference comes from, I interviewed the mothers of nine students about their small childhood situation. A student with a graphic flash has been hooked to a toy in shape as a baby, he seems to have played without getting tired for days or days. Another student who can find the extension line immediately in them seems to have been good at "ayatori" (Japanese hands play with yarn),when he was young. Another student who can improve the field of analysis seems to discover that many numbers of phone numbers can be made by combining numbers while playing with the cell phone toys made by his mother. Looking at these examples, I felt that mathematical thinking might have something to do with actual experience in early childhood. So I decided to shift to arithmetic education for children.

2. EAR-HAND-MATH

It is often said that Japanese people dislike arithmetic like calculation. So where is the cause of arithmetic dislikes? A woman who cannot get a job because she doesn't understand the meaning of the consumption tax visited me. I was in trouble. I did not know how to teach arithmetic to adult. But I thought of teaching the way of proportion, I brought twelve felt balls that were rolling around that and I told her. "please represent to divide twelve by three using these" Then her hands did not move at all. I was surprised. Then I noticed that people who do not know arithmetic have no movement of the number in their heads! So I moved the felt ball. I taught her each calculation mechanism. She said and cried after completing an hour's lesson. "No one has ever taught arithmetic in this way until now." I was shocked to touch the hardships of the people who do not know the arithmetic. So I devised a new arithmetical method to experience by moving the felt ball instead of using their head. That is the "EAR-HAND-MATH" It is just only listen and move.

3. How to EAR- HAND -MATH

I. The leader speaks the story.
II. Learners think of that scene in the head.
III. The leader instructs the arithmetic problem out of the story to express numerical values t by felt balls.
IV. The learner moves the felt ball as instructed.
V. Learners can derive answers to arithmetic problems.

The point of note here is that the story must be one that stimulates learner's interest.

You do not need to understand arithmetic by just one experience. Depending on the age and thinking habits of the learner, the timing when mathematical theory matches felt ball exercise is different.

4 Three problem examples of EAR-HAND-MATH

4.1 Calves go to the zoo

"It is a sunny day. I would like to go out on such a day. Surely, the cows' mother seems to be thinking about the same thing. She seems to go to the zoo with a lot of calves in the neighborhood. One, two, three ... There are twelve calves. It seems that the number of boys is four more than the number of girls. Here is the question. Do you know how many boys and girls each? Let's try using felt balls. Please take twelve felt balls instead of calves first. Are you OK? The number of boys is four more than the number of girls, so if you remove four boys, the number of boys and girls will be the same. Then remove the 4 felt balls. How many are the rest? Let's halve because it is the same number of boys and girls. Let's return four felt balls that you removed earlier.

Oh, it is strange, you understand that there are eight boys and four girls."

4.2 A cheetah and a Leopard run around the Colosseum

"This is the Colosseum in Rome. There is a battle of the beasts from now. Oh, just a moment!

There are a cheetah and a leopard from the entrance. And each began to run around the Colosseum in the opposite direction at a tremendous speed. What shall

I do. They hit themselves. Here is the question. How many seconds after will the disaster occur? What kind of information do you want to know for that? The length around the Colosseum? The speed of cheetah and leopard?

Then I teach you them. The Colosseum is around 600 meters. The cheetah can run 100 meters in two seconds, the leopard can run 50 meters at the same time. Because it is hard to use the head, let's use felt balls. As the area around the Colosseum is 600 meters, let's create a Colosseum circle with twelve felt balls as 50 meters per felt ball. Could you do it? Since they run in the opposite direction, there is a distance of 600 meters between the cheetah and the leopard. But the distance between them is zero meters when they hit themselves. Let's start! After two seconds, cheetah runs 100m, so remove two felt balls, leopard does 50 meters, please remove one felt ball.

After another two seconds, please remove two felt balls of the cheetah and remove one felt ball of the leopard. After another two seconds, please try it the same way as before. After another two seconds, please try it the same way as before. Oh, have you completely removed the felt ball yet? you have repeated it four times so far. Two multiplied by four is eight. You know that they hit themselves after eight seconds."

4.3 A hungry lion goes shopping

"A hungry lion went shopping in the evening supermarket. A discount of 40% was made for ten euros beef. A discount of 20% was made for pork with eight euros. He does not know which is cheaper. Let's think with felt balls. Please take out ten felt balls. Because 40% is a percentage of 100. Since there are not 100 felt balls, in this case let's consider it as a percentage of ten. Are you OK? In the case of beef, ten represents ten euros, so one is one euro. let's remove four felt balls, because it is discounted 40, How many are the rest? It is six. You know the price of the beef is six euros. In the case of pork, please take out ten felt balls. ten represents eight euros.

Then one represents eighty cents. Please remove two felt balls, because it is 20% discount. How many are the rest? It is eight felt balls. Since eighty multiplied by eight is six hundred forty. You know the price pf the pork is six hundred forty cents, six euros and forty cents. So you know that the beef is cheaper than the pork. Very good!"

5. Practice report of EAR-HAND-MATH

I conducted an experiment to see if you can truly understand the arithmetic by doing EAR-HAND-MATH. Twenty-seven people came to the experiment. The age was three-seventy years old.The time required to do the above three questions was 10 minutes. I will report the subject's impressions.

- I was able to materialize the meaning of how to calculate in my head. (female in her 40s)
- The problem of leopard and cheetah was fun (10 year old girl, 14 year old boy)
- I hated arithmetic so I wanted to meet up this when I was a child. female in her 40s
- I'd like to do EAR-HAND-MATH while talking with my three year old daughter. (female in her 30s
- I would like to teach the problem of the lion to my students who do not know the ratio. (Male elementary school teacher)
- I would like you to make EAR-HAND-MATH problem for kindergarten as well (female in her 30s)

- It was fun to move the felt ball (three year old boy)
- Even though I do not understand the meaning at first, I became happy when I understand it later (female in her 30s)

6. Summary

Even in the age group who is not interested in arithmetic in this way, by doing EAR-HAND-MATH, they begin to be interested in arithmetic. I think that any person has arithmetic innately as Socrates proved using it as an ignorant young man to understand the anamnesis in “Meno” [1] If anyone has arithmetic, how exactly should we educe? In the interview survey of my student’s mother, they draw their own arithmetic from getting absorbed in the childhood play. The woman who did not understand the consumption tax calculation cried gladly understanding arithmetic. Also, the EAR-HAND-MATH seems to have raised interest in people’s arithmetic by using colorful felt balls or making it interesting. Is it necessary something that stimulates our senses to educe arithmetic within us? It may be a crazy play, a gentle touch, a beautiful color, a good sound. I have the arithmetic textbooks for elementary school students written 85 years ago in Japan. [2] It is called “Green cover” that gained global evaluation at the time. That for the first grader of elementary school is all the picture that shows their life and play. I asked a 6-year-old child, sometime. Even though it is an arithmetic textbook, why only pictures? He said, “because I have arithmetic”. It seems that the time has come to change the way of arithmetic education.

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Flipping a Science Course: Influence in the Students' Cognitive and Affective Performance

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Abstract

One of the main challenges that professors have to face when teaching science is to find teaching strategies able to increase the interest of the students toward scientific contents. Poor cognitive and affective performance are among the main consequences that this lack of interest produces in the students. Following students' centered methodologies have been proved to be an effective strategy to increase students' interest to science, and improve both the results of the cognitive and affective components of learning. In order to follow this teaching methodology, more in-class time is required to perform hands-on activities and to let students apply the theoretical scientific contents delivered in the course. To achieve that, this research explores the application of a flipped-classroom methodology to a science course. In the flipped-classroom methodology, the traditional roles are inverted: the time students spend in their houses is used to work the theoretical contents by means of video-lectures delivered by the instructor, while classroom time is used to complete the students' centered and other collaborative activities to put in practice the scientific contents delivered. This classroom setting aims to engage students more successfully with the course. In order to gauge this relatively new methodology, a comparative study was conducted. Precisely, a traditional classroom was compared with a flipped-classroom setting for the same science course. The study was conducted at the Teaching Training College of the University of Extremadura (Spain). The comparison was carried out in terms of how the instruction methodology had a significant influence in the students' affective dimensions toward the course and the learning outcomes achieved. According to the results, the students had a general positive perception to a flipped classroom setting, showing more positive attitudes toward the course. Besides, the students' emotions analysis revealed that they were more positive and less negative in the flipped classroom compared with the traditional one. Therefore, regarding the course learning outcomes, statistically higher average grades were achieved in the flipped-classroom course, as well as the number of students passing the course.

Keywords: Science education, training science teachers, learning outcomes, teaching methodology, inverted classroom

1. Introduction

To find proper teaching strategies is one of the main challenges that professors should face when teaching science. Through these, it is able to increase the interest of the students toward scientific contents. However, current lack of interest to science produces poor cognitive and affective dimensions as the main consequences in the students. Therefore, students-centered methodologies have been substantiated to be an effective and efficient strategy to increase students' interest and attention to science [1, 2]. Also, this methodology improves both the cognitive and affective learning results [3, 4]. Particularly, in this active teaching methodology, it is required more in-class time, which can perform hands-on activities and can let students that apply the theoretical scientific contents delivered in the course [1, 5].

The flipped-classroom methodology is a somewhat new instruction and teaching methodology [6, 7]. In a regular flipped-classroom, lectures and classes are offered to home-based forms of video-lecture resources along with printed deliveries and on-line quizzes and tasks [7, 8]. Therefore, more students-centered learning activities will happen in-class time, will create more interactive and cooperative courses and will address specific certain questions, which can deliver just-in-time lectures [1, 5].

Also, a flipped-classroom methodology can be deliberated as a combination of both traditional and online education structure by exploiting in- and out-of-class time, which can complete more effective and efficient learning chances and perspectives [2, 9].

Consequently, when a flipped-classroom methodology is esteemed, the cognitive and affective dimensions of students ought to be considered in order to entirely fix this somewhat new instruction and teaching methodology.

This research objective is to explore the application of a flipped-classroom methodology to a science course. This classroom setting along with the proposed methodology aims to involve students more positively to the course. In order to measure this somewhat new instruction methodology, a comparative study and analysis were directed. Specifically, a traditional classroom setting was compared with a flipped-classroom setting for the identical science course. The study was performed at the Teaching Training College of the University of Extremadura (Spain). The comparison study and analysis were carried out in terms of how the instruction methodology had a meaningful influence and effect in the students' affective dimensions toward the course and the learning outcomes accomplished as the students' cognitive dimensions.

2. Materials and Methods

This research assesses the students' cognitive and affective dimensions when a flipped-classroom methodology is respected as an instruction methodology for teacher training students in science education. During two courses of 2014/2015 and 2015/2016, particularly, this research was carried out in a general science subject. With the post-task questionnaires survey, we acquired the information and measurement to measure their cognitive and affective dimensions toward the course.

2.1 Sample explanation

This work was completed in a general science course with a second year of the Primary Education bachelor degree in the Training Teaching School of the University of Extremadura (Spain) during 2014/2015 and 2015/2016 courses. 153 students, 65 and 88 students, respectively, partaken in the study with the particular demographic information (61% male and 39% female in 2014/2015, 65% male and 35% female in 2015/2016, 21 years old average age, 6.81 average GPA in 2014/2015, 6.95 average GPA in 2015/2016, 71% social science background in 2014/2015 and 63% social science background in 2015/2016).

2.2 Flipped-classroom methodology

The flipped-classroom methodology at the beginning of the semester was exhibited to the students together with the class flowchart containing all the important dates and class activities predetermined. Particularly, with theoretical and laboratory contents, the course has 3 sessions (50 minutes) per week and 1 session (50 minutes) per week for all three groups, respectively. It has five chapters in the context of the contents and its difficulties. Herein, all students had utilized a Moodle, university virtual interface, that can distribute the contents of the flipped-classroom. As shown in Figure 1, various software tools were employed for detailing asynchronous and seamless video lectures.

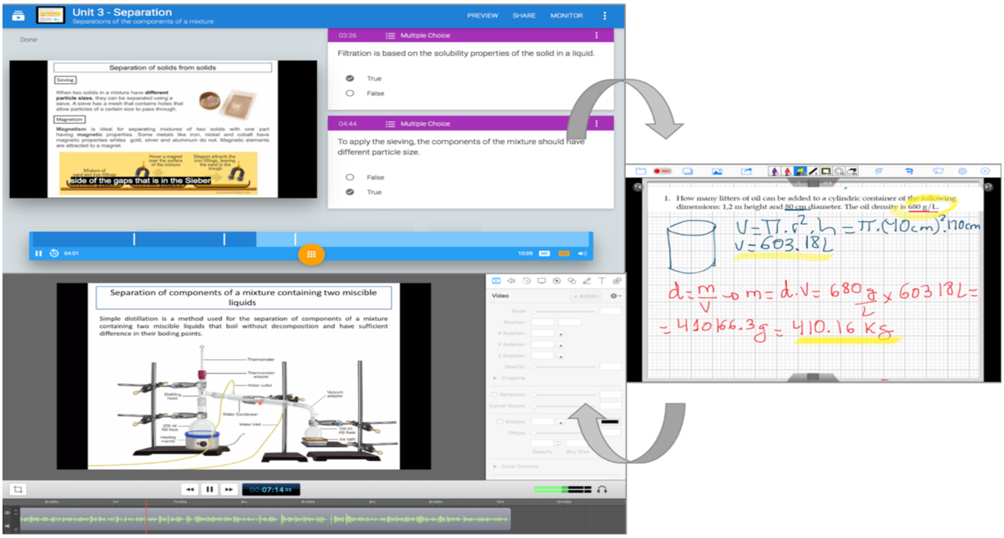

Fig. 1. Software to be used for flipped-classroom methodology in this study

3. Results and Discussion

Based on the data from the University, students continuously have had some difficulties and problems to complete the subject suggested for this study. Particularly, students took 2.5 years in average to finish this subject. Thus, small portion of students even took more than 4 years to pass it. So, we proved students' successful completion percentage in this subject with the flipped-classroom methodology proposed. 2014/2015 course has 56.6% passing rate and 2015/2016 course has 57.2% passing rate, an increasing tendency comparing with the previous years that indicates the flipped-classroom methodology was over the previous years' passing rate. With various tasks and activities created, we also can notice the similar results that the flipped-classroom methodology was over the passing rate of various tasks and activities in previous years. Thus, in the perception analysis, we can find out that the results showed the students inclined to a general positive perception to the flipped-classroom methodology employed.

The mean values of affective dimensions, emotions, were provided and assessed by the whole students based on 0 to 10 scale as shown in Figure 2. The overall scores indicated were very high in positive affective dimensions. Amongst these four positive affective dimensions, the students articulated the highest point to fun and enthusiasm and confidence attained the lowest point amongst the positive affective dimensions. In the context of the negative four affective dimensions, the lower points were consistent to them. Boredom was chronicled with the lowest point and concern was acquired as a highest point of amongst the negative affective dimensions. Herein, we can tell the finding discovered that all positive affective dimensions had a noteworthy positive correlation and connection between them and the negative affective dimensions were positively correlated and connected as well.

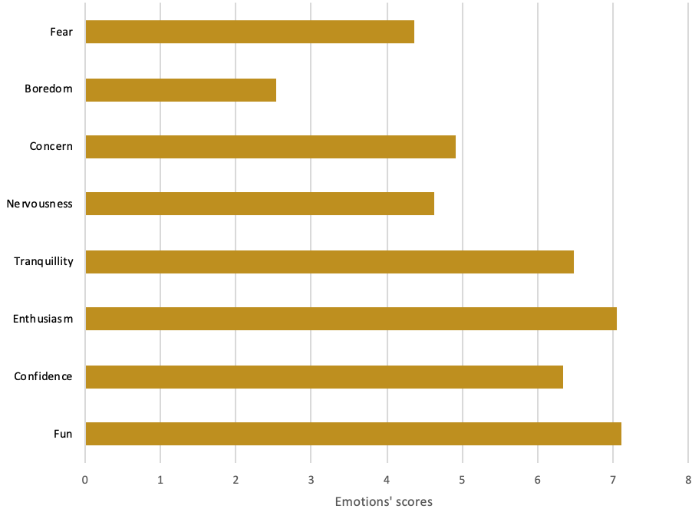

Fig. 2. Affective dimensions analysis (0 to 10 scale) of students' answers in particular eight different affective dimensions

4. Conclusions

The measurements and results of the students' cognitive dimension were determined through the subject passing rate, that is, final exam grades and other exercises grade of students when the flipped-classroom methodology was utilized as instruction and teaching methodology. They confirmed that the flipped-classroom methodology contributed much better outcomes than previous courses not employing the flipped-classroom methodology, viz. traditional instruction setting. For example, the students' passing rate was more than 10% increase in the same year for the first time registered. Also, similar variances we can find were perceived final exam, in-class assessments and the lab activities during the course. For the measurements and results of the students' perception, the students had a general positive opinion and perception to the flipped-classroom methodology pertained for this class designated.

The measurements and results of the students' affective dimensions can be detected that the highest scores were specified to the positive affective dimensions, fun and enthusiasm as the most pointed positive affective dimensions. Amongst the negative affective dimensions, boredom was acquired as lowest point. Therefore, the students with a flipped-classroom methodology had a more positive and less negative affective dimensions.

According to the results, the students had a general positive perception to a flipped-classroom methodology and setting, presenting more positive attitudes toward the course. Besides, the analysis of students' affective dimensions, emotions, revealed that they were more positive and less negative in the flipped-classroom methodology compared with the traditional methodology. Therefore, the course learning outcomes are statistically higher in the flipped-classroom course than average grades were achieved in traditional course, as well as the number of students passing the course.

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Implementing the Topic of Sustainable Nutrition In and Outside the Classroom Based on an Inquiry-Based Teaching Approach

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Abstract

The intention of this paper is to outline the theory-driven development of a teaching and learning module on the topic of 'sustainable nutrition'. Building on the model of educational reconstruction, the self-determination theory as well as the approach of inquiry-based learning, teaching and learning materials are evolved to implement the conception of an educated sustainable nutrition in and outside the classroom. To establish a causal relationship between aspects of sustainable nutrition and healthy diets the food trend 'smoothie' is employed. In four learning units (e.g. workshops), held at an Austrian youth centre and at a botanical garden as part of the H2020-EU-project "BigPicnic: Big Questions – engaging the public with Responsible Research and Innovation on Food Security", juveniles (aged 14-18) tested the educational materials. Besides moderate participant observation, data were gathered by recording learners' oral contributions. The preliminary findings seem to suggest that the teaching and learning materials made particular components of the complex topics of nourishment and sustainability accessible to learners. Consequently, the presented teaching model may give suggestions on how the topic of a healthy and sustainable nutrition can be inbuilt into integrated science lessons in and outside the classroom.

Keywords: socioscientific issues, decision-making, education for sustainable development, model of educational reconstruction

1. Introduction

In recent years, there has been growing interest in the high relevance of food and nutrition to people's personal lives as well as its impact on the local, regional and global society [1; 2]. The European Horizon 2020 project "BigPicnic" aims for both, addressing issues related to the umbrella concept of 'food security' and developing educational activities for stimulating the public debate [1]. Food education is not just about conveying scientific expertise but also about recognizing and questioning societal value systems [1; 2]. Scholars of the Stockholm Resilience Centre have demonstrated that "food" connects to all of the 17 Sustainable Development Goals (SDGs). Furthermore, they propose that the scientific community should move away from the sectorial approach segregating social, economic and ecological developments and think of them as inextricably linked [3]. Hence, a central question that needs to be addressed in this context is which aspects learners should take into account in their diets to comply with the so-called "principles of a sustainable nutrition" [4]. So far, in didactic teaching and learning research, the topic of nutrition has been dealt with health issues primarily. However, this restriction of the field of vision corresponds neither to the nourishing habits of juveniles, nor to the nourish-specific challenges, which our society faces [5]. Previous research has concentrated on the identification of nutritional orientations of students and the derivation of guidelines for learning environments, which aim to foster students' abilities regarding sustainable nutrition [5].

Astonishingly, little attention has been paid on the establishment of educational materials that impart an appropriate understanding of both, a healthy diet and a sustainable nutrition system. A key issue, therefore, is to make these socially highly controversial issues suitable for teaching in and outside the classroom with the goal of education for sustainable development, by including nutritional orientations of young people on the one hand, and ecological, economic, social and health implications of nutrition on the other.

2. Theoretical background

Based on the model of educational reconstruction following Kattmann and colleagues [6], in the clarification and analysis of the science content, a suitable scientific understanding of sustainable nutrition is driven from literature. Nutrition aspects regarding smoothies as a meal are used to mediate the learning process.

The term 'sustainable nutrition' tends to be commonly referred to von Koerber, Männle and Leitzmann's concept of a "*«wholesome nutrition»* […]*, a mainly plant-based diet, where minimally processed foods are preferred*" [4, p. 3]. This concept incorporates five dimensions: individual, environment, economy, society and culture.

It includes seven so-called "principles of a sustainable nutrition", ranked according to their potential to save on CO_2-equivalents. These are 1) preference of plant-based foods; 2) organically grown foods; 3) regional and seasonal products; 4) reference of minimally processed foods; 5) fair trade products; 6) resource-saving housekeeping, and 7) delicious meals. Following these seven recommended actions, a sustainable nutrition contributes to the requirements for health, environmental, economic and social compatibility simultaneously. Due to the reason that Austrian pupils do not eat enough fruits and vegetables [7], a current food trend, namely fashionable smoothies, has been used to establish a relationship between aspects of a sustainable nutrition.

In this sense, a smoothie is according to de Moura *et al.*, [8, p. 216] "*a drink composed of a mixture of vegetables (e.g., fruits, vegetables),* […] *being a high creamy, healthy beverage*." Hence, a self-made smoothie from fresh, regionally and organically produced as well as fair-trade certificated ingredients of the season perfectly links to the conception of a sustainable nutrition.

3. Methodology: Designing a theory-driven learning environment

Motivation and interest of the learners are essential elements of a successful and sustainable learning process, which is why these components have been considered for designing the learning unit [9; 10; 11]. In her study, Gralher identifies several, prevailingly ego- and ethnocentric, nutritional orientations of students as most important aspects for young people's dietary habits. She derives four guidelines for planning lessons to promote student's ability for a sustainable nutrition behaviour [5].

The presented teaching concept particularly relies on Gralher's recommendations. Building on the approach of inquiry-based learning [12; 13] and Bybee's 5E instruction model [14], a workshop has been designed to provide an overview of the conception of a sustainable nutrition by making smoothies (Tab. 1). The objectives of this course are: 1) make participants aware of their own nutritional behaviour; 2) strengthen awareness of the effects of one's own nutritional behaviour; 3) demonstrate sustainable eating habits, and 4) provide knowledge for an informed decision. By scaffolding the learning process and with the help of self-reliant and active discovery, workshop participants try to exemplify their previously established hypotheses and conjecture. Teenagers (mainly aged 14-18) worked with the educational materials in four 90 minutes workshops. Two workshops took place at a youth centre in a Tyrolean small town; participants were mainly male apprentices between 14 and 18 years, some of them with a migration and refugee background. Two workshops were held at the Botanical Garden of the University of Vienna; students attended a private lower secondary school, were 13 to 14 years old and hold a multicultural background. Data were collected using moderate participant observation and by recording the learners' oral contributions to small group and plenary discussions. A case study approach was used to analyse the data.

Tab. 1. Overview of the didactic preparation in form of a curricular or extracurricular workshop

PHASE	CONTENT	METHOD & MATERIAL
Preparation of the place of performance	Preparing the workplaces and smoothie-bar; Preparation of several smoothies	
Welcome; presentation of the procedure	Guidance on the issue of 'sustainable nutrition'	Informing entry into teaching
Tasting of several smoothies; allocation of the participants to their workplaces *Engagement*	First discussion on the topics of sustainable nutrition and smoothies; group allocation	Tasting of smoothies; worksheet
Presentation of the research question or problem *Engagement*	Presentation or finding process of a research question depending on the level of requirements of the participants	Research question(s); if necessary: concept cartoon for the common finding of a research question (inquiry level 3); brainstorming
Preparation of smoothies by means of a test protocol *Exploration & Explanation*	Preparation of smoothies; discussion on the topic of sustainable nutrition (answering the research question and key questions)	Independent working in small groups; recording; working and testing materials

Presentation and marketing of the smoothies *Explanation & Evaluation*	Bringing together the evidence and thoughts; finding and illustrating demands on sustainable nutrition habits in connection with the food trend smoothie; repeating and consolidating the learning content	Presentation by the group speaker; critically plenary discussion and reflection; justification of the results
Farewell	Tasting of self-made smoothies; closing words	Give-away: recipes and recommendations for preparing smoothies

4. Results and discussion

The statements of the workshop participants specifically highlighted the importance of a sustainable diet and food system. Preliminary results show that after participating in these workshops, key concepts such as nutritional aspects of fresh-made smoothies in opposition to convenience smoothies (e.g., content of sugar, fibre, vitamins, phytochemicals); the origin (e.g., regional and seasonal foods); transport distance (e.g., global food chains), and transport routes (e.g. different means of transportation, emission of climate-active gases) of fruits and vegetables recurred throughout the dataset. Moreover, participants explicitly addressed ecological effects in relation to cultivation of these food crops (e.g. organic farming, use of herbicides and pesticides in monocultures). Social (e.g. fair trade) and occasionally economic aspects of the cultivation, trade and marketing of food were raised in plenary discussions at the end of the workshops. The issue that smoothies are rather a meal than a drink in terms of its nutritional effects was mentioned frequently. It was striking that learners showed vivid situated engagement, which maintained nearly throughout most of the 90 minutes time span.

5. Conclusions and recommendations

The findings, so far, seem to suggest that the inquiry-based educational materials are successful in supporting learners to make a link between sustainable nutrition and food trends such as smoothies. A more detailed data analysis and future research are required to confirm whether the knowledge gained by the learners in this course is also applied in every day decision making, and whether the acquisition of knowledge leads to sustainable nutritional behaviour. The investigation demonstrated that the teaching approach applied in both, formal and informal educational institutions, lead to an awareness in particular components of sustainability and shows the potential to create and expand nutritional knowledge in this area. However, the findings ought to be treated as tentative until further research is conducted to determine the likelihood that awareness will lead to behavioural nutrition change.

Acknowledgement

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Made by them to them: The Students in the Learning Process

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Abstract

The social and technological evolution reaches the school, so the pedagogies implemented in it no longer correspond to the expectations of students and society. There is a need to do different, innovate to make the teaching and learning process more natural and engaging for students, articulated and meaningful. We propose a pedagogy in which students are the producers of resources that they use in the learning process. This study aims to understand the importance of meaningful learning, focused on cognition, behavior and affectivity. In this sense, the Flipped Classroom methodology was used. In Primary School, Storytelling and Video Recording were experienced as knowledge enhancement resources. In Higher Education collaborative and oriented research was experimented and the results were treated, synthesized and shared in presentations made by the students and presented by them to them. Methodologically it is a case study whose data collection, in Primary Education, was made from the collection of reflective narratives carried out by trainees regarding the pedagogical practices implemented in real contexts. In Higher Education the data collection was performed by the teacher through direct observation. The data, in both situations, were objects of thematic analysis. The results point out that the pedagogy "made by them to them" (1) activates previous knowledge, (2) promotes personal and group efforts in achieving better results, (3) creates emotion in the learning process, since it generates involvement, recognition of oneself and of others. It was concluded that involving students in their learning process through active and participatory methodologies makes learning more meaningful and leads to the construction of learning in an active, participative and autonomous way.

Keywords: pedagogical innovation, 21st century competencies, active methodologies

1. Introduction

In a world marked by complexity, diversity and interconnectedness, reflected in the changing ways of living personal, professional and social life and the unpredictability of the future, there is a need for innovation in education methodology in relation to the generation that grows in the 21st century. The current scenario launches the renewal or disruption of the "old" paradigms, based on patterns of social conformity and behavioral passivity, presenting a panorama that distances itself from the conceptions and educational models of the industrial era. Indeed, in today's global, ubiquitous digital world, Education must respond to both the interests of students and the challenges of an increasingly organized society around complex digital networks. Many authors, for example Azevedo [1] and Guerra [2], who consider that the school does not respond to the needs of the new generation, which generates demotivation. Also, several official documents emphasize the need for up-to-date training in teaching methodologies and resources, as teacher training plays a decisive role in the transition to a knowledge-based society and economy [3-7].

2 Theoretical framework

Contemporaneity shows that adapting to today's reality and building a sustainable world requires skills that allow us to respond to complex challenges, mobilizing scientific, technical and technological knowledge and psychosocial resources that include attitudes, principles and values in a particular context, as revealed by the DeSeCo project [8]. Thus, for the critical understanding of the world, personal participation and conscious and responsible social intervention are required. In this context, a frame of reference for the profile of the student of the XXI century [9] was designed with a focus on critical thinking, flexibility, entrepreneurship and responsibility, among others, for which they point to an autonomous student with empathic and collaborative attitudes, entrepreneur, resilient and with ethical and moral responsibility. In cognitive terms, it should present critical, creative thinking and problem solving ability, be able to build knowledge from diverse sources using multimodal technologies to communicate them. The above mentioned student profile points to young people with cognitive and metacognitive competences, emersed in emotional and social capacities, and values such as motivation, trust, respect for diversity, as well as individual, local and global character [8-11]. We are faced with a curriculum of humanistic tendency that is based on the personality of the human being and emphasizes a paradigm based on the results and the logic of the competences, for which it imposes strong changes in the process of teaching and learning and in the use of varied digital pedagogical resources aligned with active methodologies troubleshooting. In this context, the teacher's training and creativity are vital, with the need to transform his pedagogical practices in order to adopt active, collaborative, and problematizing methodologies, always focused on the student and his teaching and learning processes.

In this study, we combine two distinct approaches, Flipped Classroom [12] and Storytelling, and articulate individual work and collaborative work. We did so because we believe that this alliance allows students to be involved in tasks, developing socio-emotional and cognitive competences as mentioned above. The Flipped Classroom puts emphasis on "prepare-to-do" and Storytelling on the "do-count" allowing "see-reflect-evaluate". These are three important steps in the learning process, as they involve the student in the active construction of knowledge. Thus, Flipped Classroom enhances how students interrelate with knowledge outside the classroom and activate prior knowledge, important organizers in the bridges of knowledge, as well as providing the teacher with the possibility of freeing himself from the presentation of content and to take advantage of class time for activities of discussion and construction of knowledge and pedagogical differentiation [13]. The same author considers that this inversion declines the unidirectional paradigm and promotes the reinforcement of classroom learning in a dynamic and satisfying work environment, enhancing the development of competences, namely creativity and autonomy in the use of technological resources. Lopes, Gouveia and Reis [14] show that the success of this pedagogical model depends on the initiative and the responsibility of the students to study the contents proposed outside the classroom, so that they can participate in the classroom with the necessary knowledge to discuss and debate ideas. For their part, Hugo and Johan [15] mention several studies that reveal that there are conditions for this approach to work well. They recognize that students become more active, participatory and accountable in the classroom, improve communication with peers and teachers, understanding and deepening curriculum content, collaborative learning, digital literacy and the ability to trust in themselves, skills that tend to improve the outcome of their learning. However, the same authors point out that other studies show that continuity of the methodology is fundamental for deep learning effects.

Since the work of both teachers in the preparation of materials and of students in self-study is greatly increased, it is necessary to have methodological continuity without this meaning that all content must be worked in this way.

Storytelling can become an indispensable ally that gives meaning to non-classroom learning, since such knowledge is needed to create the stories, which in turn will be the digital learning resources on which learning is based. Storytelling captivates children and fosters them in educational activities, especially because they participate in history, thus stimulating emotions, dialogues and synergies. We assume that if children have worked outside of school to build Storytelling, with their voices and materials, as a learning resource in learning, it may make learning more meaningful.

Consequently, it would increase the predisposition to do homework and to fulfill higher level goals, and perhaps the excitement in carrying out the educational activities and didactic resources will motivate them to an easy and happy learning process, and perhaps the prior knowledge and stimulate more extensive and broader participation.

2. Methodology

Methodologically it is a case study [16] that seeks to understand the importance of meaningful learning through cognition and affectivity. It was based on the premise that there are three broad competencies whose categories interrelate in such a way that they represent key competences that promote a successful life and contribute to the good functioning of society: “Use Tools interactively (eg language, technology), interact in heterogeneous groups, Act autonomously” [8]. As far as primary education is concerned, the Flipped Classroom approach, Storytelling and video recording were applied. The sequence of the work was as follows: in class 1 a Brainstorming was done on the subject to study and verses, text or book for individual reading by the children (Flipped Classroom) was sent as homework. In class 2, in the classroom, a video was produced collaboratively, or a Storytelling that included the voices of children. In class 3, also in the classroom, the storytelling created in the previous class was used as didactic resource for understanding the poem, text or literary work.

The student teachers reflected on these practices, carried out in real contexts within the mother tongue, with students from different years of elementary school education. These reflections take the form of narratives. From these narratives five were selected and these were the data analyzed in this article.

In the scope of higher education, the direct observation and recording in the field diary was done by the teacher. The students belonged to an engineering course and the teaching activities had the following structure: in class 1 the subject was approached and the materials related to the theme were sent through the Moodle platform. At home, the students communicated with each other to distribute assignments, each assuming responsibility for a part to be investigated and presented in the classroom.

In class 2, tutorial, each group reflected on the topic studied at home and built a

PowerPoint presentation. In class 3, in class, each group presented their work to the class. For the analysis of data, both narratives and field notes, thematic analysis were used [17]. From this analysis, emerged the three major categories that we present below.

3. Findings

From the analysis of the narratives, to the work carried out in primary school, and from the diaries, related to activities in higher education, several themes emerged.

For this study we select the three that best evidence the characteristics of MADE BY THEM TO THEM: a) Activates previous knowledge; b) Promote personal and group efforts to achieve better results; and c) It creates emotion in the learning process, since it generates involvement, recognition of self and others. We justify each of these thematic categories below. We do it for each subject, first for primary school and then for higher education. The amount of evidence presented in each case is related to the amount of work developed and that in higher education there was only one teacher involved and in primary school there were five student teachers.

a) Activates previous knowledge

One of the students says that in the strategy of Flipped Classroom "students have a first contact with the materials, or contents, that will work before the class, considering this process as part of the learning (...)", allows to carry out tasks that lead to higher levels of knowledge, since the basic knowledge can be worked out prior to class, with time in the classroom for more challenging and pedagogically richer activities" (N1).

It is verified, therefore, that resorting to previous knowledge learned or remembered before the class frees the time of the class for a work of greater cognitive requirement.

This idea appears in the diaries of more students as it is verified in the following two examples: "a video cast was carried out with the students (...) activity to appropriate and understand better the work that they would accomplish (...). This moment served simultaneously as a pre-reading moment, where previous knowledge was activated and motivated to read and understand the history ... a relationship was established between the textual comprehension and the previous knowledge of the reader, allowing the construction of meaning" (N3); "The children identified the verses they read the day before, beginning to speculate about the application of their voices (...)".

"This recognition of the verse's lyrics immediately called their attention by improving the interactions and the quality of student participation" (5).

Regarding higher education, we extract the following excerpt from the teacher's field notes: "sending the topic to be treated outside the classroom, gave the student the opportunity to relate the new subject with knowledge and representations they already had and also the opportunity for everyone to participate in the production of group products that resorted to the mobilization of the knowledge acquired at home." (NC6)

b) Promote personal and group efforts to achieve better results

The data in the narratives confirm that "the possibility of the students recording their speech stimulated the improvement of the reading; (...) the fact that they can listen, reflect on their performance and still use their own reading as a support for learning moments, has significantly elevated learning by placing the student at the center of this process" (N3). In another narrative we can read "the time spent on autonomous exploration by the students, provided the creation of links between the contents covered ... knowledge was built with the contribution of the students, which, from the perspective of the master, enriched the learning of each one of the others, in the group" (N2); it entailed hours of commitment and improvement outside the school (home) (...), "elicited the interest of the group demonstrated in the accomplishment of the subsequent exercises, which improved student performance and school results" (N5).

The higher education teacher emphasized in the field notes that "sharing with the group, the information resulting from individual research, stimulated the individual to strive to find scientific news that would surprise colleagues; was also felt as a way of compensating the other elements for the research information received from the group.

In addition, the presentation to the group of the products made in group, allowed to overcome some shyness and was leveraged by the stimulus of competition, since it stimulates the group in the achievement of better results relative to the other groups, promoting a greater involvement and effort of the group" (NC6).

In summary, and in both cases, it is verified that the previous preparation of the work, to be carried out in the classes requires motivation and effort of the student and ends up translating into more solid, more lasting and deep learning, in effect with better results.

c) It creates emotion in the learning process, since it generates involvement, recognition of self and others

Since the works of Antonio Damasio, the connection between rational and emotional aspects is widely recognized, also in learning. This is what was verified in the data extracted from student teachers' narratives.

... "The previous involvement of students in the activities that were to be developed throughout the class provided great enthusiasm; they anticipated what would follow, by recognizing one or another aspect or content that they identified as having been worked on previously (...); the fact that the students get involved, even before the lesson, with contents and learning and that they would be approached, makes them more participative and more committed to the success of their learning process, promoting a climate in the classroom, a class that is more prone to dynamization of more complex tasks that reach higher levels of challenge (N1); "There was a greater concentration on the part of the students (...); full motivation and enthusiasm on the part of the children who were genuinely fascinated to see themselves on the other side of the screen (...); participated in the construction of resources, in this case storytelling, which contained elements that trigger predisposition for active participation in class; work that they will not easily forget "(N3). From another narrative we take the following words that end up synthesizing this third thematic category: "Managing the emotions is not easy! Students like to recognize who speaks, enjoy listening, self-evaluate and evaluate their classmates, which is a very enriching moment of reflection in this learning process" (N5).

In the words of the professor of higher education, "the investigation of a given subject by the individual student and the group discussion facilitates the exchange of knowledge and experiences generating an emotive load that infects the members of the group, causing them to remember the contents and facilitating the process of applying the concepts in real life. As a side effect of this teaching learning process, a great value has been created, consisting of the natural memorization of information that results from the process of involvement, discussion and sharing provided through the repetitive approach of concepts. In the subsequent laboratory classes, the improvement of understanding of experimental work was evident, leading to a higher class output. This effect is even more noticeable in student-workers who have little time to study and who often present themselves in laboratory classes without having done the pre-study of recommended preparation” (NC6).

4. Conclusions

Our proposal “Made by them to them: the students in the learning process” is an approach that envisions the student as the main driver of his motivation and of his learning process, making him simultaneously a producer and a direct consumer of his production.

At both levels of education it was found that students were committed to developing to their full potential, both individually and in the collaborative process of building products such as video, storytelling, or PowerPoint. “Made by them to them” makes learning meaningful because it has included the student at the center of the learning process since class preparation. Thus, it activates the fundamental prior knowledge in a meaningful articulation, by which it facilitates the understanding of the curricular contents. The involvement of the student and the opportunity to share his knowledge, results in a greater personal and group effort with an impact on the performance and fluency of the teaching/learning process. It also results in an emotional process that generates recognition of self and others, of places and tasks, where the student becomes aware of himself and takes responsibility. On the other hand, it gives the teacher an opportunity to rethink the action plan by aligning the previous knowledge and the competences of the students and interests with curricular contents, which allows to create new levels of complexity and challenges.

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Talkin' About the Resolution

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Abstract

How do astronomical images work? Astronomical images (and, actually, all the digital images we are used to) are representation of reality mediated by an instrument that has its own characterisation (resolution, sensitivity, etc.). We developed a series of new creative and fun educational hands-on activities to play with children aimed at communicating the science of digital images and understanding concepts like image resolution in a multidisciplinary, participative environment. The educational activities we are proposing have a learning by doing approach and use favorite children's toys (e.g. pegs and bricks) as a research tool in order to introduce forefront science concept in a playful and inclusive environment. The use of familiar objects and ludic equipment prevents gender barriers and encourages immediate commitment and engagement of all the participants.
The project we will present is carried out in the framework of Italian National Institute of Astrophysics (INAF) SKA related projects (e.g., "SKA-Genesis", "ESKApe-HI", "FORECaST"). SKA (Square Kilometer Array) is one of the most ambitious international science projects and so we think that for astronomers it is of crucial importance to communicate its science, starting from the fundamentals. It'll be the world's biggest (radio) telescope and it'll give us insight into the major open problems: formation and evolution of the first stars and galaxies, the role of magnetism, the nature of gravity, possibility of life beyond Earth.

Keywords: Astronomy, Image Resolution, Participation, Inclusiveness, Hands-on

1. Introduction

1.1 The framework

The activities we are presenting are developed and being tested by the Italian National Institute of Astrophysics (INAF Istituto di Astrofisica) in the framework of SKA related projects ("SKA-Genesis", "ESKApe-HI", "Towards the SKA and CTA era: discovery, localization and physics of transient sources" e "FORmation and Evolution of Cosmic STructures with Future Radio Surveys).

SKA, Square Kilometer Array [1], is one of the most ambitious international science projects, it is currently under construction in Australia and South Africa and it will become the world's biggest telescope, tens of times more sensitive and hundreds of times faster at mapping the sky than today's best radio telescopes. Italy through INAF is strongly participating at its concept, design and operation and is playing a major role defining the scientific cases and building and infrastructure in preparation of the scientific exploitation. We believe that for astronomers it is of crucial importance to communicate the science of SKA, starting from the fundamentals. The SKA telescopes will give us insight into major open astronomical issues: formation and evolution of the first stars and galaxies, the role of magnetism, the nature of gravity, possibility of life beyond Earth… SKA will produce a data flow that is 100 times the global internet traffic: these data are not real pictures, but can actually be visualized as images: but what, in fact, these *images* are? In our hands-on activities, we introduce children to the science of (astronomical and radio-astronomical) imaging and data visualization, with a learning-through-play approach.

1.2 The approach

"Learning through play" describes a pedagogical and psychological approach according to which children make sense of the world through play. The concept is mainly based upon John Dewey's contribution [2] to the theory of constructivism [3] and Seymour Papert's theory of constructionism [4]. They basically suggest that "education is not an affair of 'telling' and being told, but an active and constructive process" ([2] Dewey, p. 85) and that "the best learning takes place when the learner takes charge" ([4] Papert, p. 25). Play-based learning programs are student-centered learning approaches, focused on the fully autonomous development of children's cognitive, social, experiential and creative potential through play (think also of the Montessori Method [5] and the Reggio Emilia Approach [6]).

Play-based approaches not necessarily employ toys as work equipment, nevertheless in this activity we take advantage of children's toys that use image sampling and make use of simple, very little structured playful stuff for reproducing images at different resolutions. Also, we build upon real children's interest (such as bricks!) to let them build their understanding of complex characteristics and phenomena. The main aims of this activity are:

- to introduce basic concepts of astrophysical imaging, such as spatial and chromatic resolution
- and sampling through toys and playing;
- to create an inclusive and participative environment, leaving much space to personal intuition and autonomous discovery;
- to prevent literacy barriers and encourage all children's commitment thanks to familiar objects as their toys.

2. Description of the activities

The activity mainly addresses elementary school students (8-10 years old) but has also been tested with middle school teachers. It includes at least two sessions of 2 hours each, involving the whole class divided in working teams of 5-6 children.

2.1 First part: the pegs

In each team, two of the students acting as "*operators*" are given a pegboard with a colour image under it: the image is only visible to them, whereas the other team members will have to guess the subject. The "*operators*" will use the board as a colour sampler, inserting in the holes pegs of the colours corresponding to the image they see under the board, in order to make the image recognizable to their fellow team members (Fig. 1). They start with a limited set of the biggest available pegs of different colours. The other group members will try to guess the subject being reproduced; meanwhile they also help the *operators* by winning more pegs for the representation.

The additional pegs are obtained by drawing and guessing astronomical subjects and kids can choose, in collaboration with the *operators,* what colour they need and also among 3 different peg size. During this phase, facilitators provide the additional pegs and the paper sheets indicating what subject to draw, but also provide the language necessary to help children articulate what they see happening and if needed ask questions, in order to expand and enhance play. Kids soon understand that smaller pegs (good resolution) are useful where the image details need to be defined, nevertheless they take much longer to be put in place; whereas when they want to represent large one-colour areas, no details are needed, and bigger pegs could provide a quicker solution (Fig. 2)

Fig. 1. Children starting to put pegs in the pegboard

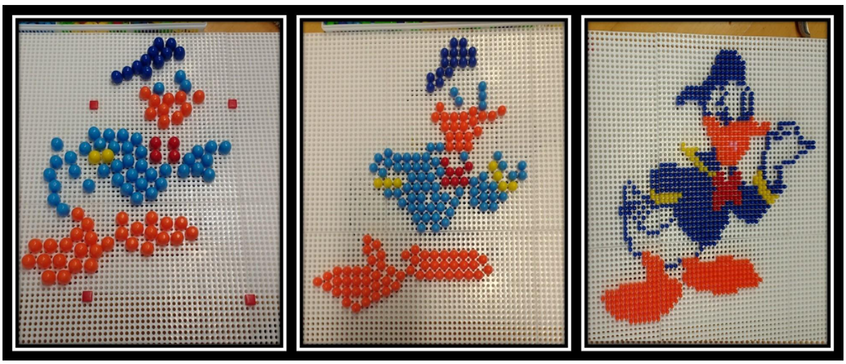

Fig. 2. Different peg sizes, different resolution of the image!

2.2 Second part: pixelization

In the second part of the activity, each group is given a colour image and a transparent baseplate for Lego-type bricks. The plate has to be transparent, so that the image under it is well visible. The kids will also have different sized and colour bricks (4x4, 2x2 and 1 button) and will try and reproduce the image using the different sized bricks as pixels, choosing the colour that best represents each image portion.

First, they will use the 4x4 bricks, so to realise that the image resolution they get is too poor to even understand what it is about; then they will try the 2x2 and finally the 1x1. Also student can try this activity individually, using images and sheets with grids of different sizes (resolutions), colouring each cell of the grid with a single colour, chosen in order to be the most representative of the "overall" colour of the box (in this case the range of possible colours is given by the ones already owned by the students). This can add an occasion of re-thinking and different perspective to the team work with bricks (Fig. 3).

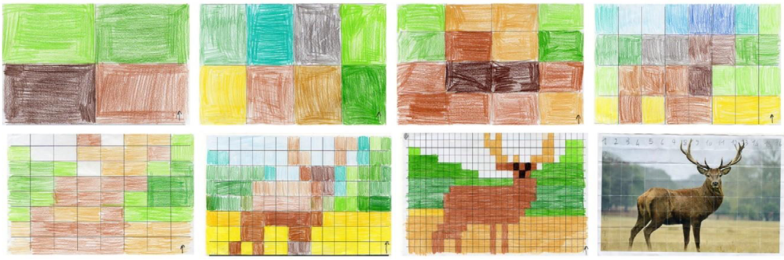

Fig. 3. Example of an image "pixelated" by the children

At the end of each phase, we took some time to discuss with children. We recap the main concepts arisen during play, discussing different ideas about the concept of resolution and also highlighting the limitation of our materials. We played the game "what if?" (e.g., if we had more pegs, smaller pegs, more shades of colour, different subject to pixelize). Through discussion, we relate this experience with familiar experience for kids (e.g., streaming file on *you-tube* with low connection). Finally, we connect the activity with the work of an astrophysicist again through a sort of play.

We visualize an astronomical object such as a galaxy and we let them decide how to measure it fixing a certain amount of time for the overall observation (a certain amount of pegs). In the test class, thanks to their experience, they immediately suggested it will be better to cover the object with a lower sample and then focus on the more "interesting areas" that they point out.

3. Results

The main results of the activity are:

- the simplicity of the used materials, together with their friendly and "interesting" nature, favoured an extremely positive attitude of the students;
- basic scientific concept seems to be deeply rooted thanks to various "eureka moment" that actually occurred and we observed the children really experiencing spontaneous learning;

- the lab encouraged a deep personal involvement and a proficient team work.

In this phase, when the activities were tested in a few different situations, we just carried out some qualitative evaluation, mainly related to observation, self reflection and documentation. We are planning a deeper evaluation, which in our view will necessarily have to deal with an assessment of the approach and the methodology (other than knowledge or content learning) as we are interested in the spontaneous learning that occurs in this situations.

4. Conclusions

This lab clearly proved as “the true value of play is not that it can teach children facts, but that it can help them acquire important procedural knowledge, which is beneficial in acquiring declarative knowledge” ([8] Pinkam, p. 31) We have literally seen the idea of images as data carriers rising in these children’s minds, while they experimented the limits of the medium and tried to overtake them. Next step will be to create a consistent, repeatable activity, with standard equipment, such as arranged kit or a list of material. Already we made an agreement with the peg producer, in order to have useful kits at a special affordable price for schools and educators (please contact us if you are interested!) and part of the activities has already been carried out in other countries (Ireland) and different situation (e.g., science fairs).

We have also discussed a possible third phase, which could include the digital elaboration of the images, with dedicated graphic software or educational software such scratch [9], to dig dip on the concept of quantity of information in an image.

We are also working on turning this lab multidisciplinary, in particular in connection with art experts and teachers, creating an art gallery of deconstructed images with less and less information and relating with the work of e.g. Piet Mondrian and also contemporary artists that are using pixelization as a distinctive signature of their work.

We would like to thank the kids (5°C Scuola Primaria Marella IC12 Bologna) and their teacher Stefano Rini that kindly hosted our very first attempt of this activity.

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The MathE Project: Effective Teaching of Mathematics

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Abstract

The article is a study based on MathE (Improve Math Skills in Higher Education) project coordinated by Pixel (Italy) in cooperation with technical universities and educational centres from Ireland, Lithuania, Portugal and Romania. The project is funded by the European Commission under the Erasmus+ Programme, KA2 – Strategic Partnerships for Higher Education. The project's idea stems from the fact that university students studying science and economics often lack the basic maths skills to effectively follow their lectures. The partnership has collaborated in this respect to find the most effective solutions and to prepare students for a world where mathematics is of central importance and extensively applied to diverse fields. The project aims to help teachers identify their students' gaps and to provide mathematics teachers with the necessary teaching sources so that they can help their students to overcome existing gaps. The article presents the project's main objectives, activities and outputs. It gives insights into the project's research and focuses on the effective instructional approaches used by teachers of mathematics to meet the diverse learning needs of their students.

Keywords: mathematics, students, research, collaboration, teaching methods

1. Context

At the dawn of the fourth industrial revolution characterised by an unprecedented development of science and technology Europe is facing a paradoxical challenge: students, even higher education students studying scientific and economics subjects such as engineering and Economics, often lack the basic maths skills to effectively follow their lectures. It is imperative to find the most effective solutions and to prepare students for a world where mathematics is of central importance and extensively applied to diverse fields. The MathE (Improve Math Skills in Higher Education) project aims to help teachers to identify their students' gaps and to provide mathematics teachers with the necessary teaching resources so that they can help their students to overcome existing gaps.

2. The MathE project: its objectives, target groups and activities

The main goal of the MathE project is to enhance the quality of teaching mathematics by encouraging the use of digital technologies as well setting up transnational teacher training courses and strengthening cooperation between teacher training universities.

The specific objectives are:

- To identify students' gaps in the knowledge of maths so that they effectively attend their courses
- To provide Math teachers with the necessary teaching resources so that they can help their students to overcome existing gaps
- To enhance a transnational sharing of teaching resources, tools and strategies in the field of Mathematics teaching and learning at higher education level

The MathE project addresses the following target groups: higher education students and mathematics teachers. From the student's point of view, the MathE project will stimulate students' motivation to study mathematics and make the best use of digital educational resources to increase their mathematical knowledge.

From the teacher's point of view, the MathE project promotes digital educational tools for the classroom, provides teachers with resources for the evaluation of students' progress in learning mathematics and also offers them evaluation and assessment tools; the platform enables discussion among teachers and researchers about good practices in teaching/learning mathematics.

3. The MathE project's research in Romania and its findings

The MathE project's research used interviews and data collection questionnaires, carried out on the people (academics and teachers) participating in the project. The interviews and questionnaires were administered at the beginning of the MathE project: 25 persons from the mathematics and engineering departments of the "Gheorghe Asachi" Technical University of Iasi and teachers from several high schools in Iasi.

The group was treated as a whole and the answers were interpreted qualitatively.

The focus was on the main methods teachers used in their work with their students. The teachers were encouraged to highlight the benefits and drawbacks of their teaching approaches.

All teachers participating in the interviews and questionnaire agree that traditional methods are still widely used in teaching mathematics in higher education; those methods are non-interactive: the student is the receiver of what the teacher lectures.

Traditional approaches are rooted in theory and do not meet most students' needs.

Teaching mathematics is abstract and decontextualized based on memorization and drills. Thus, the teacher explains an abstract concept, writes exercises on the blackboard and asks the students to copy them down. After that the students solve exercises. The students are rarely taught how to apply their knowledge into practice [1]. However, respondents also state that new tendencies have emerged recently which demand the introduction of innovative pedagogical approaches which encourage students' conceptual understanding. The new approaches follow the main principles of constructivist theory: learning is a student-centred process; students' autonomy is fostered; learning should be contextualised and connected with the real-world; social interaction and discourse is part of learning; the new knowledge should be made relevant to the learner and linked with the learners' previous knowledge.

Learning becomes an active process in which the learner is deeply involved; learning becomes a process of constructing knowledge by students themselves [2].

According to constructivist learning theory, knowledge is constructed as students integrate new information into their previous knowledge base.

The research has identified the following teaching methods: lecture method, inductive-deductive method, heuristic method (discovery/inquiry method), analytical-synthetic method, project method, brain storming and Think-Pair-Share method. Most teachers use all methods depending on the content, context or students.

Ten academics state that the lecture method is the most widely used form of presentation. They agree that this method addresses small and large groups and can be used to introduce new topics, summarize ideas, show relationships between theory and practice, highlight main points, etc. However, they all draw attention towards its limitations: students have a passive role as it encourages one-way of communication: teacher's lecture; therefore, the lecturer may find it difficult to perceive students'problems and realize how much students have understood from the lecture.

Nine interviewees stress that the inductive-deductive methods they use stir students' interest by resorting toexperiences and discoveries. This method develops independence and self-confidence in the students who discover the solution themselves.

The majority of respondents note that the heuristic method (discovery/inquiry method) allows students to lead and control their own learning experiences. The teacher acts like a facilitator and a guide. He/she is a resource person facilitating learning by stimulating or motivating students, clarifying and explaining. The learning atmosphere is relaxing and non-threatening.Students become active participants who solve problems they understand bystructuring their own learningexperiences.

Respondents also agree that it is a time-consuming method.

Fifteen respondents consider that the problem-based method is one of the most popular methods among students. Learning relies on organizing problem situations, defining problems, helping and guiding students to solve the problems, checking solutions and managing the process of systematizing and reinforcing the required knowledge. The problem-solving method enhances critical thinking.

The project method is another popular method as it promotes interaction among the students. It gives students an opportunity to work in a team and apply theoretical knowledge they learned in the classroom to meaningful contexts.

Analysis and synthesis methods complement each other and in the teaching of mathematics, the two should always go together. Generally, analysis is the procedure by which we break down an intellectual or substantial entity into its main components, parts or elements. Synthesis is the opposite procedure: we combine separate parts, elements or components in order to form or to reconstruct a coherent entity.

Educational games are by far the most popular. They centre around a problematic situation, which can offer students pleasant learning opportunities by engaging them in panel discussion, simulation, drama, etc. Games prepare students for life by ascribing different social roles to them and by exposing them to environmental phenomena which require deep analysis of various situations.

A few teachers use analogies as teaching and learning strategies because they create nice atmosphere, are flexible, memorable and ease of use. An analogy is a comparison between two things. Academic analogies are useful for teaching and learning because they require students to examine and analyze things and thenthey have to transfer that analysis to another thing. This kind of transfer requires conceptual understanding [3].

Think-Pair-Share, the technique encourages students to think about a question or an issue (Think) on their own, and then discuss their work with their deskmate (Pair).

Finally they have to report to class their findings (Share). Students appreciate the opportunity to test out ideas in a safe nonjudgemental environment. The last stage stimulates discussions: students share their variety of opinions and ideas in a relaxing an dstimulating atmosphere.

The learning by doing method enables students to see science, engineering 'in action'. Math is often thought of as reying on memorization of formulas and practicing skills. However, the test comes when students do not remember these formulas and have to reconstruct them. Students often use manipulatives to solve problems.

All teachers agree that they systematically integrate the use of concrete and digital manipulatives into their classes because they help students to make connections between concrete manipulatives and abstract mathematical ideas. Manipulatives can support student learning by helping students create links between theory and practice, abstract and real things.

All respondents state that there is no specific teaching method that leads to successful teaching of mathematics; they agree that there is a variety of methods of teaching which can be used in different classes depending on several factors such as: the sizes of the classes, students' ages needs and interests. All the above mentioned methods may not be equally appropriate and suitable for all levels of mathematics teaching. The teacher should feel comfortable with all these methods, their advantages and drawbacks and should adopt methods which ensure maximum participation of students [4].

4. Conclusions

The teacher and the student are partners in the teaching/learning process and are both equally responsible for the results of joint work and effort [2]. The teacher facilitates students' comprehension of the new material. To this end s/he connects the new knowledge to what students know and helps students to relate and apply it to their context (personal, family and community experiences). Contextualization of a course's content and concepts can improve student motivation and learning. Students understand the new knowledge as it is relevant to their context. These connections consolidate and make newly acquired knowledge meaningful and increase student engagement with learning activities. Effective teaching demonstrates that abstractions are rooted in and applied to the everyday world. Relating abstract knowledge to daily life helps students to retain information better. In the new teaching approaches the teacher and the student take on new roles. Thus, students become active participants, responsible for their learning process. The teacher is no longer the only knowledgeable authority; s/he is a guide, a facilitator, an advisor and an organizer. S/he is versatile with all teaching and learning methods but s/he knows that s/he has to embrace and adapt those methods which stimulate his/ her students' participation in his classes [5].

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STEM Education

Development of Learning Skills in Medical Students through PBL-STEM

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Abstract

The dynamics in the requirements of professional practices is changing rapidly the goals of higher education. Apart from the theoretical knowledge there is already a number of requirements, such as: team work, communicational, time management skills etc. that are essential for a successful career. This paper outlines some findings about the relationship between the way the teachers plan their courses, and the quality of the results that the students achieve. In particular, the article looks into the role of the Project-Based Learning (PBL) in STEM as an educational method that successfully supports the concept of contemporary teaching strategies and stimulates the students to strive toward self-actualization and lifelong learning.

Keywords: Project-Based Learning, Self-regulated Learning (SRL), learning skills

1. Introduction

The way in which the students perceive and understand learning context and therefore their own studying, is a major interventional factor which influences the relationship between the teaching and learning outcomes. An occurring tendency since the end of the last century in the field of educational studies has been the growing interest among researchers toward SRL. This new orientation is at least partially due to the rejection of outdated perceptions of putting emphasis on certain aspects of learning – especially in regard to university education – which according to many authors [1], [2], [3] have become impractical if not pointless. These researchers share the view that educational theories from the past have lost their popularity and usefulness. New, much more practical and purposeful concepts are needed. SRL might prove to be the starting point for the development of up-to-date concepts and ideas for the improvement of the academic environment which would enable the students to acquire the needed competence to become adequate and effective learners.

Even though Natural Science, Medicine and Engineering education is for the most part based on relatively conventional teaching methods and applying new methodology is key to achieving the contemporary goals of education. PBL provides fertile ground for the successful combination of learning content and practice, which would, in turn, broaden the students' academic perspectives and help them acquire useful professional and academic skills.It could be applied in practical exercises to stimulate SRL encourage the students to look into various possibilities, test out new ideas, work as a team, revise their thinking, and present their best solutions.

This paper is part of a research that is focused on the analysis of the possibilities to manage the process of establishing SRL practices among students in their early academic education, by applying the methodological inventory of the PBL using the principles of STEM-PBL. The research was conducted 88 first year students from the Faculty of Medicine at Sofia University "St. Kl. Ohridski". All of the students were working on a group project for Parasitology as part of the Human Biology course.

2. Materials and methods

PBL provides the students with the opportunity to study actively by getting fully immersed in the content of the various tasks, and thus not only does it help them improve and further develop their learning and communicational skills. This makes PBL suitable for university education, but it should be carried out with caution as it is possible for certain problems to arise in the process of project activities. Such problems are usually caused by lack of experience, too much pressure, disagreement between the participants, or by failing to register each member's individual contribution to the project.

In the experimental design students are tasked with a project that is divided in several stages which allow for a mid-work reporting and assessment. This makes it possible to track the individual contribution of each participant, and to make corrections where necessary, without sacrificing the freedom of personal choice and the successful completion of the project by all of the students.

2.1 Subject

"Study of the parasite agents, the spreading and treatment of some human parasitic diseases"

2.2 Goals

Professional and academic competence development.

2.3 Structure of the Project

The project comprises of three separate stages (Fig. 1) and has an overall duration of 6 weeks. The start of the project coincides with the period of the last four parasitology exercises of the semester.

Stage I consists of mainly individual work done by each student. Their tasks include gathering and analysis of information from various sources on the parasites, vectors and hosts in several human parasitic diseases. During Stage II, the students form small groups of two or three based on the biological relations of the organisms that they had researched in the previous Stage and the students' tasks are related to the studying of the human diseases caused by the said parasites. At Stage III students perceive themselves as part of one big group that incorporates all the small groups formed during the preceding Stage. Here the participants have to prepare and then make a presentation of the final joint product of the project. Each student shows the audience the slides that display information on the particular disease that he or she has researched during the project. After the whole presentation is over a short discussion ensues in which the participants share their thoughts and impressions in regard to the project.

Figure 1. Structure of the project

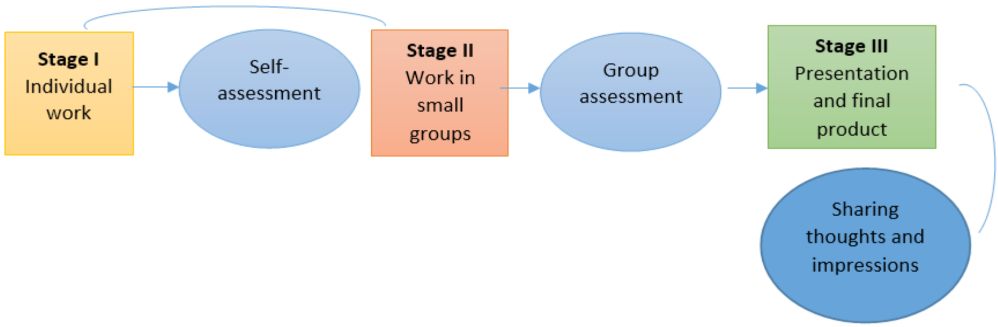

Fig. 1. Project structure

For the purposes of the project a shared Google Drive account is opened where each participant creates an individual folder in which to upload their work at all stages. On the one hand, the shared storage space makes it easier for the students to cooperate with one another and to exert better self-control, and on the other hand, it allows the professor – and in this particular case the author of this research paper – to discreetly gather information about the work process and the progress of the project, and to receive important feedback [4] on the level of clarity and the consistency of the instructions given to the students in regard to each task. As a means to gain access to additional information about the work process in the group, when needed, the professor assumes the role of a “friend-critic”, which proves to be a good strategy for ensuring the students’ effective performance.

2.4 Assessment of the Project Work

The project works assessment carried out in a complex manner where the final grade is determined by three separate components: 70% of the grade is based on the external assessment, 20% from self-assessment and the last 10% – intragroup assessment.

There are three elements that are taken into account for the formation of the professor’s grade: 1) the extent to which the final presentation meets the preset requirements, 2) the level of active participation and the integrity of the student while working on his or her tasks, and 3) the quality of the results and the final presentation.

Additionally, a survey on the level of satisfaction with the project is conducted among the students which provides a valuable feedback on the effects the PBL has on the development of learning skills. The questionnaire is divided into three parts containing a total of 37 five-point questions. Part C, titled “Group Assessment”, focuses on the students’ diligence and the degree of group cooperation.

3. Results and Discussions

3.1 Data Analysis

All students are grouped on the basis of the answer of following question: "How do you assess your work/performance in this project?" Depending on how the students responded to the question, four groups (G_1, G_2, G_3, and G_4)are formed as follows: G_1 – 39 people who answered "Excellent", or 44.32% of all the respondents; G_2 – 44 people who answered "Very Good", or exactly 50% of the students; G_3 – 3 people who answered "Good", or 3.41%; and G_4 – 2 people who answered "Not Good", or 2.27%.

The quantitative part of the analysis looks into the frequency of usage of the responses from Part A of the questionnaire, where the most frequently given answer is a relevant descriptive statistic [5] displaying the general tendencies among the students in regard to the impact the PBL has on the development of learning skills.

The qualitative part of the analysis is based on comparing and contrasting [6] the responses from Part A between all four groups. The comparing and contrasting of answers shows that the students react in a similar way to certain aspects of the development of skills in project-centered teamwork conditions.

3.2 Results

This article deals with the responses of Part A of the self-assessment questionnaire, and more specifically – the responses to the questions related to the importance of PBL for the development ofboth learning skills, and teamwork and management skills by the students.

Table1. Results from the responses to questions no.15, 16 & 21 given by the students in G_1 and G_2

15	Does the execution of project tasks help you learn the subject terminology more easily and more quickly?	Yes, absolutely	Rather yes	I'm not sure	Yes, but not completely	Absolutely no	
		68.18	29.55	2.27	0	0	'Very good'
		71.79	28.21	0	0	0	"Excellent"
16	Do you think you can apply what you learned during the project in other academic disciplines too?	Yes, absolutely	Rather yes	I'm not sure	Yes, but not completely	Absolutely no	
		70.45	25	2.27	2.27	0	'Very good'
		69.23	30.77	0	0	0	"Excellent"
21	The project work stimulates the students to take responsibility of their own personal and academic growth.	Yes, absolutely	Rather yes	I'm not sure	Yes, but not completely	Absolutely no	
		77.27	15.92	2.27	2.27	2.27	'Very good'
		64.1	30.77	5.13	0	0	"Excellent"

The results of the analyzed questionnaire answers as shown in Table 1 make it clear that working on a project in academic environment is readily embraced by the students who perceive PBL as a more open educational approach for achieving the desired educational goals.

Table 2. Responses to the statement: "Project work helps you…"

Project work helps you to develop …	Yes, absolutely	Rather yes	I'm not sure	Rather no	Absolutely no
skills for working with professional and academic literature	73	23	2	1	1
communication skills	58	36	2	2	2
critical thinking skills	45	32	14	7	2
creativity	64	25	11	0	0
perform assignments in different subjects	57	32	9	1	1
responsibility for your own personal and academic growth	63	31	6	0	0
ability to take the initiative when working in group	57	38	5	0	0

Table 2 shows the results of the improvement of the skills targeted with this project. In regard to the development of learning skills through PBL, the most frequently used answers for all of the components researched in this paper are once more "Yes, completely" and "Rather yes", given by more than 70% of the respondents. The answer "I'm not sure" is also present for all of the listed skills, varying in range between 2 and 14 percent. More specifically, a little over five percent of the respondents picked "I'm not sure" when answering questions related to the application of education in developing such skills as critical thinking, creativity, taking the initiative, etc. These results could be pertinent to either personality traits or the level of recognition and application of components of the cognitive activities which were not well represented in the students' previous experience.

In terms of qualitative results from this research, it must be noted that the overwhelming majority – 87 of 88 students – perceive PBL as a constructive educational approach that contributes to the development of personal skills as well as leaning skills that would help them achieve better efficiency in their academic education.

4. Conclusions

4.1 Findings

The research aspect of this paper on the effects of project work on the development of learning skills and some personal skills by the students could be presented by the following findings:

1. The projects activities provide ample opportunity to improve personal and learning skills, i.e., the students learn not "what to think", but rather: "how to think" when faced with a variety of tasks.
2. Team work requires that the professor pay special attention to his or her teaching approach.
3. PBL-STEM is student-centered approach that encourages the students to recognize the relationship between the development of personal skills and their efficiency as professionals.

4.2 Concluding Remarks

The design of education based on solving real problems is applicable from the very first stages of academic education. PBL could be utilized in courses on fundamental science subjects, and thus change the orientation of the teaching towards learning skills development. The results show that PBL encourages the students to have independent thinking when faced with academic problematique, and stimulates them to develop a higher level of cognitive skills.

PBL provide student-centered and independent learning. Students that have achieved a certain level of independency in learning would in turn acquire the skills needed to become much better professionals in future.

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Evaluations of Interns' Performances after Intervention Program Using Hierarchical Fuzzy Conjoint Analysis Model

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Abstract

Internship programs is a platform for the on-the-job training module that provide relevant hands-on or real work experiences for undergraduates within a specific period of time. In preparing the students with necessary skills prior to the students embarking the internship program, the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM) Malaysia has carried out an intervention program. The program is a special graduate employability program with industry collaborations focusing on effective employability skills such as Interpersonal Communication, Business Professional Communication, Public Communication, and Executive Skills Development that are important components for the students to excell in their internship. At the end of the internship program, the performance of interns' have undergone the intervention program prior to their internship were rated by their respective companies' employers based on seven employability attributes and twenty nine sub-attributes. As human preferences are rather fuzzy and uncertain in nature, a hierarchical fuzzy conjoint analysis model is proposed and employed in analysing the employers' ratings or preference levels on the interns' performance with respect to the attributes. The findings show that the employers were very satisfied with the interns on their Ethics and Values attribute and satisfied with other six attributes which are Communication Skills, Problem Solving, Practical Skills, Social Skills, Technological Skills, and Information Management Skills.

Keywords: conjoint analysis, employability skills, intervention program, performance, internship

1. Introduction

In today's highly competitive job market, managers are looking for individuals that have proper scholarly proficiencies and are exceptionally talented to fill positions in their organizations. Malaysian managers are searching for a more adaptable and versatile workforce as they themselves try to change their organizations into a more adaptable and versatile one [1]. However, graduates today face appalling challenges in meeting the market demand in terms of skills, quality and also qualification. Graduates with sound employability skills such as work ethics, self confidence, communication skills, leadership skills and good attitude are highly valued by employers would definitely succeed in paving their way into the labour market [2, p. 2]. Many studies indicate that graduates who have trouble in finding a proper job are partly due to lacking of employability skills [3, 4].

Some predictors of employability include English language proficiency, ethnicity, and the types of degree obtained [5]. According to [6], Malaysian graduates did not lack the skills and talent or competency to be employed. But they need proper direction and inputs to nurture their natural talent, interpersonal skills and abilities as stated by The National Education Blueprint 2015-2025: Higher Education [7]. Graduates must have the evidence to prove to the employers that they have the ability to deal with uncertainty, the ability to work under pressure, show action-planning skills, communication skills, information technology skill, team work, a readiness to explore and create opportunities, self-confidence, self-management skills and the enthusiasm to learn something new to gain their employer's interest [8]. In addition to that, graduates who have the traits to work within a team also can lead to team success and they will be hired by the employer. Employers are searching for graduates that can converse fluent English and good interpersonal skills since they have the ability to express ideas, explain about issues and resolve problems [9]. In 2012, Ministry of Higher Education Malaysia (MOHE) launched the Graduate Employability Blueprint [8] for 2012-2017 with the aim to increase the graduate employability as well as to fulfil the need for skilled and professional manpower towards nation building. Many of the programs suggested involved collaboration of industry with universities [8] and universities are encouraged to implement programs through Graduate Employability Grant from MOHE. To embed employability skills into students' activities, the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM) Malaysia proposed a model for graduate employability [11] through Graduate Employability Grant. The aim is to prepare the students prior to their internship as shown in Figure 1.

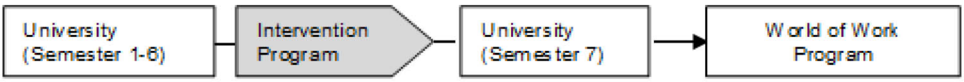

Fig. 1. An intervention program before internship

This intervention program named as "Born to be a Diamond" involved industry participation. They found that after the intervention program, the actual performance of these interns is much higher than expectations of their employers. Twenty three students voluntarily participated in this program which was held for 22 days focuses on effective employability skills such as Interpersonal Communication, Business Professional Communication, Public Communication, and Executive Skills Development. Also sessions such as visioning, personal development, interpersonal communication, personal finance, personal grooming, etiquette and protocol are embedded in the program. Apart from that, some other modules such as business acumen, entrepreneurship skills to empower self or create a startup, design thinking and Business Model Canvas for a new economy and Internet of Things (IoT) skills, e-commerce is also being introduced to prepare them for the new world of work.

Some of the modules were conducted by captains of industries. At the end of their internship, the questionnaires were given to their respective companies' employers to rate their performance. Some of the reputable companies (Multinational Companies and Government Linked Companies) were the American Insurance Association (AIA), Tune Protect Malaysia, Petronas, AmBank Group Malaysia, Bank Muamalat Malaysia Berhad, Commerce International Merchant Bankers Berhad (CIMB), Telekom Malaysia Berhad (TM) and Bank Islam Malaysia Berhad Securities (BIMB Securities).

2. Methods

In this paper, a Hierarchical Fuzzy Conjoint Analysis Method (HFCAM) which is an extension of the Fuzzy Conjoint Method (FCM) [12] and fuzzy set preference model [13] isproposed and employed in evaluating the interns' performance after intervention program, the application of HFCM enables the performance of the interns' to be studied by specific attribute as well as by the overall achievement across attributes as laid out in Table I. Basic theories and related operations on fuzzy sets used in the procedure can be found in [15,16]. Ratings of employers on the interns are extracted from questionnaires which are designed based on [3,12] with slight modification to suit with the intervention program involving 7 attributes and 29 sub-attributes as listed in Table 1.

Table 1. Attributes and Sub-attributes

Attribute	Sub-attributes	Attribute	Sub-attributes
Communi-cation Skills (X_1)	Understand and follow instructions correctly (x_{11}) Communicates and expresses ideas effectively (x_{12}) Speaking clearly and effectively (x_{13}) Communicates ideas in writing effectively (x_{14})	Ethics and Values (X_4)	Punctuality (x_{41}) Dress appropriately to work place (x_{42}) Take full responsibility on the task given (x_{43}) Able to distinguish between personal and workplace matters (x_{44})
Problem Solving (X_2)	Applies problem solving technique effectively (x_{21}) Applies creative thinking producing ideas (x_{22}) Applies critical thinking in decision making (x_{23}) Able to provide an explanation of the problem clearly and accurately (x_{24}) Able to create new ideas (x_{25})	Social Skills (X_5)	Carry out a task from start to finish based on quality standards (x_{51}) Ability to finish a task in a given time(x_{52}) Ability to cope with work pressure (x_{53}) Ability to work without supervision (x_{54})
		Technological Skills (X_6)	Use computing and information technology effectively (x_{61}) Willing to learn new IT skills (x_{62}) Have adequate IT skills to apply in a given task (x_{63})
Practical Skills (X_3)	Able to work in a team (x_{31}) Demonstrates good analytical skills (x_{32}) Willingness to learn in accommodating change (x_{33}) Able to lead a work in a team (x_{34}) Entrepreneurial skills (x_{35})	Information Manage-ment (X_7)	Able to retrieve information from maximum references (x_{71}) Highly engages in independent learning (x_{72}) Excellent use of references (x_{73})

The general procedure of the HFCM is presented as follows:

<u>Step 1:</u> Identify the set of attributes, $X = \{X_i\}$, sub-attributes, $X_i = \{x_j\}$ with $i = 1,2,...,m$, $j = 1,2,...,|X_i|$, where $|X_i|$ is the cardinality of the set X_i.

<u>Step 2</u>: Set the predefined linguistic rating defined by discrete fuzzy sets, $L_k = \left\{ \frac{\grave{\imath}_{L_k p}}{p} \right\}$, $p,k = 1,2,...,t$.

Step 3: Obtain the fuzzy sets representing:

- The aggregated linguistic ratings $\widetilde{x}_{ij}$ with respect to the sub-attributes x_{ij} where:

$$\widetilde{x}_{ij} = \sum_{k=1}^{t} \frac{r_{ijk}}{\sum_{k=1}^{t} r_{ijk}} L_k = \left\{ \frac{\mu_{ijp}}{p}, p = 1,2,...,t \right\} \tag{1}$$

where r_{ijk} is the number of for each linguistic rating, L_k , $k = \{1,2,...,t\}$.

- The aggregated linguistic ratings $\widetilde{X}_i$ for the *i*-th attributes X_i , $i = 1,2,...,m$ such that:

$$\widetilde{X}_i = \sum_{j=1}^{|X_i|} w_j \, \widetilde{x}_j = \left\{ \frac{\mu_{ip}}{p}, p = 1,2,...,t \right\}, \quad w_{ij} \in [0,1] \tag{2}$$

- The overall rating $\widetilde{X}$ across attributes such that

$$\widetilde{X} = \sum_{i=1}^{m} \omega_i \widetilde{X}_i = \left\{ \frac{\mu_p}{p}, p = 1,2,\ldots,t \right\}, \omega_i \in [0,1] \tag{3}$$

Note that the sub-attribute weights w_{ij} and the attribute weights ω_i can be generated using any appropriate attribute weight determination methods available in the literature.

Step 4: Calculate the degree of similarities of the following pairs of fuzzy sets representing:

- The aggregated linguistic ratings for sub-attributes $\widetilde{x}_{ij}$ and the linguistic ratings L_k where

$$S_{ijk}\left(\widetilde{x}_{ij}, L_k\right) = \frac{1}{1 + \sqrt{\sum_{p=1}^{t} (\mu_{ijp} - \mu_{L_k p})^2}}, \quad i = 1,2,...,m, \quad j = 1,2,...,|X_i|, \quad k = 1,2,...,t \tag{4}$$

- The aggregated linguistic ratings $\widetilde{X}_i$ for the *i*-th attributes and the linguistic ratings L_k :

$$S_{ik}\left(\widetilde{X}_i, L_k\right) = \frac{1}{1 + \sqrt{\sum_{p=1}^{t} (\mu_{ip} - \mu_{L_k p})^2}}, \quad i = 1,2,...,m \quad k = 1,2,...,t \tag{5}$$

- The overall rating $\widetilde{X}$ across attributes and L_k where:

$$S_k\left(\widetilde{X}, L_k\right) = \frac{1}{1 + \sqrt{\sum_{p=1}^{t} (\mu_p - \mu_{L_k p})^2}}, \quad k = 1,2,\ldots,t. \qquad (6)$$

<u>*Step 5*</u>: Identify the linguistic term that represent the performance with respect to the sub-attributes, attributes and overall evaluation (across attributes) based on the highest similarity degrees calculated in Step 4.

3. Results and Discussions

The number of responses based on the linguistic rating by 23 employers with respect to the sub-attributes based on the questionaires are displayed in Table 2.

Five predefined linguistic terms defined by discrete fuzzy sets used in rating the performance of the interns are:

Not Satisfied, $L_1 = \left\{\frac{1}{1}, \frac{0.7}{2}, \frac{0.3}{3}, \frac{0}{4}, \frac{0}{5}\right\}$; *Less Satisfied*, $L_2 = \left\{\frac{0.7}{1}, \frac{1}{2}, \frac{0.7}{3}, \frac{0.3}{4}, \frac{0}{5}\right\}$;

Quite Satisfied $L_3 = \left\{\frac{0.3}{1}, \frac{0.7}{2}, \frac{1}{3}, \frac{0.7}{4}, \frac{0.3}{5}\right\}$; *Satisfied*, $L_4 = \left\{\frac{0}{1}, \frac{0.3}{2}, \frac{0.7}{3}, \frac{1}{4}, \frac{0.7}{5}\right\}$;

Very Satisfied, $L_5 = \left\{\frac{0}{1}, \frac{0}{2}, \frac{0.3}{3}, \frac{0.7}{4}, \frac{1}{5}\right\}$.

Table 2. Number of Responses based on Linguistic Ratings

Attribute		Linguistic Rating				
		L_1	L_2	L_3	L_4	L_5
X_1	x_{11}	0	0	2	7	14
	x_{12}	0	0	4	8	11
	x_{13}	0	0	2	9	12
	x_{14}	0	0	4	13	6
	x_{15}	0	0	6	13	4
X_2	x_{21}	0	0	3	5	11
	x_{22}	0	0	6	7	10
	x_{23}	0	1	4	10	8
	x_{24}	0	1	3	13	6
	x_{25}	0	0	8	13	2
X_3	x_{31}	0	0	1	6	16
	x_{32}	0	0	3	6	14
	x_{33}	0	0	1	10	12
	x_{34}	0	1	7	9	6
	x_{35}	1	1	15	4	2
	x_{53}	0	0	4	6	13
	x_{54}	0	1	2	12	8

Attribute		Linguistic Rating				
		L_1	L_2	L_3	L_4	L_5
X_4	x_{41}	0	1	0	7	15
	x_{42}	0	0	1	6	16
	x_{43}	0	0	0	6	17
	x_{44}	0	0	1	6	16
X_5	x_{51}	0	0	3	11	9
	x_{52}	0	1	2	6	14
	x_{53}	0	0	4	6	13
	x_{54}	0	1	2	12	8
X_7	x_{61}	0	0	1	12	10
	x_{62}	0	0	0	16	7
	x_{63}	0	0	4	14	5
X_7	x_{71}	0	0	4	11	8
	x_{72}	0	1	2	14	6
	x_{73}	0	0	7	13	3

From Table 2, the fuzzy sets representing the aggregated linguistic ratings for each sub-attributes, $\tilde{x}_{ij}$, main attributes, $\tilde{X}_i$, and the overall performance, $\tilde{X}$, are derived using (1), (2) and (3), respectively. For x_{11}, the corresponding fuzzy set is obtained as

$\tilde{x}_{ij} = \left\{ \frac{0.026}{1}, \frac{0.152}{2}, \frac{0.483}{3}, \frac{0.791}{4}, \frac{0.848}{5} \right\}$. Applying (4), the similarity degree between fuzzy sets $\tilde{x}_{11}$ and $L_k, k=1,\ldots,5$ is calculated as $S_{11}(\tilde{x}_1, L_1)=0.8$, $S_{12}(\tilde{x}_1, L_2)=0.4$, $S_{13}(\tilde{x}_1, L_3)=0.5$, $S_{14}(\tilde{x}_1, L_4)=0.3$ and $S_{15}(\tilde{x}_1, L_5)=0.7$. Note that the highest similarity degree $S_{15}(\tilde{x}_1, L_5)=0.7$ is associated with the linguistic term L_5 indicating that the employers are Very Satisfied with interns on the attribute x_{11}. The respective degrees of similarity for the rest of the sub-attributes, main attributes and the overall performance with the predefined linguistic terms i.e., $S_{ijk}(\tilde{x}_{ij}, L_k)$, $S_{ik}(\tilde{X}_i, L_k)$ and $S_k(\tilde{X}, L_k)$ are calculated accordingly using (4), (5) and (6). The results are displayed in Table 3.

Table 3. Employers' Preference Ratings towards interns' performance

Attribute		Sub-attribute	
$\tilde{X}_i$	Rating	$\tilde{x}_{ij}$	Rating
$\tilde{X}_1$	Satisfied	$\tilde{x}_{11}$	Very Satisfied
		$\tilde{x}_{12}$	Satisfied
		$\tilde{x}_{13}$	Satisfied
		$\tilde{x}_{14}$	Satisfied
		$\tilde{x}_{15}$	Satisfied
$\tilde{X}_2$	Satisfied	$\tilde{x}_{21}$	Very Satisfied
		$\tilde{x}_{22}$	Satisfied
		$\tilde{x}_{23}$	Satisfied
		$\tilde{x}_{24}$	Satisfied
		$\tilde{x}_{25}$	Satisfied
$\tilde{X}_3$	Satisfied	$\tilde{x}_{31}$	Very Satisfied
		$\tilde{x}_{32}$	Very Satisfied
		$\tilde{x}_{33}$	Satisfied
		$\tilde{x}_{34}$	Satisfied
		$\tilde{x}_{35}$	Quite Satisfied

Attribute		Sub-attribute	
$\tilde{X}_i$	Rating	$\tilde{x}_{ij}$	Rating
$\tilde{X}_4$	Very Satisfied	$\tilde{x}_{41}$	Very Satisfied
		$\tilde{x}_{42}$	Very Satisfied
		$\tilde{x}_{43}$	Very Satisfied
		$\tilde{x}_{44}$	Very Satisfied
$\tilde{X}_5$	Satisfied	$\tilde{x}_{51}$	Satisfied
		$\tilde{x}_{52}$	Very Satisfied
		$\tilde{x}_{53}$	Satisfied
		$\tilde{x}_{54}$	Satisfied
$\tilde{X}_6$	Satisfied	$\tilde{x}_{61}$	Satisfied
		$\tilde{x}_{62}$	Satisfied
		$\tilde{x}_{63}$	Satisfied
$\tilde{X}_7$	Satisfied	$\tilde{x}_{71}$	Satisfied
		$\tilde{x}_{72}$	Satisfied
		$\tilde{x}_{73}$	Satisfied

Based on Table 3, the employers are very satisfied with the interns' "Ethics and Values" skills. The employers are basically satisfied with the rest of the attributes, namely "Communication Skills", "Problem Solving", "Technological Skills" and "Information Management". The sub-attribute Entrepreneurial skills (x_{35}) received the lowest linguistic preference rating by the employers i.e., 'Quite Satisfied' as compared to the rest of the sub-attributes. Overall, the respective employers are "Satisfied" with the interns' performance in the internship program of their company.

4. Conclusions

This study focuses on the implementation of Hierarchical Fuzzy Conjoint Analysis Method (HFCAM) in analysing the level of preference or ratings of employers towards interns' performances on the employability attributes. The result showed employers were satisfied with the overall interns' performances, it can be concluded that the intervention program before the students enter the world of work can be served as an effective model for the future employability program.

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Evolution and Perspectives of Science Curriculum in the Czech Republic

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Abstract

The education system in the Czech Republic went through a series of significant changes in the last 30 years; changes related mostly to the society-wide changes after 1989 and gradual connection of Czech Republic into the European Union. After 40 years of implementing unified school system and centralization of education, the educational system was transformed from 1990s onwards and the autonomy of the schools increased thanks to the unified curriculum. Despite that, the contents and methods of teaching of scientific subjects in primary and secondary education have changed only little. This relates to the overall problem of current concept of science education not only in our country but also in the rest of EU.

The goal of the first part of the article is to introduce the evolution of the science teaching paradigm in the Czech Republic in the last 30 years using the thematic qualitative analysis with the help of strategical and conceptual documents of the Ministry of Education and other documents created by organizations that are responsible for education in the Czech Republic. In the second part of the article, we would like to use an analysis of curricular targets in science education since 1990s to focus on transformation of science education goals and on projecting of alternative methods and educational processes into science curricula. We will also state current main problems and necessary changes that are being prepared on the basis of the analysis.

Keywords: science education, primary and secondary education, content and methods of the curriculum, STEM and STEAM, IBSE

1. Introduction

The tradition of science education at primary and secondary level in the Czech Republic is long. However, the approach to science education has stayed almost unchanged for over 30 years. Since the current world is actually changing and evolving very fast in all of its areas and the Czech Republic is an inseparable part of the world, it's not possible to stagnate at the achieved science education level.

Many studies point out the problems of the scientistic approach to science which eventually leads to lack of understanding and interest about science at all levels of education. We can observe a worldwide swerve from this concept of education and focus on science themes that students could use in their future lives regardless of their eventual profession.

Apart from the requirement about changes in science curriculum contents, there is also emphasis on new methods and processes that should be used in teaching of those subjects. One of the demands is an interdisciplinary approach that would better correspond to real scientific research. There is also an emphasis on the connection between science and mathematics/ICT. EU projects focused on science education often talk about the "STEM" approach (including mathematics), or the "STEAM" approach (that also includes arts). Research shows that use of the abovementioned methods and techniques brings positive results in science education. Therefore, changes in teaching of science are now being prepared, even in the Czech Republic.

2. The evolution of science education paradigm

The science education has been going through many changes since 1990; changes that go in the name of new standing and concept of science disciplines. Some authors, like Osborne and Wittrock (1983) even talk about science education crisis.

Both science paradigms that were used up to that point – humanist and scientistic – seemed to be too rigid. Therefore, they had to be replaced by other paradigms that would better reflect dynamic changes in science, technology and organization of society (Maršák & Janoušková, 2006). However, the beginning of the 21st century also brings another challenge in the area of national education, and that is globalization.

Globalization is usually meant to be the worldwide intensification of social relations that lead to local events being formed by things happening thousands of kilometres away and vice versa (Held, 1991). For this reason, globalization erases, to a point, national borders, enhances and requires certain cohesiveness and has significant effect on the organization of national identity (Torres, 2002). This necessarily had to reflect in the education politics (and it does), especially since the globalization was supposed to act as a introduction and development of knowledge-based society and economics.

At the same time, we have to realize that while the world started to approach science education as a way to understand the world and get oriented within it, there was a significant decline in students' interest about the study of science and technological disciplines (Osborne & Wittrock, 1983). This crisis lasted until the beginning of the 21st century and the deciders saw its existence as a serious problem since science and research of new technologies that stems from it have been and are one of the strong preconditions of success and competitiveness of individual countries (Krammer, 2017).

However, 1990s are not just the period of searching for new approaches to science education; they are also a period of creation and implementation of the first globalized research studies in measuring of the students' results in science. The impact of these comparative surveys on participating countries' educational systems was extraordinary, which might come as a surprise for some of those countries. The first survey, which is regularly implemented globally in a four-year cycle (usually encompassing over than 50 countries) since 1995, is TIMSS (Trends in International Mathematics and Science Study) coordinated by the company The International Association for the Evaluation of Educational Achievement (IEA). The second survey, by the Organisation for Economic Co-operation and Development (OECD), is the PISA research (Programme for International Students Assessment), implemented in three-year cycles since 2000 (however, the preparation stated in late 1990s). Czech Republic is a regular participants in these surveys.

However, these international surveys were not the impetus for changes in science education in the Czech Republic. There were two reasons for that. The first one was the necessity to focus on fundamental transformation of the whole educational system and make it conform to the needs of new democratic society. This task was fairly complicated even from the point of view of curriculum transformation – there was gradual increase in the autonomy of schools. The second reason, just as important, was the fact that the Czech Republic achieved above-average results in the international survey TIMSS from 1995. It would therefore seem that the contemporary approach to science education had good results (ÚIV, 2002). In 2000's PISA survey, Czech students achieved an above-average scientific literacy rating among the OECD countries. At the beginning of the 1990s, the science education had a unified curriculum (for lower secondary education since 1982, for upper secondary education since 1984). Attempts to make the curriculum less strict led to the curricular synopsis becoming non-mandatory, but mid-1990s saw the publication of new curricular documents, so-called Educational Standards. The Standards contained mostly educational goals and basic subject matter. The educational goals delineated the basic framework of education students should achieve by graduating from the specific kind of school. They included knowledge goals, skills and competencies, values and approaches. The basic subject matter expressed the contents of the education; its important elements. It was divided according to education areas and disciplines into the areas of language, social sciences, mathematics/IT, science, esthetics/pedagogy and healthy lifestyle.

In 2005-2007, the educational standards were gradually replaced by *framework education programs* (FEP). These delineate generally binding demands for various stages of schools and individual scientific disciplines. They also contain binding rules for creation of *school education programs* (SEP), curricular documents that should be the guide for implementation of education at a specific school. According to FEP specification, each school should create its own SEP, opening space for asserting the potential of the individual schools.

Each stage of education has its own individual FEP that states specific *key competences* for that stage. Each key competency is then developed using bullet points that state what a student should know in that particular stage of education. Apart from the key competencies, FEP also defines *education areas*. The education areas are understood to be a widely concepted whole formed by one or more education disciplines whose contents is related. Scientific disciplines are a part of the area Man and Nature. Each area lists its characteristics and target focus, each discipline lists expected outputs and subject matter. FEPs contain so-called *cross-section themes*, focused mostly on upbringing – developing and affecting the students' approaches, value systems and conduct. They are a mandatory part of education and their pedagogical and integratory content focus helps with acquisition of key competencies.

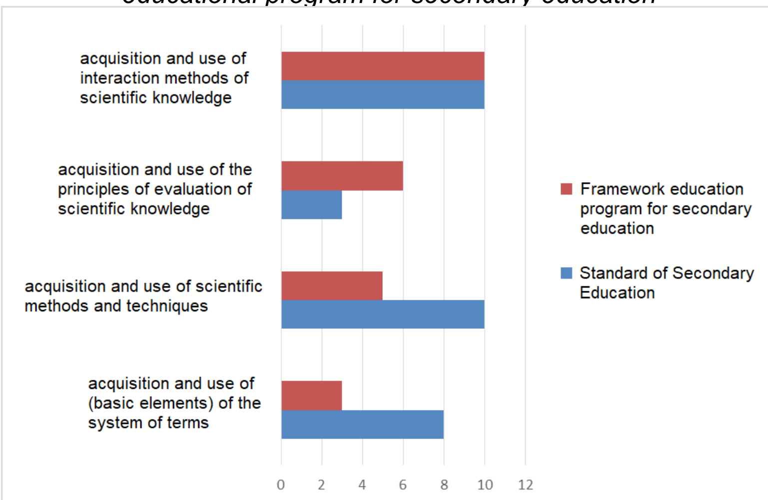
Next, the area of science education was impacted by another new worldwide phenomenon: inquiry-based science education (IBSE). Although IBSE was far from a new concept and many countries worked with it since 1960s, we can assume that a report of the European Commission by Michel Rockard called *Science Education NOW: A Renewed Pedagogy for the Future of Europe* was a major factor in achieving greater prevalence of this concept. This report concluded that young people's interest in studying science is declining in European countries, despite the fact that science's importance for society is seen as fundamental. It also concluded that one of the reason for this disinterest in science is the way it's taught. The report repeatedly emphasizes the necessity of support such methods of science education at schools that would lead from primarily deductive education methods to inquiry-based ones; this is also reflected in the recommendations and conclusions of the report. (EC, 2007). A British study called "Science Education in Europe: Critical reflections" helmed by renowned scientists Osborne a Dillon (2008) also supported the EC report in this regard

3. Evolution of the goals of science education

The evolution of goals of science education at the secondary level can be well-illustrated by analysis of the primary curricular documents from the last 30 years. We have chosen the Standard of Secondary Education (MŠMT, 1995) and the Framework education program for secondary education (MŠMT, 2007) for our analysis. The documents were analysed as a whole, i.e., the goals of science education were identified not only in the specific goals of the disciplines or in the characteristics of the education area of the scientific disciplines, but also in the introductory general parts of the curricula.

We used the Atlas.ti software as a coding system; this allowed for synoptic highlighting of parts of extensive text documents related to science education and for categorizing the data. The categories were deductively derived (Mayring, 2000) from the definition of scientific literacy according to the study "Literacy in education" with a slight change in the fourth category where we have included a new subcategory *health and healthy lifestyle*. The reliability of the data was ensured via double independent coding of the documents and via a consultation with a creator of both curricula who helped with interpretation of unclear parts. The results of the analysis of these curricular documents are shown in Graph 1.

Graph 1: Frequency of categories in the Educational Standards and Framework educational program for secondary education



This graph shows that the FEP significantly reduced the category of acquisition and use of terms, compared to the Educational Standards, corresponding to the demand for reduction of the subject matter scope of scientific disciplines. What's less positive is the finding that there was a significant reduction of acquisition and use of scientific methods and techniques in the FEP. On the other hand, acquisition and use of the principles of evaluation of scientific knowledge has more space in the FEP, and the scope of acquisition and use of the interaction methods of scientific knowledge is quite extensive (and almost identical) in both documents. Therefore, we cannot claim that FEP unequivocally pushed the teaching of science subject in the required direction, and this is also the opinion of the analysis of the Department of Education which summarizes basic flaws of FEPs and the necessary changes.

A revision of the FEP system is due shortly. Its goals are:

Goal 1: To make the curricular document system more transparent for schools and public and to conceptually unify all FEPs so they would form self-contained, internally logical system of demands on education from pre-school to secondary.

Goal 2: To make creating SEP easier for schools via formulation of clear goals and expected outputs and via the offer of model school educational programs that would be available to them.

Goal 3: To remove the curriculum overload, to make the individual curricular documents more transparent, to have only demands necessary for education in the FEP, and to work the key competencies directly into the educational disciplines.

Goal 4: To focus the general education curriculum on what's important in the 21st century: practical applicability of knowledge and skills in further study and life, distinguishing core subject matter and expanding subject matter, meaningful integration of education content into wholes and into the following evaluation system.

4. Conclusion

An extensive search of approaches to science education in the last 30 years on both national and international levels and analysis of the goals of science education showed that the Czech Republic respects most of the trends from abroad that appear in teaching and that the curriculum revision shifted science education in desirable direction, at least when considering the intended curriculum. The current setting of the curriculum allows to develop all interconnected dimensions of scientific literacy. These dimensions correspond to the analysed literature on current delineating of science literacy, as well as with the general goals of education, given by the current strategic documents, both national and international.

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Implementation and Didactic Validation of STEM Workshops in Primary Education

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Abstract

Several studies have analyzed the emotions experienced by students in the primary education stage (6-12 years), revealing positive results in students of this age. This is relevant to begin to build from these levels an effective STEM (Science, Technology, Engineering and Mathematics) education, which allows a motivating and meaningful learning in the students. The general objective of this research is to implement and validate from a didactic point of view the use of STEM workshops in the primary classroom. For this purpose, a quasi-experimental research design has been followed with control groups, experimental groups, pre-test and post-test. Specifically, several parallel studies have been carried out in various schools. The control groups worked with a traditional methodology and the experimental groups with an active methodology with STEM workshops. In particular, a sample of 234 students between the ages of 9 and 12 has been used, divided into control groups and experimental groups. Questionnaires used as pre-test and post-test were designed as measuring instruments depending on the selected theme in each group. The results obtained in the pre-tests show the existence of low initial knowledge in the contents under study. However, after the execution of the different didactic interventions, there can be found an evolution both in the cognitive and affective domain in the students. In addition, an intergroup comparison has been carried out, which has revealed that the students who worked with STEM workshops scored better in the post-test than the students in the control group. These results allow us to conclude that this type of practical and hands-on experiences in the primary education classroom contribute to improving the teaching-learning of scientific areas in this group, both from the learning point of view and from the attitudinal and emotional point of view.

Keywords: Primary education, STEM, Workshops, active methodologies

1. Introduction

Many state trusts worldwide have developed programs and strategies designed to improve the overall quality of STEM (Science, Technology, Engineering and Mathematics) education [1]. One of the objectives of strengthening STEM education at different educational levels is to foster scientific-technological vocations in students of all ages, so that they respond to the technological demands of the 21st century [2].

To reinforce interest in STEM areas, integrated activities are being developed in schools that promote discovery and innovation both within the school curriculum and through extracurricular programs with STEM activities and programs [3, 4]. STEM education programs encourage students to make new and productive connections through interdisciplinary integration, resulting in better learning, greater interest and commitment [5]. In order to transmit an adequate conception about STEM areas, it is essential to include in the didactic programming the realization of manipulative works [6]. However, it is the teachers, both primary and secondary, who must also be prepared to offer this type of STEM activities or programs based on innovative teaching tools [7]. Therefore, in this work, STEM workshops have been implemented in the primary education classroom aimed at improving the scientific literacy of students from the earliest stages of schooling.

2. Methodology

The research developed follows a quasi-experimental design with control groups, experimental groups, pre-test and post-test. Specifically, several STEM didactic interventions are carried out in the primary classroom. The general objective of this research is to implement and validate from a didactic point of view the use of STEM workshops in the primary classroom.

The sampling process that has been carried out to select students has been a non-probabilistic sampling of convenience due to the ease of access to different schools. Specifically, 234 4th and 5th grade primary school students (9-11 years old) belonging to five schools participated, in each of which a different STEM workshop was developed. The students in each centre were divided into two homogeneous groups, one control group and the other experimental. As scientific content, some concepts that are studied in the primary education sciences (Density, Pressure, Physical and Chemical Changes, Light and Matter and Forces) were selected.

Two measuring instruments were developed in relation to the chosen themes. One as a pre-test to evaluate the initial level of knowledge of the participating sample and another as a post-test to check whether the learning of the students improved after the explanation of the contents by means of two didactic methodologies. A traditional methodology based on the use of the textbook and worksheets with the control groups was carried out as opposed to a practical methodology based on the implementation of a STEM workshop with the experimental groups. All the groups had the same time to learn the selected STEM contents.

The research was structured in several phases. In the first phase the students had to answer the pre-test questions in order to detect the previous ideas and the initial knowledge of the groups. In this way, a common starting point is established for the control and experimental groups. The second phase took place several days later with the implementation of the traditional didactic intervention for the control groups and the practical intervention for the experimental groups. Finally, in the third phase carried out several days after the intervention, the students carried out the post-test to evaluate the degree of acquisition of the contents worked in the classroom. In this way, it was possible to compare the didactic validity of the intervention carried out in the experimental groups (EG) with the intervention proposed in the control groups (CG).

3. Results

The mean scores achieved by the students in the pre-test revealed little initial knowledge about the topics selected in the different schools. Specifically, it was decided to choose topics of content that had not been previously studied by the students of the participating groups, in order to establish a homogeneous starting point. Table 1 shows the average grades obtained by the different groups in the pre-test. It can be observed that the students of the experimental and control groups obtained low grades in the initial questionnaire, which was to be expected as these were topics that had not yet been explained.

	Pre-test	
	C.G.	E.G.
Centro 1: Density	1.71 (n = 21)	1.60 (n = 21)
Centro 2: Pressure	2.23 (n = 21)	1.90 (n = 21)
Centro 3: Physics and chemical changes	3.71 (n = 28)	3.40 (n = 27)
Centro 4: Light	1.57 (n = 21)	1.80 (n = 23)
Centro 5: Matter and forces	3.56 (n = 25)	2.50 (n = 26)

Table 1. Average scores of the control and experimental groups in the pre-test

Table 2 shows the results obtained by the control and experimental groups in the post-test carried out after the didactic interventions. As can be seen in table 2, there has been a positive evolution at cognitive level in the participating sample after the development of the different didactic interventions. The results confirm that the students of both groups improve their level of knowledge after the didactic intervention.

The average scores achieved exceed the passing mark in all groups and schools.

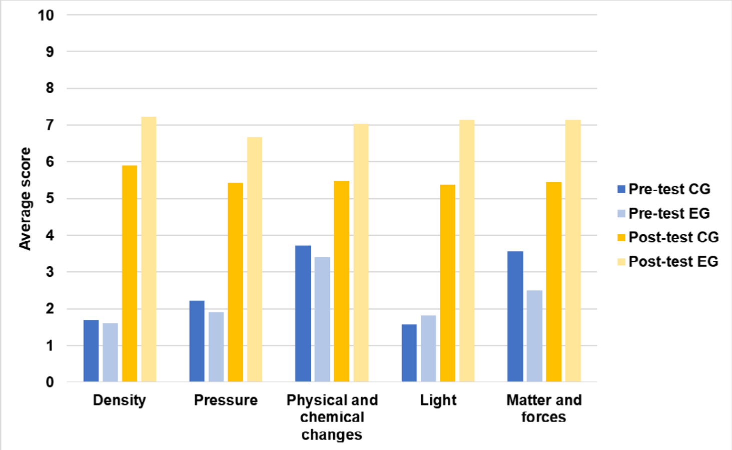
However, the students of the experimental groups that followed a methodology based on STEM experiences obtained a higher score than their respective control groups in all the schools.

	Post-test	
	CG	EG
Centro 1: Density	5.90	7.23
Centro 2: Pressure	5.43	6.67
Centro 3: Physics and chemical changes	5.47	7.03
Centro 4: Light	5.38	7.15
Centro 5: Matter and forces	5.44	7.15

Table 2. Mean scores obtained by the control and experimental groups in the post-test

Figure 1 shows a comparison of results between the pre-test and the post-test in the different groups and themes.

Fig. 1. Comparison of the average grades obtained in the pre-test versus the post test



As can be seen in figure 1, STEM workshops produce great benefits when it comes to learning science and technology concepts. The experimental groups have improved their post-test score compared to the pre-test, but they have also achieved better grades than the students in the control group. However, in order to know if there are statistically significant differences in the post-tests of each pair of groups and to be able to validate the effectiveness of the STEM workshops, a Student's t-test was carried out for independent samples. The results obtained are shown in table 3 below.

POST-TEST	t	df	*Sig. (two-tailed)*	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
DENSITY	-2.586	40	0.013	-1.333	0.515	-2.375	-0.291
PRESSURE	-2.087	40	0.043	-1.238	0.593	-2.437	-0.039
CHANGES	-3.428	53	0.001	-1.560	0.455	-2.474	-0.647
LIGHT	-3.940	42	0.000	-1.771	0.449	-2.678	-0.864
MATTER AND FORCES	5.756	49	0.000	2.083	0.361	1.356	2.810

Table 3. Student T-test (post-test)

Table 3 indicates that there are statistically significant differences (Sig. < 0.05) between the means of the control groups and the experimental groups in all the selected subjects, favouring this qualification to the students who participated in the STEM workshops.

4. Conclusion

As a result of the analysis and interpretation of the results presented in the previous section, it is concluded that, in the STEM areas, theory and practice must complement each other in order to achieve significant student learning [8]. In addition, methodologies based on hands-on workshops that integrate scientific-technological areas are more popular with students because they place them in the real context of what they have to learn and provide learning that lasts over time.

In this sense, it would be convenient to include STEM workshops in the didactic programs, especially in the first years of education with younger students, that include activities and practical experiences to introduce the students in these areas of knowledge and contribute to improve their practical and cognitive capacity [9]. Finally, we agree with other authors [10] in considering that the relationship of scientific concepts with the experiment is difficult for the students, that is, the application of the theory to a specific context is complicated, so that the scaffolding provided by the teachers is a key factor for the resolution of this type of activities.

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Interdisciplinary Educational Experiences for Engineering Students

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Abstract

University level engineering science education, in Canada and elsewhere around the world, is often provided exclusively to a given cohort of engineering students that progress through their collective university educational experiences together. These educational experiences will often consist of little to no interaction with other student cohorts from diverse disciplines and faculties. Engineering students that graduate and enter their longer-term engineering careers may only then be required to work and interact with people of diverse interests, skills and educational backgrounds. As such, traditional engineering educational experiences can fall short in preparing engineering students for their future work environment. This paper reviews an initiative to help address this short-fall through providing an interdisciplinary educational experience that brings together student cohorts from a Media, Art and Performance faculty with software engineering students. The bringing together of diverse student cohorts in a classroom setting requires significant changes to the traditional educational experience of engineering students. These changes include exposing engineering students to different educational experiences, teaching methods and educational content that they would otherwise not experience. In addition, this educational experience also provides participation in building and working on interdisciplinary teams that leverage the unique and diverse skills of its members.

Keywords: Interdisciplinary, Engineering, Education

1. Introduction

The tendency of most post-secondary educational institutions is to focus narrowly on a given area of study. For example, in most post-secondary schools an individual student maybe an "arts" student or an "engineering" student but typically not both.

Post-secondary educational institutions by their very nature guide individual students down separate educational paths and often through very specific programs-of-study.

In Canadian engineering schools program content is often highly prescribed. It normally requires very specific courses and a rigid progression through the engineering degree program. This is primarily due to the educational standards and prescribed content set-out by provincial and national engineering regulators. These regulators require strict compliance by educational institutions in order to maintain accredited engineering programs [1].

Prescribed engineering content will sometimes recognize the need for what has been termed "complementary studies", but it rarely recognizes the importance of the interdisciplinary nature of successful teams in the workplace. Creating and building systems and products often require teams of people with a highly diverse set of skills and education coming together in the workplace. This is particularly true in software engineering as software products are utilized across all fields of practice and disciplines.

Collaborations between engineers and artists is not new. The successful Experiment in Art and Technology (E.A.T.) group formed in the mid-sixties by a Bell engineer and an Artist offered numerous insights into the benefits of multidisciplinary research teams [2]. These insights have been demonstrated repeatedly since then including various research endeavours involving engineering and art collaborations in research units such as Xerox PARC [3] and others [4].

These types of collaborations are not constrained to research endeavours. The success of several products in the marketplace such as video games [5] and even computing platforms, applications and devices [6] can partially be attributed to collaborations of this kind. It is through these types of collaborations, the innovation, economic potential and cultural shift are now being recognized by both arts and science institutions [7].

2. Methodology

The outcome of an engineering education is intended to prepare students for the workplace. It can be argued that in addition to a technical engineering education, effort should also be put into interdisciplinary experiences as an important aspect in preparing students for the workplace.

To this end, an interdisciplinary elective course at the University of Regina in the Software Systems Engineering program was created and offered. The same course was also offered within the Media, Art and Performance faculty simultaneously. The course had limited enrolment in each faculty to assure that the course offering would include students from both faculties and provide a purposeful mix of students with different skills and educational backgrounds.

There were two instructors in charge of the course, one from each respective faculty. This ensured students were exposed to both arts and engineering content in addition to the teaching and learning styles of each respective faculty. The course focused on "Sound Art" where there is both significant artistic content and technical engineering content. The following is the course description:

This course introduces the artistic practice and engineering design concepts within sound art. It covers a range of sound art practices including avant-garde sound, Musique Concrete, sound and 1960s art movements, electroacoustic music, sound sculpture, radio art, Acoustic Ecology, community-engaged sound art, sound art in performance, and engineering design concepts of new media.

3. Discussion and Results

The course ran once a year in fall over five consecutive years from 2012 until the end of 2016. The total number of students enrolled in the course over those years was 111 students. Approximately one-half of the students were Software Systems Engineering students (53 students) and the remaining students were primarily from the Media, Art and Performance faculty.

Student feedback on the course was gathered from students through a formal course evaluation survey questionnaire at the conclusion of the course. The questionnaire consisted of 15 formal questions on a 5-point Likert scale. Thequestions included topics such as instructor performance, course material, grading, course workload and labs with the option to leave written comments on the back of the questionnaire. 78 of the 111 students completed the survey.

Each student cohort's background knowledge varied widely. It was considered important for the instructors to strike the correct balance of lecture content such that both arts and engineering students could grasp and understand the content of the lectures. For example, the technical knowledge had to be presented in a more fundamental way for arts students then would be required for engineering students.

Similarly, the arts knowledge presented to the engineering students had to include fundamental art concepts that they may not have been exposed to anywhere previously. The intended effect is that each cohort would learn more from the other faculty's instructor while still learning new things from both instructors.

The instructor communicated well and explain[sic] concepts clearly.
Average: 4.28 Variance: 0.50 SD: 0.70

The result of the survey question above demonstrates that the students did not seem to have trouble understanding the content and a reasonable balance was struck for both cohorts. The student comments also included similar evidence such as:

"Great prof. Made understanding for Fine Arts students easy."

There is an inherent difference between teaching styles of any two instructors, but teaching style difference is generally more exaggerated between instructors from different faculties. The difference in teaching style between instructors in this course was intentional in order to expose students to different styles of teaching and learning.

The instructor used class time and visual aids effectively.
Average: 4.26 Variance: 0.62 SD: 0.79

The result above tends to demonstrate that each cohort was willing to accept the significant differences in teaching/learning styles between instructors. For example, for the technical content, it was expected that students write notes and work-out technical details with the instructor whereas the artistic content was delivered through lecture slides and instructor-led discussion of the relevant concepts/topics.

"I found the combination to be quite different. Craig's lectures were really different from Rebecca's."

An anecdotal observation was that the engineering students seemed less likely to participate in classroom discussion on subjective artistic topics. This leads to the question of student buy-in of the course, its content (technical and artistic) and whether it was considered a worthwhile experience.

The instructor displayed enthusiasm and energy and presented material in an interesting way.
Average: 4.42 Variance: 0.59 SD: 0.77

Putting aside the instructor portion of the above question, the result indirectly suggests that students may have at least found the material interesting. The below comments further demonstrates student sentiment about the course content and the learning experience.

"I enjoyed the interactions and practicality of the lectures"

"Great course. It was a really nice change of pace from the usual Software classes"

However, despite these positive indications of student buy-in, not all of the students felt the course provided educational value.

"The offering of this course, even as an elective is wasteful. No useful concepts or information can be learned from this course."

As this course was a significant change in both content and learning methodology for engineering students, it is not surprising that there would be some students that did not recognize value in this interdisciplinary educational experience.

The course included numerous assignments, smaller projects and an open-ended larger final sound art project which was required for completion of the course.

Another interesting anecdotal observation was that several engineering students had trouble with the open-ended nature of creating an artistic project. In several cases, the engineering students just wanted to be told what to do. This is not a complete surprise since normally for an open-ended engineering problem, the problem is known up-front.

When confronted with creating absolutely anything they wanted without being given any particular direction, some of the engineering students experienced frustration deciding where to begin and what to do.

The students were also exposed to the element of "play" as a learning experience.

In this case, it meant giving students free class time to simply play around with the software and/or hardware provided to them in order to gain some unrestrained experience with it.

Labs were instructive and relevant.
Average: 4.12 Variance: 0.86 SD: 0.93

The in-course labs were designed with the element of play in mind. These labs did not include any specific tasks but rather only some overall instruction on how to use the software and/or hardware and students were expected to play with them with little to no supervision. Once again it was observed that the engineering students experienced some frustration with not having specific directions on what to do with the resources and time provided.

4. Conclusion

The result of an engineering education is meant to prepare engineering students for entry into the workforce. Often, engineered products, systems and services are created by a diverse team of individuals with differing skills and educational backgrounds. As such, it is incumbent upon engineering schools to provide educational experiences that are widely diverse in teaching and learning experiences. This includes teaching and learning experiences from other disciplines as well as interaction with students outside of their engineering student cohort in order to better prepare them for their professional lives after graduation.

To this end, this paper reviews a course initiative where students from an engineering faculty and an arts faculty were put together in the same classroom to provide an interdisciplinary educational experience. The students were exposed to teaching and learning styles from each respective faculty and encouraged to work with each other on assignments and projects in an interdisciplinary way. The educational experience was generally well received by students and provides experiential benefits that a typical engineering course cannot provide.

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Mathematical Modeling in Object Localization Based on Signal Strength

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Abstract

Object localization is used on a daily basis in the form of GPS use. Examples of indoor applications of positioning systems can be found in the care of the elderly, indoor navigation apps for museum visitors… When modeling the distance between sender and receiver in localization problems in wireless communication, the dependency of the received signal strength can be expressed mathematically by an exponential function. Therefore the distance is commonly expressed in a lin-log scale as a function of the received signal strength. For engineering students it is more than interesting to see that the discipline of mathematics is at the service of a typical engineering field as telecommunication. Moreover this STEM topic is useful to make students reflect on the error of the estimated parameters when using the technique of linear regression to model the distance based on measured data obtained from a real-life test bed. The measured quantity is the received power expressed in dBm. Localization algorithms are close enough to the real world of students and interesting enough form mathematical point of view to use it in STEM classes.

Keywords: Curve fitting, telecommunication, estimation, logarithm

1. Introduction

Students are familiar with object localization in daily life in the form of GPS (Fig. 1). The underlying technical background is interesting to understand the influencing factors. This paper describes a project adequate for high school students interested in engineering themes. Section 2 explains the essential physics of wireless communication. Section 3 describes in a concise way the mathematical tools such as linear regression and logarithmic scales, required to build out of data a theoretical mathematical model that explains the object position with the signal strength.

Fig. 1. Global Positioning System

2. Object localization by means of RSSI of antennas

A Wireless Sensor Network (WSN) is built of spatially distributed autonomous sensors or nodes to monitor the physical environment and to transfer the data to a main location. Localization with WSN [1, 5] is an important field within communication networks and has multiple consumer indoor applications (indoor guiding of persons in complex buildings, offering location-based information). The Received Signal Strength Indicator (RSSI) is expressed in dBm and is used to measure the relative quality of a received signal to a client device. The unit dBm is used to indicate that a power ratio is expressed in decibels (dB) with reference to one milliwatt (mW). Hereby the relation between the powerratio and RSSI can be expressed as

$$RSSI = 10 \ log_{10} \frac{P}{1 \, mW}$$

The Friis transmission equation [3] states that

$$\frac{P_r}{P_t} = G_t \, G_r \, \frac{\lambda^2}{(4\,\pi)^2 \, R^2}$$

with quantities as defined in Fig. 2.

$\boldsymbol{P_r} =$ power of receiving antenna

$\boldsymbol{P_t} =$ output power of transmitting antenna

$\boldsymbol{G_r} =$ gain of receiving antenna

$\boldsymbol{G_t} =$ gain of transmitting antenna

$\boldsymbol{\lambda} =$ wavelength

$\boldsymbol{R} =$ distance between the antennas

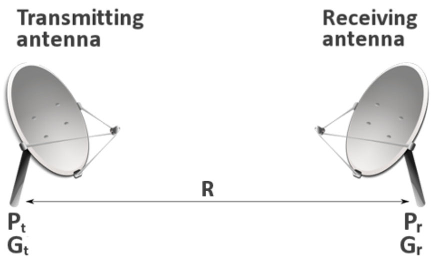

Fig. 2. Boundary conditions for the Friis transmission equation

Friis showed that in free space, RSSI degrades with the square of the distance under the assumption that the transmit antenna is omni-directional, lossless and that the receive antenna is in the far field. In practice, the actual attenuation depends on multipath propagation effects, reflections, noise, etc. In realistic models R^2 is replaced by R^n, $n=3..5$. Localization algorithms are often based on the strength of the received signal, which should be a predictor for the unknown distance.

3. Mathematical tools

As the goal is to model the dependency of the distance on the RSSI, mathematics can serve as description tool. As noise with measurements is inevitable a regression technique is of great benefit to obtain the best fitting model. Least squared differences are used to find the optimal estimates. The linear type of regression will be adequate admittedly after logarithmic transforming the data.

3.1 Lin-log scale

Inspired by the definition of RSSI, the logarithm of Friis' equation shows the linear relation between RSSI and the distance . The implies that when plotting measurement points (RSSI, distance) on a graph in a lin-log scale (Fig. 3), a linear trend will reveal.

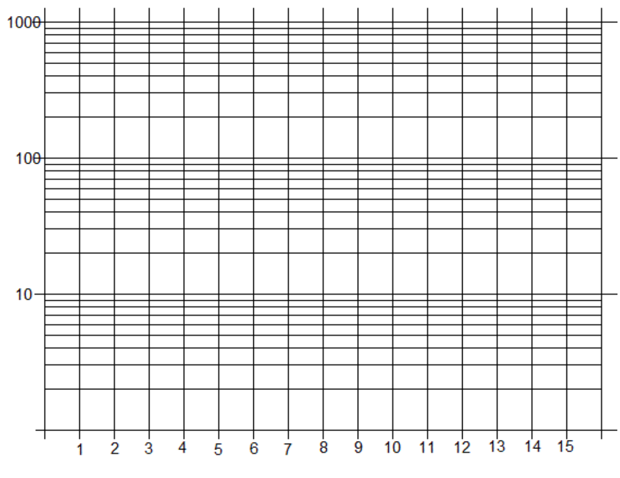

Fig. 3. Lin-log scale

3.2 Linear regression

A least-squared curve fitting method [2,4] is used to fit a model $y=f(x, \gamma_0, \gamma_1, \gamma_2, \dots, \gamma_{k-1})$ on the basis of data points (x_i, y_i), $1 \leq i \leq n$. The parameters $\gamma_0, \gamma_1, \gamma_2, \dots, \gamma_{k-1}$ are chosen in order to minimize the mean square error (MSE) defined by

$$\mathrm{MSE} = \frac{1}{n-k}\sum_{i=1}^{n}(y_i - \widehat{y_i})^2$$

with $\widehat{y_i} = f(x_i, \gamma_0, \gamma_1, \gamma_2, \dots, \gamma_{k-1})$ and k is the number of estimated parameters in the model. The errors r_i in the y-direction are minimized as illustrated in Fig. 4.

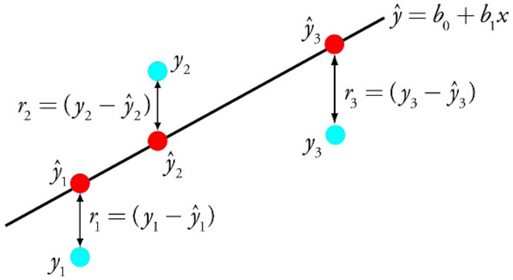

Fig. 4. Error measurement with linear regression

The regression model in the context of the antenna data uses the distance R as the outcome of RSSI as input as we want to predict the location by measuring the signal strength. Here the technique of linear regression can be applied to find estimates for the determining parameters β_0 and β_1 in the linear model

$$log_{10}R = \beta_0 + \beta_1\, RSSI.$$

RSSI	-56.9	-39.0	-54.1	-52.0	-43.0	-55.4	-55.0	-56.9	-59.6	-57.1	-61.1
R	12.1	4.1	13.0	6.0	4.8	15.4	10.2	8.7	18.8	14.6	14.3
RSSI	-57.4	-62.3	-74.7	-69.0	-58.0	-58.0	-75.0	-73.7	-79.9	-75.0	-88.0
R	19.3	19.1	23.9	26.8	24.0	28.8	31.2	29.5	35.7	34.4	40.2
RSSI	-78.7	-81.9	-91.7	-86	-89.1	-88.9	-87.9	-86.0	-84.9	-63.1	-82.0
R	44.7	43.9	49.4	48.6	67.6	58.0	54.2	53.3	52.7	22.7	39.1

Table 1. Measurement data (RSSI, distance) from a test bed

The estimation details of the parameters based on the data of Table 1, can be found in Table 2. This can be generated by statistical software such as R, SPSS, Matlab, etc. Fig. 5 and Fig. 6 show the data accompanied by the linear and non-linear regression lines respectively. Fig. 6 shows the bounds of the confidence intervals for the distance R as well.

Parameter	Estimator	95% confidence interval
β_0	−0.0256	[−0.2291, 0.1779]
β_1	−0.0202	[−0.0231, −0.01734]

Table 2. Parameter estimations for the linear regression model describing the distance as a function of the RSSI.

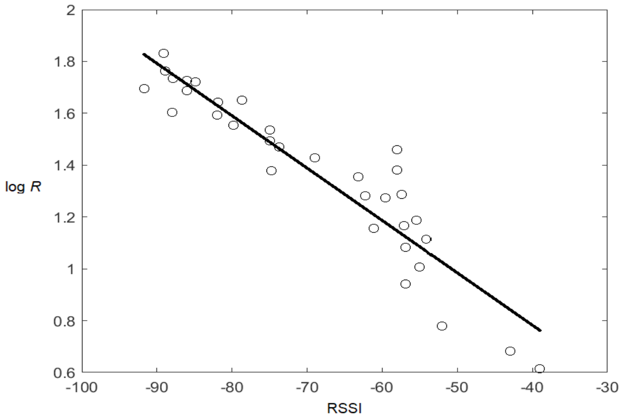

Fig. 5. Linear model for log-transformed distance versus RSSI obtained by the linear regression technique

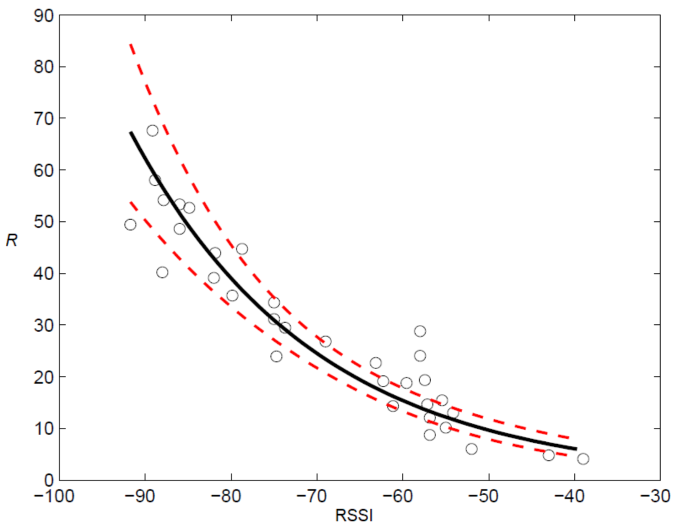

Fig. 6. Non-linear model and confidence bound for distance R versus RSSI obtained by the linear regression technique applied on $\log_{10}$ transformed distance

The coefficient of determination [4] of the regression model reaches the value of 86.86%, which guarantees its quality. The confidence bounds in Fig. 6 are wider for small values of RSSI due to the log_{10} transform. This implies loss of accuracy for small values of RSSI.

4. Didactical Advice

Before reaching a complete understanding of the connection between signal strength and object localization, teachers need to guide students through several intermediate stages. Important goals are:

- Getting students aware that $log_{10}R$ is related to RSSI in a linear way. This can clarified by taking the log_{10} of Friis' equation. Hereby the properties of logarithmic functions

$$log_{10}(ab) = log_{10}(a) + log_{10}(b)$$

$$log_{10}\left(a^b\right) = b\ \ log_{10}(a)$$

$$log_{10}\left(\frac{a}{b}\right) = log_{10}(a) - log_{10}(b)$$

can be used. Taking into account the definition of RSSI, the linear relation is visible.

- Getting students aware that a line appears when plotting an exponential function in a lin-log scale. The site https://www.desmos.com/calculator/toms4x34af is useful to let students experiment with plotting exponential functions in different scales (lin-lin, lin-log, log-log) to achieve deeper understanding of logarithmic transformations.

Critical questions can also contribute to reach the level of deeper understanding, such as:

- Why do we have negative RSSI values?
- Will the RSSI be lower or higher when the signal becomes better, i.e., less loss between sending and receiving ?
- Can you explain why there is a decreasing trend when plotting the distance between sending antenna and receiving antenna in terms of the RSSI?

5. Conclusions

Modeling the distance between sender and receiver in localization problems in wireless communication, is a challenging subject for high school students interested in mathematics and applied sciences. Teachers can use the well-known GPS as starting point for the subject of object localization. From mathematical point of view the dependency of the received signal strength, expressed by an exponential function, can bring the logarithmic function and the lin-log scale under the footlight. This topic shows engineering students that the discipline of mathematics is at the service of a typical engineering field as telecommunication. Moreover this STEM topic combines a theoretical and a practical approach as measurements can be connected to a physical model. This can be carried out by students starting from data obtained from a real-life test bed.

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Measuring Technology Integration in Science Classrooms

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Abstract

Today's science teachers are challenged with immersing their students in the practices of science inquiry, while also using technology as a learning and organizational tool. Researchers and practitioners need instruments to identify and describe applications of technology that support and even transform instruction. Classroom observation protocols provide critical tools for examining impacts on student learning. However, of 11 existing English-language technology-based protocols, most only acknowledge the presence of technology or simply describe it in broad terms. Just five of the 11 address the integration of technology with key pedagogical practices, and none of these consider alignment of technology implementation with specific attributes of science classrooms, such as the pursuit of authentic science questions. Using a published framework, we developed, piloted and validated an observation protocol that captures the quality of technology use to support science inquiry in secondary schools. We conducted four iterative rounds of testing in 26 high school science classrooms across the U.S. The resulting protocol focuses on the integration of technology into (1) science and engineering practices (from the U.S. Next Generation Science Standards); (2) student-centered teaching (with students accountable for their own learning), and (3) contextualization (grounded in local geographic contexts, focused on real problems and solutions, and connected to the work of science professionals). The protocol couples numeric codes with written descriptions of evidence, and then synthesizes these into a multi-dimensional measure of quality. Overall, our observation protocol fills a gap in understanding technology's role in supporting science inquiry in schools. It can serve as an instrument for researching applications of technology that enhance science instruction, and can also be used as an evaluative tool by coaches and teachers to reflect and improve technology integration in the context of science inquiry.

Keywords: observation protocol, technology science inquiry;

1. Introduction

Both ubiquitous and novel technology applications offer opportunities to support and extend student learning and application of science inquiry [1]. Researchers, evaluators and practitioners need instruments that help them distinguish applications of technology in science classrooms that support, enhance and potentially transform classroom instruction from those that are ineffective. One option are classroom observation protocols, which can examine impacts of pedagogical approaches, curricular resources and student learning [e.g., 2], and can be triangulated with other data types to substantiate findings [e.g., 3]. In this paper, we review existing protocols, identify a gap among these protocols for science instruction, and describe the new Technology Observation Protocol for Science classrooms (TOP-Science) that addresses this gap.

2. Existing classroom observation protocols

In a review of existing English-based classroom observation protocols, we uncovered 35 tools published since 2001 that document and describe a variety of classroom-level variables [4]. Eleven of these provide opportunities for observers to describe the quality of technology use in classrooms. All 11 capture the presence of technology, either through checklists or descriptions of technology type [e.g., 2].

Seven of the 11 protocols move beyond documenting technology presence to broadly describe its use [5]. However, they address technology as an add-on piece of instruction. Only five protocols specifically look at the integration of technology with key pedagogical practices such as individual instruction and technology standards [6]. But, none of these comprehensively capture the quality of technology use in the context of science instruction.

3. Theoretical framework

The TOP-Science tool addresses this gap by building directly on a published framework, which is based on a review of classroom artifacts and relevant literature [7].

Drawing from Cox and Graham [8], the framework categorizes technology by type: ubiquitous, instructional and STEM workplace. It considers integration of these types within three dimensions: science practices using the U.S. Next Generation Science Standards [9], student-centered teaching with students accountable for their own learning [e.g., 10], and relevance to student lives. For example, teachers can capitalize on technology capacity to support personalized learning and promote student ownership [11], or can ground lessons in local geographic context, focus on real problems, and connected to the work of science professionals [12].

4. Protocol design

We created an initial draft of the TOP-Science tool with indicators for each of the framework dimensions. We then refined it through four rounds of iterative testing.

In total, 68 observations were made by eight different observers in 26 high school science classrooms across seven U.S. states. Our team of eight observers used reflection worksheets to discuss the protocol strengths and weaknesses, made necessary revisions, and re-test.

We addressed content validity by aligning the TOP-Science tool with our framework and relevant literature, and comparing it to similar protocols. We established face validity with an expert panel who provided feedback, which we used to refine the protocol drafts. We conducted inter-rater reliability during the final pilot testing with at least two team members simultaneously observing 41 class periods. From this, we calculated reliability using Krippendorf’s alpha [13]. The codes for three dimensions had acceptable reliability estimates that varied from 0.51 to 0.78.

5. Key protocol elements

This process produced the final protocol, which consists of four parts: (1) pre-observation teacher questions to understand teachers' intention for technology integration in their class; (2) observation sheets to record codes and field notes in 10-minute intervals for each of the framework's dimensions (see Fig. 1); (3) post-observation teacher questions to gather the their reflection on the lesson; and (4) a summary sheet that produces a multi-dimensional measure of technology integration quality (see http://topscience.edc.org/index.php/resources/ to accessnthe protocol).

In initial drafts, we considered technology use separately from the three framework dimensions. However, piloting revealed the importance of framing observations around the integration of technology. Thus, we developed a coding system to classify and describe the degree of technology integration within the three dimensions of the framework (science practices, student-centered teaching and contextualization).

We sought to design a straightforward observation system for these dimensions that extended beyond simply recording technology presence but that also did not mire observers in complex details. Numeric coding offers a fast and efficient means to describe observations but our testing revealed difficulties in consistently distinguishing more than three codes. Written text provides a more comprehensive description of technology integration but detailed field notes proved onerous to complete in 10-minute intervals. We balanced these challenges by creating a system of three-level numeric codes coupled with brief written evidence of each one. Specifically, observers first code the "level" of each dimension, then code the "extent" of technology integration, and finally provide written evidence for both codes.

Our 10-minute interval data provides a streamlined and comprehensive view of technology integration for the entire class period but lacks a summative term of quality.

Because the protocol produces quantitative and qualitative data, we developed a final worksheet that summarizes data for each dimension. Specifically, observers determine average and highest value for each code and write an synopsis of the overall evidence based on their field notes. Together, these dimensions provide an aspect of the quality of technology integration.

6. Conclusions

Classroom observation protocols can help identify technology applications that support and even transform science instruction. However, few existing protocols examine the integration of technology with key pedagogical practices, and none of these address the alignment of technology implementation with specific attributes of science classrooms. The TOP-Science tool described here fills this important gap by providing a robust multi-dimensional measure of technology integration with science practices, student-centered teaching and contextualization. It offers a comprehensive view with consideration of teachers' pre-class intentions and post-class reflections, and balances coding with written descriptions of evidence. It does have limitations.

It suggests full integration of technology offers the highest quality, when this may not always be possible or even desirable. Further work is needed to determine technology use relative to its benefits and affordances. Additionally, the protocol does not incorporate students' perspective or their learning outcomes. Despite these limitations, the TOP-Science tool successfully frames the quality of technology integration from the perspective of the teacher and in the context of today's science classrooms. It can serve as an instrument for researching applications of technology that enhance science instruction, and can also be used as an evaluative tool by coaches and teachers to reflect and improve technology integration in the context of science inquiry.

7. *Acknowledgements*

The TOP-Science project is co-led by the two authors with Christina Bonney and with extensive support from Jackie DeLisi, Joe Wong, Cassie Doty and Neil Stylinski.

Fig. 1. Protocol classroom coding sheet

Ten-Minute Interval Coding & Evidence			
Category (may check more than one)	**Level[a] (select only one)**	**Tech Integration (select only one)**	**Evidence for Category, Level, & Tech Integration Codes**
Science and Engineering Practices ☐ Asking questions & defining problems ☐ Developing & using models ☐ Planning & carrying out investigations ☐ Analyzing & interpreting data ☐ Using mathematics & computational thinking ☐ Constructing explanations & designing solutions ☐ Engaging in argument from evidence ☐ Obtaining, evaluating, & communicating information	☐ 0 ☐ 1 ☐ 2	☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ N/A	
Student Centered Teaching ☐ Autonomous ☐ Personalized ☐ Competency-based	☐ 0 ☐ 1 ☐ 2	☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ N/A	
Contextualized Teaching ☐ Youth Experience ☐ Science careers or work ☐ Local/geographic context	☐ 0 ☐ 1 ☐ 2	☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ N/A	

[a]LEVEL CODES: 0 = No evidence • 1 = Incidental • 2= Embedded
[b]TECH INTEGRATION CODES: 0 = No Tech • 1 = Minimally integrated • 2 = Partially integrated • 3 = Fully integrated • Not Applicable (if category code is N or None)

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Reflexion of STEM Implementation in Ukraine

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Abstract

The article is devoted to the research of trends and mechanisms of STEM-innovations implementation in Ukraine. Attention is focused on measuring the understanding of STEM and its essence, on the prospects and difficulties of implementing these social technologies in Ukrainian realities. The paper presents the results of quantitative research conducted on the basis of author's methodologies, members of teaching staff, student youth, expert group and parents of high school students. On the basis of conducted monitoring results calculation, comparing the answers of different categories of respondents, the authors attempt to summarize the STEM technologies state in modern Ukrainian society and come to the conclusion that the implementation of relevant innovations contributes to the dissemination of dialogue among all participants in the educational process, parents and potential employers. Conducted research makes it possible to state the following.
Educators of experimental educational institutions have a sufficiently high level of motivation to innovate, open to cooperation and understand the importance of innovations in the modern Ukrainian school. STEM topics of interest to students are clearly outlined. Therefore, the majority of polled GEI students support the STEM direction and understand its prospects but do not understand in what sphere and where they will work in the future, even choosing the STEM profession. The results of the study showed that modern parents are motivated to influence the future profession choice their own children. However, the direct parents' influence on the future profession choosing is limited because a significant number of high school students have their own opinion on this issue, which is in part or does not coincide, with parents.

Keywords: STEM, society, innovation, education, strategy of education development in Ukraine

Introduction

Modern model of society progressive movement is formed under the influence of humanistic tendencies, which are represented in economic theory and economic practice. As a result, innovations that are focused on building human potential, one of which is STEM innovation, are spreading in education.

STEM – a series or sequence of educational programs designed to solve the problem of the scientific and engineering specialists lack for high-tech industries and raise the competitiveness of the state. It is a priority in state policy towards economy strengthening and state social order to the educational sector. Consequently, relevance of STEM in the modern European institutional space is beyond doubt.

However, today there is a certain dispersion of ideas, views and implementation directions of STEM-innovations. European countries have deferent initiatives for the STEM education implementation but all of them aimed at implementing policies in the following positions: development of scientific education for youth, ensuring wide awareness of the STEM industries development relevance, attracting young people to research in natural sciences and mathematics. The consequence is that today most countries have their own global approach to solve STEM issue at the national level: some have adopted national strategies, while others contribute to creation of specialized regional or local centers to improve the quality of teaching STEM subjects.

Multivariate in directions of STEM realization and implementation can be considered a definite ontological theory that deserves attention and reflection in the Ukrainian public space. In Ukraine, despite the very young direction of STEM, the implementation programs have been developed at the government level for schools, universities, science centers [1; 2]. In the other hand, STEM coalition of Ukraine brings together the efforts of the non-government sector (NGO, employers and other).

Important role in the development of Ukrainian STEM education model is played by the efforts of scientists and practitioners who are trying to develop authorial technologies in the framework of experimental research at the national and regional levels. The data for this paper comes from the Regional Ukrainian project “STEM on the river Dnepr”, which involves 41 educational centers in Dnipropetrovsk Region (secondary schools, scientific and technological lyceums, gymnasiums), STEM educators and partner organizations, representing regional industry. The main task of this STEM community is to build a unique regional innovative STEM education model, to develop young people’s interest in STEM education and careers.

Purpose of the article is to summarize the results of conducted sociological research, determine the specificity and features of STEM introduction as a topical modern innovation in Ukraine (on the example of Dnipropetrovsk Region). Continuing the approaches proposed by European researchers [3] in the inGenius project, we expanded the scope of the study and involved groups of reference people who influence the choice of a profession by young people. These are parents, teachers and experts of the region, representing different communities. The results presented in this paper can be useful for educators who are trying to build their own new model of education and solve the problems of promoting professions among young people.

GENERAL CHARACTERISTICS OF CONDUCTED RESEARCH

Respondents	Number of respondents	Purpose of the poll	Method	Dates
Principals, coordinators and teachers of experimental schools	230	Purpose of the study was to identify the level of motivation and technological readiness of pedagogical workers for experimental work on the introduction of STEM education innovative model in regional secondary education institutions	On-line pollwith google-form service (author'squestionnaire)	April 2017
10th grade pupils of Dnipropetrovsk region secondary schools	670	Purpose of the research was to investigate students' public opinion about studying subjects and selecting STEM-professions	On-line poll with google-form service (author'squestionnaire)	October 2017
Expert Group: Management of leading enterprises of Ukraine; Employees of higher educational institutions of Ukraine; The heads of local education authorities; Representatives of employment centers	40	Purpose of the survey is to study the experts' opinions of different categories on the main problems and perspectives of introducing STEM-education at the regional level (on the example of Dnipropetrovsk region).	On-line poll with google-form service (author'squestionnaire)	April 2018
Parents of high school students	486	Purpose of the survey is to study the level of parents' influenc on the professional orientation of senior students.	On-line poll with google-form service (author'squestionnaire)	October 2018

Analysis of the results

I. 'Pedagogical workers' motivational and technological readiness for experimental work on introduction of the stem-education innovative model in dnipropetrovsk region'

It should be noted that the study of teachers' opinion was very important because STEM as a direction came to Ukraine first of all through the education system, the most massive – through the school, and teachers, in this case act as agents of change, from whose thoughts and guidelines further development of STEM-innovations in Ukraine is largely dependent.

Conducted questionnaire allows assuming the following. Interviewed representatives of experimental educational institutions generally have a positive attitude towards innovation, but provided that it will be aimed at working with students, introduction of new forms and methods of work. In general, it can be stated that surveyed educators are ready to implement changes related to the implementation of innovations. Innovations implementation in any sphere of human life is always associated with a variety of difficulties. Among the reasons that may slow the introduction of new pedagogical ideas and technologies, the respondents highlight, first of all, insufficient material provision – (33%), conservatism in education – (16%), excessive saturation of educational material – (14%), hasty introduction of new in the process of training – (12%), lack of personal time for the implementation of innovations – (13%). Also, attention is drawn to the fact that only 6% of the respondents identified among the reasons that hinder innovation activity, students' psychological unwillingness to perceive innovations.

Respondents were given an opportunity to define their vision of what factors could affect the successful implementation of STEM education in their institution. (Chart № 1)

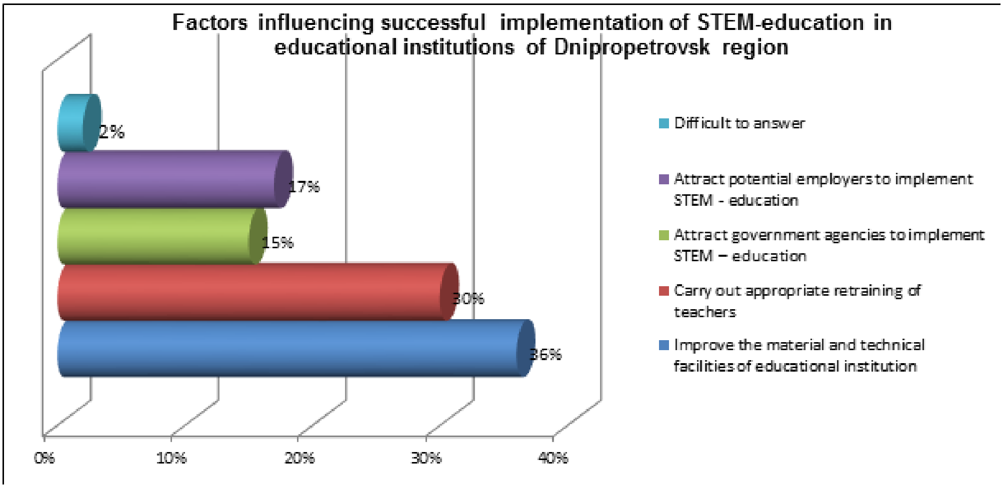

Chart № 1 'Factors influencing successful implementation of STEM-education in educational institutions of Dnipropetrovsk region

Such respondents' position may indicate a lack of understanding of potential employers and government bodies' role in the STEM education implementing process.

The vast majority of surveyed educators (85%) are convinced that introduction of STEM education will improve the quality of education at their institution. It is clear that STEM-education in educational institutions can be realized only in specific areas of study, since this concept includes application of science, technology, engineering, mathematics in the educational process. In this study, respondents were asked to decide on exactly which areas STEM education could be carried out at their institution.

Most respondents noted that in their educational institution STEM education can be carried out in the following areas: computer technologies (28%), natural sciences (27%) and mathematics (26%). A much smaller number of respondents noted that in their educational institution STEM education could be applied in areas such as biology and compatible sciences (12%) and traditional engineering (5%). It should be noted that traditional engineering is one of the STEM education key areas but as we see from the survey results, educational institutions are not ready for this direction development today because they do not have appropriate material base.

Conducted research makes it possible to state the following. Educators of experimental educational institutions have a sufficiently high level of motivation to innovate, open to cooperation and understand the importance of innovations in the modern Ukrainian school.

II. 'Studying the attitude of 10th grade students to the study of subjects and selection of stem professions'

Survey results make it assumable that the polled 10th grade students are interested in different directions of STEM – education. (Chart № 2)

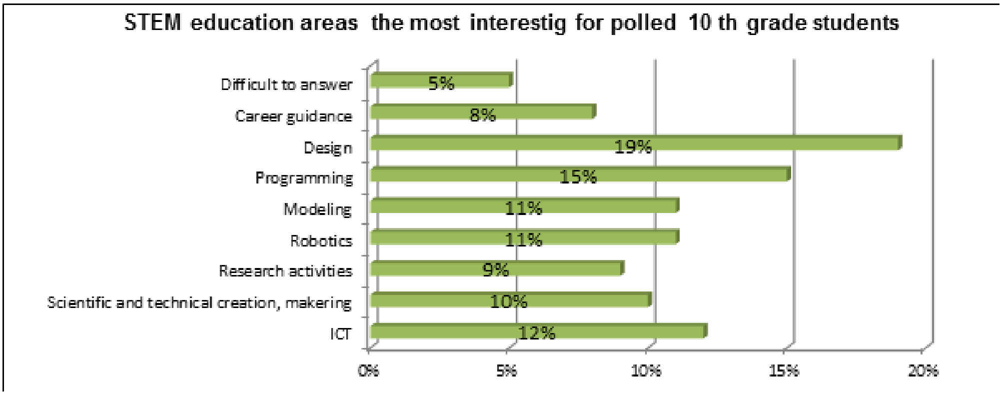

Chart № 2 'STEM education areas the most interesting for polled 10th grade students'

As shown by the research results, natural, mathematical disciplines and technological education are not very interesting for the questioned children. So, only the third of respondents (25%) noted that these are the most beloved subjects. Most respondents (almost 38%) are interested in these particular directions of education not more than other. At the same time 14% state that there would be a greater interest in natural and mathematical disciplines, but everything depends on the teacher's level of training. It was categorically noted that these subjects are remarkably difficult and they do not want to study by 14% of those polled. Absolutely do not want to learn 5% of those polled. 4% of the respondents are not determined on the question.

However, the questionnaire showed that only 25% of respondents indicated they could choose STEM-professions like industries related to natural sciences, technologies and mathematics. At the same time, respondents (29%) said that they would like to choose a profession in the industry, but do not know where they would be able to work in the future. One-fourth of respondents (25%) noted that they lacked sufficient knowledge of natural sciences and mathematics and could not choose a profession in the field of STEM. Also 10% of respondents noted that in their opinion this direction is not promising.

Conducted research gives the ability to establish the following. STEM topics of interest to students are clearly outlined. Therefore, the majority of polled GEI students support the STEM direction and understand its prospects but do not understand in what sphere and where they will work in the future, even choosing the STEM profession.

III. ‘Problems And Prospects Of Stem-Education Implementation In Dnipropetrovsk Region’ (Expert Survey)

Monitoring of expert opinions was seen relevant not only to examine the opinions of various specialists regarding the complexity of STEM education implementation, but also to attract their attention to these innovations, determine the level of readiness of different society layers and their representatives to solve professional orientation problems. The study of expert opinion on problems and means of overcoming STEM personnel deficit in various areas of professional activity, identifying the most in-demand STEM specialty, suggests the following. Today there is a shortage of STEM personnel. Experts believe that the most promising ways to overcome this deficit are: establishment of cooperation between school, university and enterprises (21% of respondents supported this position); introduction of joint projects with employers (17% of respondents supported this position), updating of school and university curricula (16% of respondents supported this position). That, in turn, confirms the prospect of certain directions of reforms in education. At the same time, insufficient methods of solving qualified employees lack problem according to experts are the following: support of the promising youth by employers (12% of respondents supported this position) and introduction of dual education (13% of respondents supported this position). It can be assumed that such percentage rate is related with regulatory norms of this work, insufficient distribution of these support forms and lack of awareness in employers about such involvement of young people to work in their companies/enterprises.

The study of supporting mechanisms for promising pupils and students by potential employers demonstrated the following. 40% of respondents believe that young people may be determined on the choice of profession while studying in grades 10-11.

Respondents believe that one of the most important criteria for choosing the future specialty is the level of wages (35% of respondents supported the position), inclinations and interests of youth (26% of respondents supported the position), demand for the future specialty (17% of respondents supported the position). Interestingly in previous studies youth’s (pupils) responses to this question were distributed as follows: more important for young people in choosing the future profession is the level of wages (46%) and the demand for future specialty (43%). Accordingly, it can be assumed that the selected expert group as a whole has its own vision of how to promote the STEM education brand in the Ukrainian society.

IV. ‘The influence of parents on professional orientation of high school students’

STEM - innovations is an area of activity that is directly related to the professional orientation of modern youth, which is why, in the context of the development of dialogue in the modern Ukrainian educational space, it is important to focus on the opinion of the parents of students of experimental educational institutions.

The survey showed that the vast majority of questioned parents (92%) discussed the problem of choosing a future profession with their children; only (4%) of respondents indicated that they did not discuss this problem with their children and (4%) of respondents are not determined on the given question. The research also demonstrated that parents' thoughts about choosing a future profession often coincide with the child's view. Thus, this was indicated by (42%) of the interviewed respondents. While 40% of parents surveyed said their opinion on the choice of future occupation was only partially equivalent to their child's opinion. Along with this 14% of respondents noted that their opinion does not completely coincide with the opinion of their own child. 4% of respondents are not determined on the given question, respectively.

Among the areas of professional activity in which respondents advise to apply the skills of high school students, it is possible to single out, first of all, information technologies (27%), medicine (11%), administrative activities (10%), production (9%), science (9%), art (7%), pedagogy (7%), sphere of service (7%), sports (5%), military affair (3%).

Thus, the results of the study showed that modern parents are motivated to influence the choice of the future profession of their own children. However, the direct influence of parents on the process of choosing the future profession of their children is limited because a significant number of high school students have their own opinion on this issue, which is in part, or does not coincide, with parents.

Conclusions

Consequently, the study made it possible to form a general conceptual vision of prospects for introduction of various STEM areas in Ukraine on the example of Dnipropetrovsk region.

STEM innovations create a new space for a steady dialogue between educators, parents and employers for the development of the economies of the states and engage youth in STEM industry.

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STEM Education Strategies Within the Sporting Context

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Abstract

The Basque Lanzadera Project (BLP) is an initiative to boost STEM competences adopting strategies that have been successfully used in a sports environment. This project starts within the framework of the "Etorkizuna Eraikiz" program in the Basque Country. This is a strategic framework of public policies launched by the Provincial Council of Gipuzkoa. It is based on experimentation, innovation and public and private collaboration as an instrument to overcome the main challenges that the territory is presented with. The purpose of this project is to promote STEM skills through the creation of teams of young people, who will participate in local and international STEM competitions. The main challenge is how to achieve a competition-based learning model in STEM which goes beyond formal or extracurricular training. The creation of a network based on collaboration, cooperation and competition, it what is proposed and which is internationally replicable in order to expand a new model of STEM education.

Keywords: STEM education, learning strategies, sporting context, cooperative-collaborative learning, teaching-learning strategies, Competition-Based Learning

Introduction

The Basque Lanzadera Project (The Basque Shuttle Project) is being presented for the development of STEM competencies in young people from the province of Gipuzkoa, Basque Country, Spain. It is a project that has been recently promoted within the framework of Etorkizuna Eraikiz, a program run by the Provincial Council of Gipuzkoa. Etorkizuna Eraikiz is an action-research process that, is meeting the challenge of moving towards more collaborative forms of policymaking in the provincial Council of Gipuzkoa. Etorkizuna Eraikiz facilitates the financing of projects proposed by citizens. The initiative is part of the citizen´s proposals financially supported by the Provincial Council of Gipuzkoa in 2017. The main contribution of this paper is the use of Competition-Based Learning (CnBL) to design a methodological process of STEM learning and teaching through competition, building up an ecosystem of learning with mechanisms and a culture similar to sports competitions.

This document is divided into three sections. First of all, the paper presents the main strategies adopted to boost STEM acquisition among youth in UK and Europe, and what are the main features of these improvements. Afterwards, the methodological proposal is presented below followed by both the expected and obtained results.

Finally the conclusions are presented and some elements that invite debate about the model are illustrated.

This project aims to facilitate the overcoming of the barriers and obstacles that the current STEM integration strategies are presented in higher education, and on the other hand, it aims to offer a response to STEM training in primary and secondary education.

New challenges in STEM education strategies

It's a widely accepted idea the fact that workers in STEM (science, technology, engineering, and math) fields play a direct role in driving economic growth. STEM sectors are seen as a cornerstone of economic growth and as such are particularly important in terms of global competitiveness. (The supply of and demand for high-level STEM skills, 2011). Both by the scientific education community and the policymakers, STEM training from a young age has been marked as a priority, in order to increase the knowledge of citizens with regard to STEM skills, as well as to increase the number of students studying STEM subjects in higher education. Each region faces the challenge of increasing the STEM competencies of its students and the educational community, from its current reality and context (Williams, J., 2011).

This has provoked the sudden appearance of strategies and proposals, that have brought to light a very wide range of resources, methodologies and educational programs (Honey M., Pearson G., and Schweingruber H., 2014). There are innumerable reflections published around the barriers that hinder the advancement of school STEM learning strategies. As a result, the need to look for new ways to face this challenge appear. (Kelley, T.R. and Knowles, J.G., 2016). On one hand, due to this context, the effective formulation of integrated educational strategies, are required connecting different learning situations as an integrated system (Kelley, T.R. and Knowles, J.G., 2016). While on the other hand, STEM learning strategies have generally been applied in higher level education and not so much at lower levels of education. (Honey M., Pearson G., and Schweingruber H., 2014).

Even if an integrated curriculum was possible (DeCoito I., 2014) another area of discussion arises. How could elementary and high school teachers develop the expertise required in all STEM subject to provide an integrated approach? (Williams, J., 2011)

In addition the implementation of many strategies of STEM learning within curriculum structures have showed a lot of resistance to change. (Williams, J., 2011)

Among others we can highlight a lack of connection with learners and a lack of hands-on training for students. (Chiu A., Price C.A., Ovrahim E., 2015). The students do not seem to be very motivated by what happens inside the classroom. (Williams, J., 2011)

Despite all these difficulties, there is little research on how to improve it or on what factors actually stimulate learning, interest, retention or performance (Honey M., Pearson G., and Schweingruber H., 2014). The BLP is presented as a proposal for action aimed at overcoming these obstacles and providing useful knowledge.

STEM training ecosystem integrats all subjects, that apply to primary and secondary students and that is compatible with the school curriculum. The new ecosystem is easily scalable, motivating and stimulating, not only to the students but to the entire community.

The Basque Lanzadera Project. The value of the sporting context

This case is framed within Etorkizuna Eraikiz that is an action-research program oriented towards a new form of governance of the territory. Etorkizuna Eraikiz is based on an innovative system of shared deliberation with the citizens and the main agents and territorial institutions of Gipuzkoa in order to effectively face their main challenges for the future. One of the main challenges identified has been the improvement of competitiveness. Financing programs from citizen´s proposals based on collaboration have been activated, through innovative projects, turning the great strategic challenges of economic and social globalization into opportunities. This project is considered by Etorkizuna Eraikiz as an educational innovation project and it is evaluated as a project that focuses on improving employment counselling for young people.

The methodological strategy aims to encourage the creation of a STEM league in Gipuzkoa and the Basque Country. The main goal is to encourage and enable the existence of a culture of STEM tournaments in Gipuzkoa. This project promotes STEM skills from a sporting point of view. STEM sports tournaments must be linked to companies and to schools and culminates in an international final. Each tournament will be run and sponsored by one or more companies related or interested in the activity. The purpose is to create an ecosystem of STEM training competitions, with an architecture similar to sports competitions, connected internationally under the framework of a tournament, with the winner providing the best resolution to a STEM challenge. Among the advantages of the competitive approach we may name: interactivity, collaborative work inside a group, active participation, challenge and motivation for the students to explore their own subject-matter. Furthermore it has the additional benefit in terms of social impact of engaging the wider community such a parents, enterprises and teachers.

This project aims to provide a STEM solution through implementing a methodology that is easily and globally replicable, and where stakeholders live an intense experiences of collaborative learning through STEM.

Results

Although it is still early to present solid results about its impact and its methodology, an initial analysis allows us to show some previous results. In quantitative terms, to start the 2017/2018 campaign five tournaments were selected, from the hundreds that exist. The tournaments are “Airbus fly your ideas”, “ESA Cansat competition”, “CERN Beam for schools”, “First Lego League” and “Odyssey”. In 2017 a Basque school team participated directly in the European Final after winning the Spanish Final. In 2018, was organized a preliminary tournament, “Cansat Euskadi”, whose winner was awarded a place in “Cansat Spain” and subsequently in “Cansat Europe”.

Overall a high level of participation has been achieved with more than 15 companies, 20 educational centers and 4 Universities taking part.

In qualitative terms we can offer the following results. STEM competition allows for the building of children’s practical science skills and knowledge through multiple experiences. It successfully engages families, increases mutual understanding and creates the capacity among parents to support their children’s learning. The learning space created in this sporting ecosystem is a meeting point where companies and educational centers can work and benefit each other.The students need both, the support of companies that have specialized knowledge and teachers who will provide general knowledge. Therefore, the young who compete in a group are more socially integrated, have an increased desire to work hard to achieve a specific goal and also gain prestige in their community. Through offering STEM activites in the form of a tournament, the schools aditionally experience the added benefit of encreased enrollments. Furthermore, the sense of belonging to a club creates stronger bonds and greater affiliations and encourages the participation of parents, friends, and the community as a whole. Therefore it contributes to positive social visibility and strengthens positive self-esteem. This methodology allows for participation from very early ages, which seems to increase the chances of a student being on track to ultimately register for STEM degree programs (Dejarnette, N.K., 2012).

Conclusion and Discussion

In conclusion, STEM in a more connected way, especially in the context of real-world issues, that can make STEM subjects more relevant to students and teachers. This in turn enhances motivation for learning and improves student interest, achievement, and persistence. (Honey M., Pearson G., and Schweingruber H., 2014).

The implementation of a STEM learning strategy through a new competition ecosystem centered around challenges that stimulate all agents involved. Nonetheless, some unknowns derived from the recent project start-up are still open. Mainly the lack of an evaluation model that allows obtaining short-term results regarding the effectiveness of the project. Nonetheless it seems interesting to explore the way in which the participation of schools is reconciled with the curriculum and school schedule.

Finally, it is worth reflecting on the suitability of imposing the STEM culture on the entire educational community. (Pit (2009) and Millar (2006)). The BLP model offers a proposal that is not imposed but rather is a facilitator, because offers the opportunity to identify STEM talent and / or vocations within a stimulating and attractive environment.

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Study of Tuned Mass Damper for Attenuating Skyscraper Oscillations Through Project-Based Learning

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Abstract

The intention of the project was to introduce a complex real-life engineering problem in an easy manner to sophomore students, namely, the topic of a tuned mass damper (TMD). Even though TMD is a multiple-degree-of-freedom vibration problem seen only in advanced university courses, the phenomenon of earthquake effects on buildings is easy to understand. In order to ease the complexity, the multi-degree-of-freedom mathematical problem was converted into a single degree of freedom, such as the behavior of a vertical single-mass cantilever beam. Through a do-it-yourself project to be done in home conditions, students are introduced to the topic of mechanical vibrations via seismic action on tall buildings. Two sections of the "Engineering Mechanics: Dynamics" course, with an overall number of 58 students, participated in the project. The project develops critical thinking and inquiry skills by designing and constructing the physical prototype of a building-like structure and its corresponding tuned mass damper; conducting an experiment under certain restrictions to test the stabilizing effect of the damper after an initial displacement; learning a proper software application to graph and measure underdamped oscillations; calculating corresponding vibration parameters; as well as analyzing and discussing experimental results. Students approach the problem of mass-damper tuning by means of trial and error, an on-purpose strategy to add fun and gambling to the process, to enthusiastically compete for the best performance in terms of efficiency of attenuation. Data were collected from direct observation, surveys, reports and presentations. The results showed that students positively and enthusiastically responded at all project stages and with a better understanding of the phenomenon and engagement in comparison with previous students of the same course without project. The impact of the project on students' engagement and implications for engineering education are discussed.

Keywords: STEM education, tuned mass damper, single-mass cantilever

1. Introduction

The purpose of the present article is to provide a project where students can learn new engineering knowledge on vibrations; relate the topic to a real-life situation, such as the effect of earthquakes on tall buildings; apply this knowledge to a do-it-yourself activity at home where students design and construct the physical prototype of a building-like structure; conduct an experiment under certain restrictions to test the effect of a damper to stabilize the structure from an initial displacement; learn a software to measure oscillations, and finally, calculate main parameters. The project aims at developing critical thinking and inquiry skills. This kind of project directly addresses all seven student outcomes recommended by the Accreditation Board of Engineering and Technology (ABET), which are intended to prepare students to enter the professional practice of engineering [1].

Project-based learning (PBL) is a widely used technique in engineering, however, there are still issues in its implementation, such as [2]:

- lack of confidence among engineering faculty members besides its heavy burden on its implementation;
- issues on the sustainability of engineering PBL experiences, since most of these activities are carried out by a single "champion" working in relative isolation. Only few universities in the world have a more structured approach to implementing PBL throughout the engineering curriculum;
- Concerns about funding mechanisms for supporting such activities.

Therefore, it is useful to present cases of PBL design and implementation to be shared with the engineering and science community.

Besides the technical merit of investigating, designing and implementing the present engineering project, the following research questions motivated authors to make changes in the teaching practice: How do students deal with a relatively complex do-it-yourself-at-home engineering problem within four weeks? How do students' engagement in a stage-wise weekly project delivery influence their anxiety and motivation? How does PBL develop students' critical thinking and inquiry skills?

2. Methodology

This project was implemented at MEF University, which is famous for being the first university in the world to fully implement flipped learning throughout all the university curricula [3]. Additionally, the project was implemented using project-based learning, a widely accepted key component of engineering programs, which is generally welcomed by students, industry and accreditors [4, 5].

Through a do-it-yourself project to be done in home conditions, students are introduced to the topic of mechanical vibrations via the effect of earthquakes on tall buildings. Two sections of the DYN 201 "Engineering Mechanics: Dynamics" course, with an overall number of 58 students, participated in the project. The teaching practice of the project consists of delivering four project stages every week (so to not interfere with the start of the first midterm period). This is because the course is a 5-ECTS compulsory theoretical course for both Mechanical Engineering and Civil Engineering students with no additional time for laboratory, so the project was to be done at home conditions in teams of up to 5 members. For this purpose, flipped home videos were reduced during that time to give priority to project activities. Within the project period, only 30 min each week were devoted to explanations and instructions about the project. The project requirements were designed to be as simple as possible to use only simple and inexpensive materials than can be found at home or be purchased from stationery or hardware stores.

Even though a tuned mass damper (TMD) is a difficult multiple-degree-of-freedom vibration topic seen in advanced or elective university courses [6], the phenomenon of earthquake effect on buildings is easy to understand. On the other hand, its mathematical formulation can be approximated to a single degree of freedom for a vertical single-mass cantilever beam [7] to avoid cumbersome theoretical calculations.

Students were asked to design and construct the physical prototype of a building-like structure and its corresponding tuned mass damper; conduct an experiment under certain restrictions to test the stabilizing effect of the damper after an initial displacement; learning a proper software application to graph and measure underdamped oscillations; calculate corresponding vibration parameters; as well as analyze and discuss experimental results. Students approach the problem of mass-damper tuning by means of trial and error, and as a competition among teams to get the best performance in terms of efficiency of attenuation to add fun and gambling to the process.

A short summary of the instructions given at each project stage were the following:

- **Stage 1. Construction of building-like frame** (week 1). Construct a 0.8-1.0 m height wood or plastic-made plane or prismatic frame. Students are given enough freedom to make their own designs. Use Ockham's Razor principle of simplicity in design, where the simplest solution is the best. Creative designs are encouraged. Oscillations can be generated manually by just horizontally displacing the frame top about 10 cm, and then releasing it. Supportive videos even with little children making a shaking table were provided [8-13] to give confidence to students. The list of the team members should be delivered by email the next day after the instruction day. Deliverables for the following week: photo of the frame together with teammates, and respond a survey. Every week delivery of stages 1, 2 and 3 represents 20% of the project evaluation.
- **Stage 2. Design of the tuned mass damper** (week 2). The TMD may be a compound pendulum or a viscous damper cylinder in the top of the frame. Tuning a damper means either adjusting the location of the mass along the pendulum string, or changing the viscosity of the damper liquid or the shape of the movable object inside the cylinder. Creative designs are encouraged, even using eggs as dampers! Trial and error should be used to tune the TMD. Deliverables: Two videos of the system, one without TMD, and the other with TMD (students are warned that adjusting the TMD is a very time-consuming procedure); and respond a survey.
- **Stage 3. Tracking the motion of a point within the frame top** (week 3). Tightly hold the frame base while another student manually displaces the frame top horizontally about 10 cm, and then release the frame to freely generate fading oscillations. A 30-cm ruler in a horizontal position close to the frame will be needed to calibrate the oscillation amplitudes. Shoot two videos of the system: one without TMD (called V1); the second with TMD (V2). The "Tracker" freeware must be used [14,15,16] to automatically track the pixels of a marked dot or edge in the frame top. Apply the software to both videos V1 and V2 to track the mark in the frame top, and obtain the graph of its horizontal position in the *x*-axis versus time. The result should look as a decaying or fading exponential (Fig.1), which should be more attenuated for V2. Take a screenshot of both decaying exponential graph for V1 and V2. Deliverables: Two videos V1 and V2; two screenshots of both decaying exponential graphs (*x* vs time) for V1 and V2; and respond a survey.
- **Stage 4. Calculations, report and presentation video** (week 4). The frame has been approximated to behave as a cantilever beam with significant masses of the beam and the end mass modeled as a single-degree-of-freedom system [17] with a total mass of $m_t = 0.2235\rho L + M_{pendulum}$ $m_t = 0.2235\rho L + M_{pendulum}$ where ρ is frame's material linear mass density, and L is frame's height. Using the logarithmic decrement method [18,19], obtain the damped period τ_d and two consecutive amplitudes X_1 and X_2 from the exponential decay graphs (Fig. 1). Calculate the following for both with/without TMD: damping ratio ζ_d, damped

natural frequency f_d, damped stiffness k_d, and damping coefficient c_d. Obtain the performance of the TMD calculating the relative efficiency of the viscous damping ratio *e = (damping ratio with TMD – damping ratio without TMD)/damping ratio without TMD*. Think critically to provide an explanation about the difference in the values in terms of the influence of the damper and its tuning. Discuss about the efficiency of the damper in attenuating the oscillation. Provide ideas how you could improve the damping effect of the damper in order to get better results. Write a final complete written report following the structure of a template provided. Within the report conclusions, describe your impressions about the project, how the experiment gave you an idea about using engineering to solve a concrete real-life problem to attenuate oscillations, and how the project impacted on your interest in engineering. From the analysis of the results, discuss and write conclusions about the findings. Finally, write what were the skills you developed during the realization of this project. Prepare and edit a final project presentation video including the videos captured from the Tracker software screen showing the oscillating frame with tracking point and its graph for both cases (with and without TMD), and calculations obtained. Deliverables: Final written report (20% of the project evaluation), and final project presentation video (other 20%).

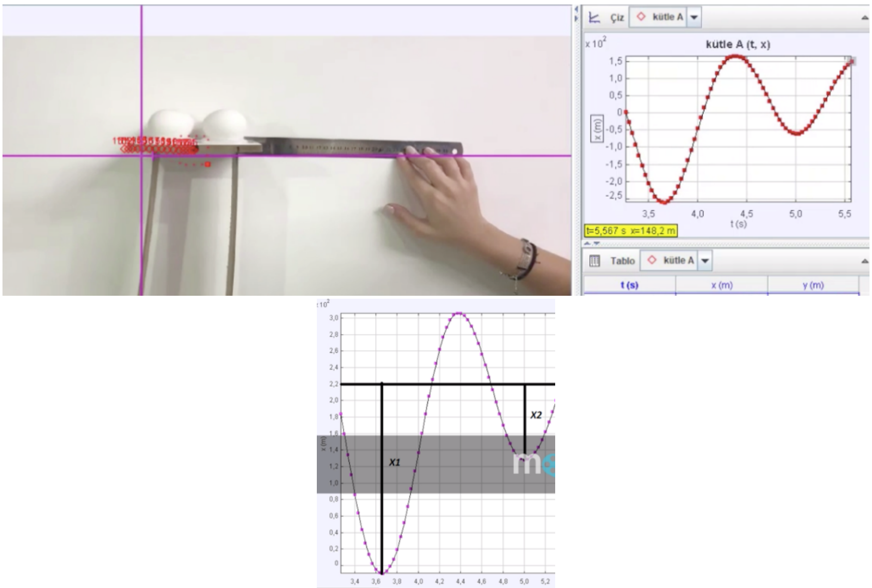

Fig. 1. Screenshot of frame motion tracking using fresh eggs as dampers, and graph amplitudes

3. Results

Data were collected from direct observation, surveys at each stage, reports and presentation videos.

Each survey included the following questions such as: While doing the project so far, what has been new for you or your teammates? Is this project sparking curiosity or any interest toward engineering? Are you enjoying and having fun with your friends while doing the project? What new skills have you learnt during this project stage?

Write any other comment or suggestion that you would like to share, if any. Besides, the reports contained extensive answers and discussions to the questions inquired in stage 4.

Findings from data analysis:

1. Surveys at each stage, final report conclusions, and final presentation videos showed that:
   - students positively and enthusiastically responded at all project stages with a better understanding of the phenomenon and with engagement. This was a change in students' feedback in comparison with students of the same course from previous years without project.
   - Students were even shocked about the fact that a simple pendulum with dampers as such used in the Taipei 101 skyscraper can attenuate seismic oscillations, and that students are able to understand and make and study of such mechanism.
   - For the first time, students learned in practice such concepts as stiffness, viscous damping, damping ratio, natural frequency, free oscillations, degree of freedom.
   - Students learned that the principle of the TMD consists of just equating the period of oscillation of the damper with the period of oscillation of the structure.
   - Students learned that a damped free response due to an initial condition of displacement in the frame top represents the same response as of a force impulse applied to the base.
   - Students learned how to use engineering approximations in a real-life case.
   - Students were eager to share their experiences and how they got fun in the process.
   - Students acknowledged the acquisition of skills, such as carpentry, using drilling tools, unexpected tools and materials, independent learning of new software to track motion from video pixels through video tutorials. This taught them lifelong learning skills, and made them more confident to face technical challenges.
   - The project topic was interesting for both Mechanical and Civil Engineering students.
   - Students acknowledged a greater true interest and motivation toward engineering.
   - The average grade for all the projects was 82/100 which is quite satisfactory.
2. From direct observation on students' performance, direct interviews, and office hours:
   - The dosage of the project in several stages, its gradual presentation, and the corresponding weekly deliverables didn't overwhelm or scare with lots of instructions or about the complexity of the activities, but instead, helped students, dosed their efforts, and their enthusiasm compensated the additional load.
   - Student were just in the third semester, and they started in the third week of classes, so they didn't know anything about rigid bodies, nor about particle kinetics, nor about vibrations at all.
   - Students were allowed to compare a massive damper frame with their frame with no damper, this was to dramatize the improvement of the TMD with even a heavier structure.
   - Students acknowledged developing critical thinking and inquiry skills every time they asked questions during class or office hours.
   - Most of student teams used a pendulum TMD, but some used a big scotch tape

rolling in the top, and others even fresh eggs. Every time a team presented a creative design, the instructor showed to the whole class to acknowledge creativeness and best ideas, this acknowledgment in public grew their ego and confidence. Creativity and fun went together.

- It was found that it is possible to measure the performance of completely different frames and TMD's through one single criterion, the relative efficiency of the viscous damping ratio, or in other words, the efficiency of attenuation.
- The gambling feeling of competition to get the best performance in terms of efficiency of attenuation boosted student competitiveness. They were able to attain very high attenuation efficiencies up to 910%. Acknowledging best teams in public grew their ego and confidence.
- Not all student teams obtained good results, there were efficiencies of 910%, 523%, 473%, 404%, 216%, 175%, 86%, but also worsening the performance with negative values: -23% and -85%. Indeed, it was not easy to tune the damper by trial and error, but students really had big fun and appreciated the real-life learning experience. Even negative attenuations were useful to learn new knowledge and skills.
- There were no comments or complains about expenses or difficulties in getting materials, so we can say that the sustainability of the activities was not an issue. The average cost of materials in every team was about 30 Euro.

Other comments and recommendations:

1. The measuring technology was free of charge just using freeware, instead of expensive accelerometers and Arduino boards presented by experts in YouTube videos such as in [8].
2. Students made their project at home, the instructors even didn't physically see many of their projects, they also didn't need laboratory for their construction, it was a do-it-yourself home project, and this is a change in the teaching practice.
3. Besides some videos in YouTube, there is not so much information about this topic in internet, so it required the authors to be creative and brave when defining the scope and specifications of each project step.
4. Writing project instructions is challenging, since the description should be complete enough, but at the same time, easy to understand and succinct.
5. Instructors recommend to ask questions during every class about the advances and their experiences, give recommendations, and encourage them to come to office hours to ask more questions or clarify their doubts.

Due to all the aforementioned findings and reasons, the impact of the project on students' engagement was significant. The project is easy enough that it can be conducted even with high-school students. To this respect, the best frames were donated by the teams to use them during open days with high-school students.

Conclusions

The article aimed at sparking curiosity and interest toward engineering; learning software tutorials for tracking motion from video pixels; learn to approximate complicated structures with multiple degrees of freedom to a single-mass cantilever beam with end mass, both with significant masses; learn how to use engineering approximations in real-life cases; and develop lifelong learning skills. Through the implementation of this project, authors were able to realize that sophomore students were able to deal with a complex do-it-yourself-at-home engineering problem under student background constraints, and accomplish it within four weeks. Focusing on a single project stage every week it is possible to create and sustain motivation and enthusiasm levels, developing not only critical thinking and inquiry skills, but also encourage creativity.

The project successfully sparked interest in engineering education in students, showing that the change in the teaching practice was worthwhile. The project is easy enough to be conducted even with high-school students. Future research will continue on the implementation of different complex engineering projects.

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Subject Choice and Performance in SEC Biology: Patterns According to Gender and School Type in Malta

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Abstract

Malta's educational system has three levels – a six-year primary cycle (ages 5 to 11), five years of secondary school, and tertiary education – and three school types: the state, the Church and the independent schools. The MATSEC Examinations Board of the University of Malta offers circa 40 subjects at the 16+ Secondary Education Certificate (SEC) level and over 30 subjects at the 18+ Intermediate (IM) and Advanced Matriculation (AM) levels. One needs six SEC passes for entry into mainstream Sixth Form, including one of the three sciences. Entry to the University of Malta requires the Matriculation Certificate (MC), comprising two AM and four IM subjects. The MC includes a language, a science subject and a humanistic or commercial subject. Some subjects are taught throughout secondary school while others are optional, starting at Form 3. Integrated Science is taught in Forms 1 and 2, and (at least) one of the science subjects is compulsory as from Form 3. The study traces the number of registrations in the three sciences through the last ten years and investigates the reasons behind subject choice. It compares patterns in subject choice, registration and performance according to gender and school type. The main focus of the study is Biology, leading to a Maltese Biology 'map' within an encompassing science 'map'. This 'snapshot' will be enhanced by stakeholder perceptions of the subject, according to gender and school type.

Keywords: Subject choice, Performance, Biology, Gender, School type;

1. Introduction

1.1 Aims of the Research Study

This research study focuses on factors which influence student subject choice, specifically in Biology, at secondary and sixth form levels, as well as performance in the subject. Gender and school type differences in Malta will be discussed.

1.2 Subject Choice in Malta

Students in Malta choose school subjects at the end of Form 2, at 12-13 years of age. Subject choice has to be taken seriously, as it affects future academic life and influences career choice (Ryrie, A. C., 1979). They study these subjects for the subsequent three years, alongside other compulsory subjects.

1.3 Student Performance in Science in Malta in the PISA Results

Some tests are carried out in different countries to monitor student abilities in various subjects. The PISA results, released biannually, show that out of 72 countries in the 2015 survey, 38 countries had a better mean score than Malta, 25 of which being EU countries. The proportion of Maltese students performing at proficiency level 5 or higher (7.7%) was close to the international average (7.8%). The percentage of Maltese students performing below proficiency level 2 (basic level) was much higher, at 14.5%, than the international average (5.5%) (PISA Results, 2015).

1.4 The General Situation at SEC Level

From around 30 in the early 2000s, SEC subjects increased to 39 by 2017. Four subjects are compulsory for sixth form entry: English Language, Maltese, Mathematics, and a science subject. Table 1 portrays SEC registrations from 2008 to 2017 for the three sciences separately, and their total. Figure 1 shows a plot of the registrations for the three sciences at SEC level, per gender per year.

	2008			**2009**			**2010**			**2011**			**2012**		
	M	F	all	M	F	all	M	F	all	M	F	all	M	F	all
B	580	1205	1785	522	1155	1677	473	1178	1651	473	1064	1522	471	998	1469
C	482	527	1009	458	457	915	398	510	908	398	475	836	366	459	825
P	2200	2091	4291	2145	2020	4165	2213	2052	4265	2213	1964	4044	2025	1886	3911
B+C+P	**3262**	**3823**	**7085**	**3125**	**3632**	**6757**	**3084**	**3740**	**6824**	**3084**	**3503**	**6402**	**2862**	**3343**	**6205**

	2013			**2014**			**2015**			**2016**			**2017**		
	M	F	all	M	F	all	M	F	all	M	F	all	M	F	all
B	488	1048	1536	488	1025	1497	455	944	1399	482	986	1468	437	862	1299
C	372	451	823	372	427	779	349	386	735	349	474	823	329	400	729
P	2018	1749	3767	2018	1782	3748	1825	1630	3455	1727	1697	3424	1631	1476	3107
B+C+P	**2878**	**3248**	**6126**	**2878**	**3234**	**6024**	**2629**	**2960**	**5589**	**2558**	**3157**	**5715**	**2397**	**2738**	**5135**

Table 1. Data for SEC registrations for the science subjects per gender per year, 2008-2017

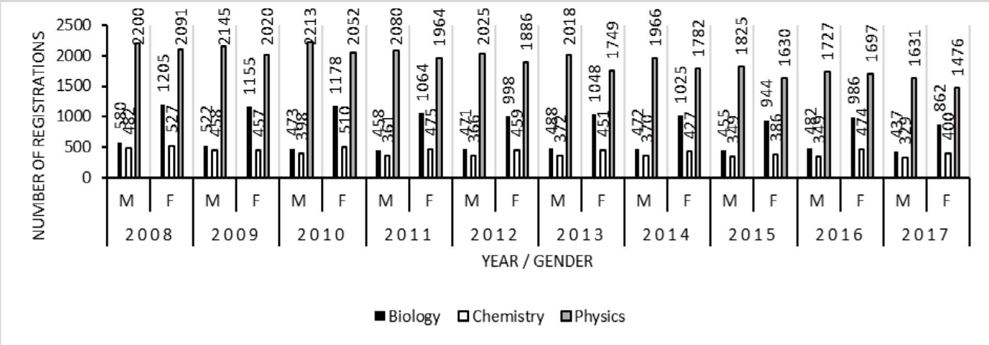

Fig. 1. Registrations for Biology, Chemistry and Physics per gender per year, 2008-2017

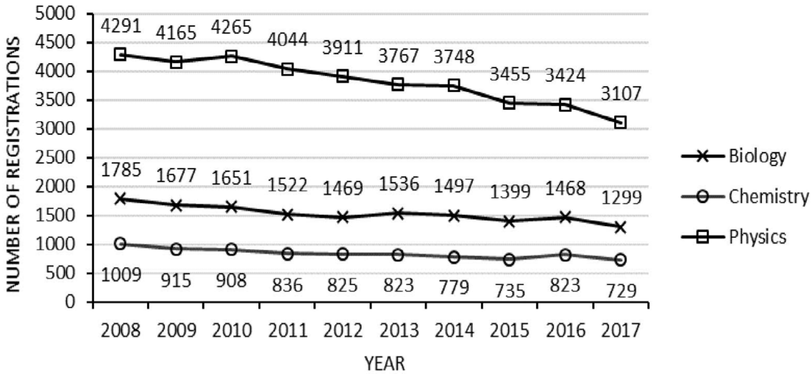

Fig. 2. Number of yearly SEC registrations for Biology, Chemistry and Physics, 2008-2017

Figure 2 shows the yearly SEC registrations for the three sciences. Chemistry is the least chosen of the three subjects, with Biology at circa twice and Physics at roughly four to five times as much. In percentage terms, they are circa 12%, 25% and 55% of total registrations for Chemistry, Biology and Physics respectively. Gender differences in Chemistry and Physics are not pronounced, but there is considerable bias in female participation in Biology (Musumeci, 2015; Musumeci, 2018; MATSEC Examinations Board, 2008-2017).

1.5 Subject Choice and Performance in Biology in Malta – Gender Differences

Females tend to opt more for Biology. In 2017, 862 females and 437 males registered for SEC Biology. Considering the choice between Paper IIA (the more difficult version) and Paper IIB, there were no major genders differences: 77.3% males and 74.2% females taking Paper IIA, and 22.7% males and 25.8% females opting for Paper IIB. A distinct difference is that, there were six times as much females as males choosing Biology as their only compulsory science subject (MATSEC Examinations Board, 2017).

There were slight differences in performance between males and females: 16.5%

males and 13.9% females getting (the highest) grades 1 or 2; 46.4% males and 48.5% females obtaining grades 3, 4 or 5; and 7.1% males and 7.0% females getting grades 6 or 7. There were 26.8% males and 28.4% females who failed the exam. (MATSEC Examinations Board, 2017).

2. Methodology

Questionnaires were used as research tools. Nearly all questionnaire items were closed questions, i.e. the answer has to fit into a pre-determined category chosen by the respondent (McLeod, 2014). Eight experts – educational officers and teachers with specialisation in Biology – were asked to suggest reasons for choosing or nor choosing Biology at Form 2 and at sixth form. These 'reasons' were the basis to construct the student questionnaires.

A total of 300 questionnaires were distributed in six schools: two state schools, two Church schools and two independent schools. In each school type, half the questionnaires were given to Form 2 students and the other half to Form 4 students, and distributed evenly between male and female students. Out of 300 questionnaires, 228 were successfully collected.

3. Analysis of Results

3.1 SEC Biology Subject Choice

Figure 3 portrays the May 2017 registrations for SEC Biology, highlighting the differences between genders and the three school types.

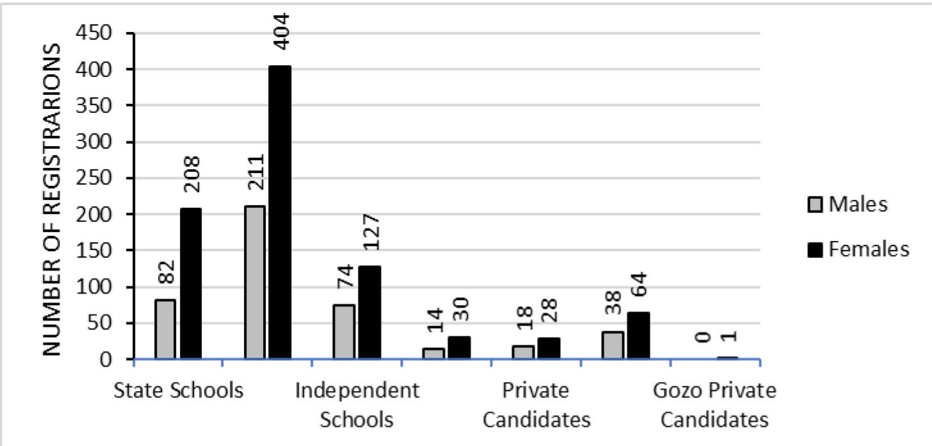

Fig. 3. May 2017 Registrations for Biology, per gender and school type

3.2 Reasons for Choosing Biology indicated by the Experts

According to the experts, the top reasons for choosing Biology at Form 2 included:

(i) a positive experience in Integrated Science, and enjoyed the subject; (ii) inspiration from parents and help from guidance teachers; (iii) need for future career options; (iv) a limited option of choices; (v) a positive experience of friends who chose Biology; and (vi) it is a rather easy subject.

The top reasons for choosing Biology at Sixth Form given by the experts were: (i) did very well in exams and feel confident in the subject; (ii) career choice where Biology is required; (iii) inspired by family, friends or guidance teachers; (iv) need of a science subject, and considering it as a softer option; and (v) a positive experience at secondary level, and enjoyed it.

3.3 Reasons for Not Choosing Biology indicated by the Experts

The experts were also asked to suggest possible reasons for not choosing Biology at Form 2. The top reasons were:

(i) very vast subject requiring a lot of memorisation; (ii) not doing very well in Integrated Science; (iii) interested in a career path not requiring Biology; (iv) a negative experience of friends who chose Biology; (v) do not enjoy topics about plants; and (vi) afraid of blood and disgusted by dissections.

The experts' top reasons for not choosing Biology at Sixth Form were:

(i) not doing very well in annual exams and not feeling confident in the subject; (ii) considering Biology as a very vast subject, with too much to memorise; (iii) guided not to choose Biology by family, friends or guidance teachers; (iv) choosing a career where Biology is not required; and (v) preferring other subjects over Biology.

3.4 Outcomes of the Study

3.4.1 Reasons for Choosing or Not Choosing Biology in Form 2

Almost two thirds (62.5%) of the students that took part in the Form 2 questionnaires wish to choose Biology. The main reasons were their positive experience in Integrated Science, their aspirations for future careers, and inspiration from parents and guidance teachers. These reasons were given high priority across both genders and all school types. A considerably lower percentage, just over a third (37.5%), of the Form 2 sample did not wish to choose Biology. The main reasons for this choice were career aspirations not involving Biology, and Biology being a vast subject requiring memorisation. Once again, high priority was given by both genders and the three school types.

3.4.2 Reasons for Choosing or Not Choosing Biology at Sixth Form

A very high portion of Form 4 students (82.4%) were interested in choosing Biology at Sixth Form. Independent school students were lowest in choice of Biology compared to the other school types. The top reasons for choosing Biology were career aspirations requiring Biology, and a positive experience at secondary level.

This was again true for both genders and all three school types. Out of the small percentage (17.6%) of students who did not wish to choose Biology at Sixth Form, the vast majority (78.9%) were from independent school students. The main reason was a career where Biology is not required.

4. Conclusion

This study indicates that there are potentially some issues as regards the science subjects in Malta's educational system. In general, males are less inclined to choose Biology at Form 2, while females tend to choose it more although they show lower performance in the subject. Considering the three school types, Church school students perform best in Science and Biology. Independent school students seem to 'focus' less on Biology, as proportionately not as many students choose it. According to the Form 2 questionnaire data, and considering the school types, independent school students are by far the least likely, at 56.8%, to choose Biology. State schools seem to be somewhat problematic with students wishing to choose Biology, but showing lower levels of performance.

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Technology and Human Education

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Abstract

This paper argues that structures of technical education are part of general education. Research areas include all objects conceived and produced by humans with an immediate intent of function utility and how this world of artefacts is embedded into the broader socio-cultural context. The omnipresence of this "Leonardo world" (Mittelstraß, 1992) has a lasting influence on our lifeworld. A localisation into a human educational idea is necessary, as argued by Nida-Rümelin (2013). His approach is based on a holistic, lifeworld orientation knowledge. The essential question is how technology can be integrated as a decisive cultural phenomenon into this holistic concept. A hermeneutic approach seems methodologically suitable. It manifests in the sense-understanding of the tangible work as well as its creation and use. The fundamental structural moments in hermeneutic understanding retain their validity. These are according to Danner (2006, 42):

1. We perceive a thing or a process sensually.
2. We recognise that as something human.
3. We understand the meaning and the sense of this as human.

A holistic approach describes the human being in a unity of thinking, feeling and corporeality-merged into a whole that is more than the sum of its parts. The analogy to artefacts is the workpiece in its unity of form, function, material and manufacturing process. It is felt, thought out and self-made. In it, human beings interpret themselves; with it they create their own world, the cultural sphere. This process manifests as a feedback loop between the worlds of objects and human beings.
Due to the technical transformation of the world, increasingly pressing problem areas with global dimensions are widening. The existential challenge is to locate technology in a human world view. This assignment is not least given to pedagogy in general and to a corresponding educational subject in particular: "Technology and Design".

Keywords: technology, human education

1. Introduction

The following examines the relationship between technology and education. In this paper, it seems inevitable to put forward a conception of humankind in which technical education has to be located. It is also necessary to determine the nature of technology and product design. Deriving from this clarification of the substantive characteristics, the legitimation of an independent subject should be consolidated in the canon of general education schools.The following questions arise from this problem structure; they form the starting point for the further course of the investigation:

- What technical reference fields justify a separate and independent subject "Technology and Design" in the canon of general education schools?
- What education-theoretical concepts provide rewarding contributions to an action-oriented and creative encounter with the lifeworld?
- What integration achievements can an educational subject "Design and Technology" provide in the ensemble of the educational canon?

2. Human education

Pedagogy has to do with humans. This simple insight has significant consequences for the selection of technical content, but also for a fundamental idea of education.

Ultimately, our image of humanity determines our ideas of science and pedagogy as parts of it. It rules the way we humans interact, communicate and shape the world and ourselves.Thus, it affects the subject canon in schools how this anthropological foundation is laid.

2.1. Holism

In his presentation of the guiding principles for humane education, Nida-Rümelin (2013) pursues a holistic approach. On the basis of a philosophical anthropology he defines the unity of the person, the unity of knowledge and the unity of society as pillars of a humane educational practice. The foundation for this is based on the autonomy of the person, which is founded on reason, freedom and responsibility of the individual (loc. cit., 15). Free of any instrumental appropriation a person should judge and act autonomously. When reasons are carefully considered and the better argument is found, the result is generally binding.

Educational concepts based on pedagogical anthropology tend towards holistic approaches. Litt (1948), for example, takes up Humboldt's idea of harmonious human formation, but criticizes its restriction to language. But he does not make the mistake of rejecting the basic idea of the classic educational ideal. Rather, he is concerned with consequently pursuing Humboldt's demand for the highest and most proportionate formation of human powers into a whole (Humboldt 1969, I: 64). Accordingly, the claim of a comprehensive and holistic education in the interrelation of people and the world in the variety of situations (loc. cit., 64) is only achievable by including the world of objects, in which utilitarian functions are fulfilled, and thus also technology.This area is an essential part of the culture and shapes it in a particularly sustainable way.

So Litt takes a turn from classical to real humanism.

3. The essence of technology

Technology plays a crucial role in human development - right from the start. The physical existence of humankind depends on technology and also the flowering of cultures. Tool finds such as the hand axe are considered proof of the first appearance of humans. Entire epochs are named after formative materials and forms of production: Stone Age, Copper Age, Bronze Age, Iron Age; industrial age with intensive mechanization, and digital age.

3.1. Technology as part of culture

Culture is everything that is created by humans - in contrast to nature. Humankind is dialectically referred to both spaces. Cultural achievements include, for example, language and science as well as the shaping transformation of art and technology.

Culture is the artificial space that humankind manages. Through culture, humans interpret and determine their nature and being. The technical world of objects occupies a significant place in culture in toto, especially in the modern world of life.

The humanities have shown a reserved attitude towards the technical world of objects. By aesthetic literary humanism technical activity has been banished from the realm of culture and thus of human nature.

Uncontrolled by meaning and value issues, the mechanisation of life assumes a separate existence and leads to technocratic conditions.

3.2. Creativity and technology

The history of technology is a history of inventions. Realizing technical devices is a mental achievement. It requires imagination, thinking of a purpose, anticipatory planning, collecting and analyzing facts, combination skills, mentality, and in-depth knowledge of material properties, manufacturing processes and environmental qualities. The creative aspect of the technical object is manifested not only in its practical function but also in its shape.

Pedagogically relevant ist not only something new, but something that is new for the individual. Postinventing has the same educational significance in handicrafts as inventing.

3.3. Technology and science

The technical functioning of devices requires the observance of natural laws.

Nevertheless, there are serious differences between technology and science. Science describes the laws of the existing world („nature“) and is based on causal correlations. Technology and product design, on the other hand, refer to the subject area of human-made objects with utilitarian functions. With them people create their own space, the cultural space. In its artificiality, it faces nature. Through the production and use of this world of objects, human beings shape their environment and interpret themselves. Because of that questions about the meaning, purpose and responsibility of human beings become relevant.

4. The technical object in a holistic view

If an image of humanity is valid, understanding human being as a whole of thinking, feeling and corporeality, the view of the whole of the product of workmanship is a natural consequence. Simplified and brought to a programmatic, formulaic denominator, this correlation expresses itself in the structure "the whole person – the whole work”. An objective-holistic view grasps the technical object as the result of a coherent interplay of production technology, material, form and function. These sections are interdependent; they interpenetrate and determine the subject matter (fig. 1).

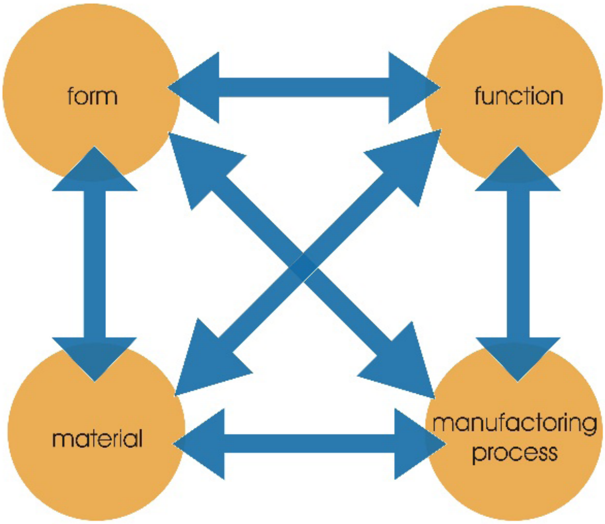

Fig. 1.

In contrast to free artistic design, the shaping of the technical object is in close contexts to its practical function. Its aesthetic level unfolds essentially as aesthetics of use (see Heufler 2004), distancing itself from art.

The technical object is comprehensively interpreted when manufacturing and use are considered in a socio-cultural context. Humans and world mutually influence each other. With the help of technology, people reshape and transform the world which retroacts on humankind.

5. The "lifeworld" (Lebenswelt)

A determining element among the self-images of humanity is the classification of "nature" and "culture", from which the organization in science and humanities derives. Science investigates causal relationships, and the humanities explore contexts of meaning. The former works "exactly" with proofs, the latter does so "strictly" with evidence (Danner 2006, 27). Science and school organization are largely based on this distinction.

Mittelstraß (1997, 82) questions this contrast between these two paradigms. In his view, both fields of science have the same basic starting point: "the world"; namely the real world, which is the conditio humana. He takes up Husserl's (1954) concept of the lifeworld as an uncircumventable a priori. As the world which is sensually, vividly, concretely, practically and physically experienceable, it forms the foundation of meaning for all academics. By use of that background Mittelstrass relates the Leibniz (interpreted world) and the Leonardo world (made world) into a transdisciplinary reason; ultimately, he unites both in a single entity. The human being reamains the measure of a human being (see Mittelstraß 1997, 87 f.).

The baselines of an educational theory and the reference fields of a holistic craft education fit easily into this idea. Technology and product design are determining parts of the Leonardo world. In order to make this meaningful for humans, the Leibniz world is needed. Technical work with representational holistic aspiration fulfills an integrative function with a formative influence.

6. Conclusion

Technical systems influence our everyday world, our actions and our attitude towards life. Increasingly, however, the ambivalence in the use of technology becomes obvious: In addition to the abundance of opportunities for enriching life and solving the constraints of encountered nature, negative effects emerge. The progressively industrialised ways of working, growing rationalisation and specialisation increase the possibilities of human control and manipulation. The global impact on Earth‘s ecology is dramatic: The use of modern technology has reached a level that seriously jeopardizes the planet‘s habitability. An increasing alienation from the lifeworld accompanies the technical transformation.

It is clear that the good and bad consequences cannot be pinned on technology.

The person using it on their own terms is solely responsible. In this network of problems, technical education fulfills an important task.

In his pedagogical concept of the mental permeation of technical educational objects, Schmayl (1987, 346 f., 355) points out the following levels of competence: ability and practical mastery, knowledge and understanding, attitude and mindset.

A core competence of technical education is the recognition, analysis and practical solution of technical problems in everyday life. In addition, technical education opens up connections between technology, product design, people and society. It imparts guidelines and categories of meaning for the humanization of the technical world of objects. It requires a separate subject “Technology and Design” with a permanent place in the educational canon of general education schools.

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The Application of Binary Logistic Regression Analysis on Transferability of Mathematical Knowledge amongst Science Students

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Abstract

Science students are required to apply mathematical knowledge at various levels. However, many students could not really relate what they have learned in mathematics classes in solving problems to another context. As such, this paper explore the factors that influence the ability of university science students to transfer their mathematical knowledge to a range of scientific contexts. The instrument was designed and comprised of mathematics and transfer questions. There are 255 university science students involved in this study. The performances of the students have been identified by determining the overall transfer score. The Binary Logistic regression model was used to identify the possible factors associated with students that would influence the knowledge transfer. The factors are namely Cumulative Grade Point Average (CGPA), gender, age, educational qualification, faculty and mathematics score. In this study, CGPA, faculty and mathematics score were found to be significantly affected the overall transfer score.

Keywords: Knowledge transfer, Binary Logistic Regression, Transfer score, Transfer questions

Introduction

Knowledge is very important in our life as it is the only way for someone to become more successful, able to give opinions, prevent people from getting manipulated and highly respected by other people. Science knowledge is a subject to the reformation of new evidence and new ways of thinking [1]. Educators claimed that understanding the scientific knowledge constructed should be done by every students. This is because, understand the scientific knowledge make people to be more careful on public scientific issues [2]. In addition, people will get better understand on science especially through structure and the nature of sciences practically [3]. Mathematical knowledge on the other hand, is essential for all science students' success regardless of the choice of discipline. Understanding mathematics is important in daily life as it is needed in the process of problem-solving and also mathematics subject is a major subject used widely as the foundation to another subject [4].

Knowledge transfer can be defined as the application of knowledge that can be applied in one situation to a different situation [5]. The transfer of knowledge can be applied to everyday activities as the students used the knowledge they learned in their classes. In addition, transfer can occur if the students can relate and recognize the previous learning task to the need of current task [5]. Science students in particular are required to use the knowledge that they have learned in mathematics classes to another context [6]. Randahl [7] found that there is some difficulties of engineering students when applying mathematical knowledge in engineering subjects. This is because students from engineering are not necessarily used that knowledge successfully in their subjects while mathematics students are able to perform well in mathematics subject. She stated that engineering students that learned mathematics are essential to understand the conceptual and procedural knowledge. Indeed, there is a clear difference between the way in which procedural students approach the transfer problems, compared to conceptual students [8].

However, many students could not really relate what they have learned in mathematics classes in solving problems to another subject [9]. The inability to transfer mathematical knowledge to other context makes them difficult to successfully pursue their study [4]. Thus, there is a need to know the factors associated with students that affect students in transferring their mathematical knowledge to another context.

Consequently this study investigate factors such as CGPA, gender, age, educational qualification, faculty and mathematics score.

Methodology

There are 255 (182 female and 73 male) third semester undergraduate students from seven (7) science-based faculties from Universiti Teknologi MARA (UiTM) Selangor Campus Malaysia involved in this study and is display in Table 1. The students were selected because they have learned the differentiation topic and their applications.

A set of questions was designed for the instrument. A pilot study was taken place with thirty one (31) students from third semester undergraduate Chemical Engineering Faculty in order to determine their ability to transfer mathematical knowledge from a mathematical context to other science context. The results from the pilot study showed that students could solved correctly the mathematical context but were unable to solve the transfer contexts. Thus, some changes were made on the transfer questions to make them much simpler and relevant to mathematical context. Also the questions were validated by peer group. Finally, there are four (4) mathematics questions and six (6) transfer questions in this study. An example of Transfer Question is shown in Figure 1 [10].

The temperature, T, is given in Fahrenheit, of a cold potato in a hot microwave, is given in terms of the equation $T=f(t)$, where t represents the time in minutes after the potato was put in the microwave.

(a) What is the sign of $f (t)$? Why?

(b) What is the unit of $f'(20)$? In practical terms, what do you mean by the statement $f'(20)=2$?

Fig. 1. The Sample of Transfer Question

This survey consists of 3 sections. Section A is on biographical information. Section B and section C comprised of mathematics questions and transfer questions respectively. The students need to answer section B first and the answer scripts were collected once they finished answered them. Finally, section C were distributed to the same students to answer. The answer scripts were collected and marks were given based on their answer.

Coding of Marks for Mathematics Questions and Transfer Questions

For each mathematics and transfer questions, the total marks for each question is 4 marks. In this study, the marks for each question were then be coded as below:

If the total marks for each mathematics or transfer question is between 0-2 marks, it will be coded as “0”, which indicates that the student was unable to solve the question. If the total marks for each question is between 3-4 marks, it will be coded as “1” which indicates that the student was able to solve the question.

Coding for Mathematics Score and Transfer Question

For mathematics score, if the total of four mathematics questions is between range 0-2, it will be coded as “0”, and if the range is between 3-4, it will be coded as “1”.

For transfer question, if the total of six transfer questions is between range 0-3, it will be coded as “0”, and if the range is between 4-6, it will be coded as “1”.

Calculating Transfer Score (TS)

In this paper, Transfer Score (TS) is defined as the ability of each student to transfer the mathematics knowledge to the scientific questions. The calculation of transfer is based on the total questions answered by the students by comparing the coded marks obtained for mathematics score with those coded marks obtained for the transfer questions.

	Mathematics Score (MS)	Transfer Question (TQ)	Transfer Score (TS)
Coded Marks	1	1	1
	1	0	0
	0	1	1
	0	0	0

Fig. 2. Transfer Score

Figure 2 shows that if a student can answered correctly for both mathematics question and transfer question, the transfer score (TS) will be coded as 1. It shows that the transfer has occurred. But, if a student answered mathematics question correctly but could not answer the transfer questions, then the transfer score (TS) will be coded as 0 which indicates that transfer does not occur. However, if a student answered mathematics question incorrectly but answered transfer questions correctly, the transfer score (TS) will be coded as 1 as it indicates the transfer still occurs. Finally, if a student answered incorrectly for both mathematics and transfer questions, the transfer score (TS) will be coded as 0 which indicates that transfer does not occur.

BINARY LOGISTIC REGRESSION

The results obtained were analysed using descriptive statistics and inference. Binary Logistic regression is used in this study to find the factors that affect the knowledge transfer. The main goal is to find the best fit model to describe the relationship between the response variable and a set of independent explanatory variables as displays in Table 1. This study considers transfer score as a dependent variable Y, whereas CGPA, gender, age, educational qualification, faculty and mathematics score as the independent variables.

Table 1. Coding of variables that influence the knowledge transfer of students

Variable	**Explanation**	**Data Type**	**Condition Used**
Dependent Variable			
Transfer Score	The student fails to transfer the knowledge	Binary	No = 0
	The student succeeds to transfer the knowledge		Yes = 1
Independent Variable			
CGPA	CGPA of student	Categorical	4.00 – 3.50 = 1
			3.49 – 3.00 = 2
			2.99 – 2.50 = 3
			2.49 – 2.00 = 4
			1.99 – 1.50 = 5
Gender	Gender of student	Categorical	Male = 1
			Female = 2
Age	Age of student (years)	Categorical	19 = 1
			20 = 2
			21 = 3
			22 = 4
			23 = 5
			24 = 6
			25 = 7
Educational Qualifications	Level of Education Attained	Categorical	Diploma = 1 Matriculation = 2 Foundation = 3
Faculty	Study Field	Categorical	Chemical Engineering (FChemE) = 1
			Electrical Engineering (FEE) = 2
			Civil Engineering (FCE)= 3

			Mechanical Engineering FME)=4
			Computer & Mathematical Sciences (FCMS) = 5
			Applied Sciences (FAS) = 6
			Education (FE) = 7
Mathematics Score	Student's score on mathematics questions	Binary	Score between 0 – 2 marks = 0 Score between 3 – 4 marks = 1

The logistics regression model is given by

$$z = log\,i\,t(p(Y=1)) = ln\left(\frac{p(Y=1)}{1-p(Y=1)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_m X_m$$

$$p(Y=1) = \frac{e^z}{1+e^z}$$

$$p(Y=1) = \frac{e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\ldots+\beta_m X_m}}{1+e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\ldots+\beta_m X_m}}$$

where;

Y Transfer score

$p(Y=1)$ The probability of student succeeds to transfer the knowledge

$1-p(Y=1)$ The probability of student fails to transfer the knowledge

$X_1, X_2, \ldots, X_m$ m independent/dummy variables

β_0 Constant

$\beta_1, \beta_2, \ldots, \beta_m$ Logistic regression coefficients

Results and Discussion

In checking the association between overall transfer score and other variables, the Pearson Chi-square test indicates that there is a significant association between the overall transfer score versus faculty, mathematics score and CGPA (shown in Table 2). This is because the p-values for the three factors is significant since the value is less than α=0.05. On the other hand, there is no significant association between overall transfer score versus gender, age and educational qualification since their p-value is greater than α=0.05. In summary, CGPA, faculty and mathematics score are the factors that significantly associated with the overall transfer score.

Table 2. Cross Tab of Overall Transfer Score

Variables	Pearson Chi-Square	df	Assumption (2-sided)	Phi and Cramer's V
Faculty	67.935	6	0.000	0.516
Mathematics score	24.811	1	0.000	0.312
CGPA	14.021	4	0.007	0.234
Gender	0.429	1	0.512	0.041
Age	10.692	6	0.098	0.205
Educational qualification	0.304	2	0.859	0.035

The Omnibus test and Hosmer-Lemeshow test of model in Table 3 show the overall indication of how well the model performs. This is referred to a ‘goodness of fit’ test. For Omnibus test, the chi-square value is 116.840 with 20 degrees of freedom.

In this case, the model is statistically significant because the p-value is less than .05.

Table 3. Overall Transfer Score Model Tests

	Chi-square	df	Sig.
Omnibus Test	116.840	20	0.000
Hosmer and Lemeshow Test	9.475	8	0.304

According to Hilbe [11], the best way to get the fit of logistic model most of statistician developed goodness-of-fit test by using Hosmer-Lemeshow test. Specifically, the Hosmer-Lemeshow test calculates if the observed events rates match the expected event rates in population subgroups. Based on the Hosmer-Lemeshow test, the value of chi-square is 9.475 and the significant value is 0.304. The significant value is greater than 0.05. It shows that the model is better and supported.

Table 4. The results of binary regression model for Overall Transfer Score

	B	S.E.	Wald	df	Sig.	Exp(B)
faculty			44.942	6	.000	
FChemE	.717	.548	1.711	1	.191	2.047
FEE	-.266	.547	.237	1	.626	.766
FCivilE	-.693	.565	1.503	1	.220	.500
FME	-.531	.608	.764	1	.382	.588
FCMS	3.121	.669	21.786	1	.000	22.678
FAS	-.468	.594	.621	1	.431	.626
math_score(1)	-1.807	.402	20.246	1	.000	.164
Constant	-.032	.399	.007	1	.936	.968

Therefore, from Table 4 the fitted model is given by:

$$p(Y=1)=\frac{e^z}{1+e^z}$$

$$z=-0.032+0.717FChemE-0.266FEE-0.693FCivilE-0.531FME+3.121FCMS-0.468FAS \\ -1.807math\_score(1)$$

The results from Wald test, as presented in Table 4, were useful for estimating which coefficients were statistically significant (Sig. <0.05) and which were not statistically significant (Sig. >0.05). The significant value of overall transfer score in the model are FCMS and Mathematics Score. This shows that the odds of able to transfer knowledge whose students are from FCMS is 3.12 times higher than those from other faculties. For the Mathematics Score, if the students are able to solve the mathematics questions, it can contribute to the transferability of mathematical knowledge to other context by odds of 0.032 times higher compared to students who are unable to solve the mathematics questions. In summary, FCMS and Mathematics Score are the variables that affect the overall transfer score.

Conclusion

The results demonstrated that CGPA, faculty and mathematics score are the variables that significantly associated with the overall transfer score by using Pearson Chi-square test. However, in using BLR, only FCMS and Mathematics Score are the variables that affect the overall transfer score. Out of seven science-based faculties, only FCMS significantly satisfied the model. This is due to students from FCMS are able to solve both mathematics and transfer questions. Besides, the other significant factor in the model is Mathematics Score. This is because having a strong fundamental background of mathematics help students better in transferring mathematical knowledge to other contexts.

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Trends and Patterns in Subject Choice by Science Students at Sixth Form Level in Malta

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Abstract

Education is crucial and it entails important choices at various stages during a student's secondary and post-secondary years. At certain stages of their schooling, students need to choose the subjects to study and such decisions affect their future careers and working lives. Students are 'influenced' in their subject choice by a number of factors, such as a preferred career path, influence of parents and/or peers, etc. In Malta, following secondary school, at 16 years of age, students choose their Advanced (A) level subjects at post-secondary level, that has a direct bearing on their eventual tertiary education. This study investigates the reasons influencing subject choice at Sixth Form level. The research sample consisted of two groups of post-sec second-year Science students, namely 243 A level Biology and Chemistry (BC) and 116 Pure Mathematics and Physics (PMP) students. The student questionnaires were constructed following an investigation conducted with eight experts, who were requested to list three factors that influence students in their A level subject choice. The outcome showed that the experts, the BC and the PMP student groups did not always concur on the most or least influential factors for subject choice. The students identified career aspirations as the most influential factor for subject choice. Experts indicated career aspirations and subject difficulty as the main influences. There was no clear agreement between BC and PMP students, and experts on the least influential factors (from SEC exam results, family and peer influence, and lack of passion towards the subjects).

Keywords: subject choice; Sixth Form; science subjects

1. Introduction

1.1 Aim of the Research Study

The purpose of this study was to elicit trends and patterns in subject choice of science students at Sixth Form level. Six factors which influence students to choose or not Biology and Chemistry (BC) or Pure Mathematics and Physics (PMP), at Sixth Form level were considered. These factors were identified in a prior investigation with eight experts.

1.2 The Choice of A Level Subjects in Malta

"The post-secondary sector represents a critical stage in the learning journey of young people." (Ministry for Education and Employment, 2017, p. 31). Teenagers between the ages of 16 and 18 can undergo a two-year post-secondary course at a Sixth Form institution, which prepares students for the Matriculation Certificate (MC) exams. The MC gives access to tertiary education institutions (Government of Malta, 2015a; 2015b).

1.3 Factors influencing Subject Choice

Many studies show that subject choice is affected by a number of factors (Ashworth & Evans, 2000; Ashworth & Evans, 2001; Van de Werfhorst, Sullivan & Cheung, 2003; Goodrum, Druhan & Abbs, 2012). Ashworth and Evans (2001) argue that, first and foremost, students choose a subject for further study if they find it interesting and/or enjoyable; they can also be influenced by peers. Another study carried out by Ashworth and Evans (2000) shows that the perception of difficulty and the grades achieved might also affect subject choice. This is where student ability can also impact subject choice (Van de Werfhorst *et al*., 2003). Another factor in play is university course requirements (Goodrum *et al*., 2012).

2. Methodology

For this study, a mixed methods approach was used. Cohen *et al*., (2011) argue that the mixed methods approach "yields real answers to real questions … [and] … avoids mistaken allegiance to either quantitative or qualitative approaches on their own" (p. 26). Three different questionnaires were used. The first questionnaire was given to eight experts in the field. According to the responses, the other two questionnaires for students were formulated. The latter were distributed to two purposive samples in post-secondary institutions.

Rank ordering was the major data scale used for the student questionnaire.

Respondents were asked to rank six factors, where '1' and '6' represented the highest and lowest priorities respectively. This data scale could have been problematic for some who find it hard to prioritize between the factors. Therefore, as recommended by Cohen *et al*., (2011), an open-ended question was also included to enable them, if they wished, to include any other factor: "It is the open-ended responses that might contain the 'gems' of information that otherwise might not be caught in the questionnaire" (p. 392).

The two student population samples were chosen from six different Sixth Form schools in Malta and Gozo. A total of 363 questionnaires were collected: 245 BC students and 118 PMP students. However, as some questionnaires were filled incorrectly, the final number of 'appropriate' questionnaire responses was 243 BC and 116 PMP. Subsequently, the data from the student questionnaires were inputted onto Excel spreadsheets, and the average rating for each factor was computed, where the most popular factor was indicated by the lowest average rating value, and vice versa.

3. Analysis of Results

3.1 The Factors chosen by the Experts

Table 1 shows the six most popular factors presented by the experts, subsequently presented for rating by the BC and PMP student cohorts. Table 2 shows how the factors were coded for easier handling and representation.

Table 1. The most popular factors chosen by the experts

Factors affecting students to choose A level subjects	**Factors affecting students not to choose A level subjects**
Students wish to follow a career that requires these subjects	Students find the subjects difficult
Students are encouraged by results obtained in previous (SEC) exams	Students wish to follow a career that does not require these subjects
Students are influenced by their family and/or friends	Students are discouraged by results obtained in previous (SEC) exams
Students have a passion for the subjects	Students are discouraged from choosing these subjects by their family and/or friends
Students believe there are more opportunities and options for employment if they study these subjects	Students believe they might not succeed in the subjects/area
Students believe they can succeed in the subjects/area	Students might not have a passion for the subjects

Table 2. Coded factors for BC and PMP student cohorts

Code	Factor	Code	Factor
BC-C-1 or PMP-C-1	I want to follow a career that requires these subjects	**BC-NC-1 or PMP-NC-1**	I want to follow a career that does not require these subjects
BC-C-2 or PMP-C-2	I have a passion for the subjects	**BC-NC-2 or PMP-NC-2**	I do not have a passion for the subjects
BC-C-3 or PMP-C-3	I believe that I can succeed in the subjects/ the area	**BC-NC-3 or PMP-NC-3**	I might not succeed in the subjects/the area
BC-C-4 or PMP-C-4	I was encouraged by results obtained in previous (SEC) exams	**BC-NC-4 or PMP-NC-4**	I was discouraged by results obtained in previous (SEC) exams
BC-C-5 or PMP-C-5	I wasA influenced by my family/friends	**BC-NC-5 or PMP-NC-5**	I was discouraged by my family/friends
BC-C-6 or PMP-C-6	There are more employment opportunities with these subjects	**BC-NC-6 or PMP-NC-6**	I think the subjects are difficult

3.2 Factors influencing BC and PMP Students' Subject Choice at A Level

The factors presented to the two student cohorts will be discussed according to the average rating obtained and the experts' rating order.

3.2.1 Factors influencing BC Students to choose A Level Biology and Chemistry

Table 3 shows that experts and BC students agreed on the most influential factor, being career aspirations (BC-C-1). There is no agreement in the rank of the other factors impacting BC students' subject choice.

Table 3. Factors influencing BC students to choose science subjects

Factor	Experts Rating Order	BC Students Rating Order	Average Rating
BC-C-1	1	1	1.79
BC-C-2	4	2	2.59
BC-C-3	6	4	3.29
BC-C-4	2	5	3.90
BC-C-5	3	6	4.91
BC-C-6	5	3	3.06

3.2.2 Factors influencing PMP Students to choose A Level Pure Mathematics and Physics

Table 4, like Table 3, shows that experts and PMP students agreed on career aspirations as the most impacting factor. The comparison of rating orders by experts and PMP students is similar to the rating orders of BC students, except for the 'belief of succeeding in the area' and 'more opportunities and options for employment' placed third and fourth respectively. There was no clear agreement amongst experts, BC and PMP students.

Table 4. Factors influencing PMP students to choose science subjects

Factor	Experts Rating Order	PMP Students Rating Order	Average Rating
PMP-C-1	1	1	1.90
PMP-C-2	4	2	2.73
PMP-C-3	6	3	3.10
PMP-C-4	2	5	3.68
PMP-C-5	5	6	5.22
PMP-C-6	3	4	3.29

3.2.3 Factors influencing BC Students not to choose A Level Pure Mathematics and Physics

Table 5 shows no agreement between experts and BC students, where BC students ranked no need of the subjects for their future career (PMP-NC-1) as most important whilst the experts gave top priority to subject difficulty (PMP-NC-6).

Table 5. Factors influencing BC students not to choose science subjects

Factor	Experts Rating Order	BC Students Rating Order	Average Rating
PMP-NC-1	2	1	2.10
PMP-NC-2	6	2	2.62
PMP-NC-3	5	3	3.34
PMP-NC-4	3	6	4.72
PMP-NC-5	4	5	4.66
PMP-NC-6	1	4	3.67

3.2.4 Factors influencing PMP Students not to choose A Level Biology and Chemistry

Table 6, similarly to Table 5, also represents disagreement between the experts and PMP students, where the students rated ‘I want to follow a career that does not require these subjects’ as the main factor influencing subject choice (BC-NC-1), in contrast to the experts who rated subject difficulty as the prime factor (BC-NC-6).

Table 6. Factors influencing PMP students not to choose science subjects

Factor	Experts Rating Order	PMP Students Rating Order	Average Rating
BC-NC-1	2	1	2.20
BC-NC-2	6	2	2.68
BC-NC-3	5	3	3.09
BC-NC-4	3	5	4.39
BC-NC-5	4	6	4.91
BC-NC-6	1	4	3.36

3.3 Analyzing the Open-Ended Questions

Participants brought up other factors that affected their subject choice: 41.2% of BC and 20.2% of PMP students. They suggested other factors such as: acquiring a comfortable lifestyle; subjects complementing each other; simply preference towards the subject/s; teacher impact; and not having the subjects at secondary school.

4. Conclusion

This study shows that the BC and PMP students ranked the factors influencing subject choice similarly, with slight differences when compared to the experts’ ranking.

Regarding the factors influencing student choice for A level Biology and Chemistry at post-secondary level, the experts and the BC students shared similar views, namely putting career requiring the subjects as the most influential factor. Similarly, the PMP cohort and the experts considered career aspirations as the prime factor. Rather than simply considering the ranking order, the other factors should also be seriously considered by the various stakeholders in the field. Furthermore, the outcomes of this study show that the rank order of the factors influencing subject choice in science as identified by the experts was different from that presented by the BC and PMP Sixth Form students.

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Studies on Science Education

Affordances and Constraints of Meaning-Making in Multimodal Science Classrooms

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Abstract

When explaining concepts in science classes, teachers make available to students a variety of communicative resources, both verbal and nonverbal. Nonverbal resources are especially useful when concepts are abstract or pertain to the microscopic world that is not immediately (visually, physically) available to students. Although the notion of teaching as a multimodal activity is well documented in the science education literature (e.g., [1], [2]), there still remains a gap in our understanding of how these multimodal resources are integrated in teaching, affording or constraining the construction of meanings [3]. In this study, we report on an analysis of teachers' use of multimodal resources while teaching the same scientific concept in different languages, in different sociocultural contexts, and to students from different linguistic and cultural backgrounds. Data was collected in two high school Biology classes, a grade 9 in an inner-city public school in a large Brazilian city, and a grade 11 in a suburban high school in a metropolitan Canadian city. Both teachers were female and native speakers of the specific language of instruction in each of the classes (i.e., Portuguese in Brazil, and English in Canada). Digital camcorders were used to capture the teacher, the students, and the board/screen in these classes. Data was analyzed with Transana® software. Comparing the two contexts by analyzing the multimodal resources the two teachers utilized while teaching about synapses, as part of the unit on anatomy and physiology of the nervous system, the affordances and constraints of making meanings available to the audience became evident. Although the scientific concepts being taught were the same, the resources used and the way in which the explanation of the concepts unfolded during classes were starkly different in the two contexts. Understanding how the multimodal resources used in teaching science help or hinder the construction of meanings have implications for researchers, science teaching methods instructors, and teachers. A focus on how multimodal resources are integrated to create the conditions for meaning-making to occur will allow us to better equip future and practicing teachers with the pedagogical content knowledge needed to effectively communicate abstract, complex concepts to students.

Keywords: Multimodality; Gestures; Classroom Communication; Biology Teaching

1. Introduction: Multimodal Science Lectures

Lecturing is common strategy for teaching science at all grade levels. Good teachers are often said to be those who know not only the concepts, but also the most effective pedagogical strategies to teach those concepts, which includes knowing how to *explain* concepts most effectively; however, how teachers *perform* concepts in science classrooms [4] is an under-investigated topic in science education, particularly as it refers to the integration of verbal and nonverbal resources during teaching.

Moreover, socio-cultural and linguistic backgrounds play an important role in how we communicate [5], yet to date we know little about how these aspects of communication are related to disciplinary discursive practices, both in terms of epistemological views of science and specific scientific content. This study is part of a larger research project that analyses the communicative and performative aspects of lectures delivered by Brazilian and Canadian secondary science teachers, focusing particularly on similarities and differences in performative aspects of teaching the same scientific concepts in different languages and socio-cultural backgrounds. The research question driving this study is, *how do communicative and performative aspects of teaching science in secondary schools vary between Brazilian and Canadian teachers when teaching the same scientific concepts?* In the particular study presented here, we focused on the types and abundance of multimodal meaning-making resources the teachers used when teaching about synapses, which are the nervous impulses that travel through nervous cells. We were particularly concerned with the ways in which each and all of these modalities combined afforded or constrained meaning-making opportunities, as these were made available by teachers during class.

2. Methods

This qualitative, cross-cultural study relied on micro video ethnographic methods to collect data in two grade 11 biology classes: in an inner-city public school in a large Brazilian state capital (approximately 1.5 million inhabitants), in a class with 25 mix-gendered students; and in a suburban public high school in a metropolitan Canadian city (approximately 750 thousand inhabitants), in a class with 28 mix-gendered students. In both classes, the teachers were experienced and data was collected in the second semester of the academic year. Multiple digital camcorders affixed on tripods were used to videotape the teacher and the students. Using Transana software, we performed a micro-analysis of data (frame-by-frame analysis), synchronizing speech and body movements, as well as other modalitites available for meaning-making (e.g., projections on the screen, drawings and writing on the board, and three dimensional objects). At the macro-level, analysis focused on socio-cultural aspects of teaching science, such as issues related to disciplinary epistemological views, as well as pedagogical, discursive and interactional choices teachers make while teaching. The relevance of including such aspects of teaching into the analysis lies on the undeniable influence they have on the micro aspects of multimodal discourse, and consequently, on the outcomes of teaching in terms of meaning-making opportunities for students.

3. Findings and Discussion

The unit on Nervous System took a total of eight 75-minute lessons in the Canadian context (approximately 600 hours of instruction on this topic), and two 40-minute lessons in the Brazilian context. The Canadian teacher employed a variety of resources to teach the unit, including talking and gesturing; writing and drawing on the whiteboard, projecting students' notebook pages on the screen, with responses to fill-in-the-blank for students to copy down; projecting diagrams on the screen; projecting computer animations on the screen; simulating the impulse transmission with a set of fixed dominos; using experiments with a ruler (for testing students' reflexes); using her own body as reference for demonstrations; and an art project (when students built a nerve cell using spaghetti and marshmallows). The Brazilian teacher also used many resources, but in comparison to the Canadian teacher, these were significantly less diversified: she spoke and gestured; she projected text and diagrams on the screen; she wrote and drew on the whiteboard; and she demonstrated reflexes on her own body, also inviting students to perform some demonstrations with her in front of the class. In terms of discursive resources, both teachers used familiar, culturally relevant examples; analogies; mnemonic devices; humour, and repetition. Both teachers also made use of their own bodies as a general human body referent to point to body parts and to perform demonstrations (for reflexes) [6].

The structural resources available in the classrooms were also very different in the two contexts. In Brazil, the teacher moves from classroom to classroom, and students remain in the same classroom for the entire duration of the school day. Alternatively, in Canada the teachers have "home rooms," and the students move from classroom to classroom to attend the various classes they have during the school day. For this reason, the Canadian classroom had several objects related to science and biology, such as, for example, posters, three-dimensional models of the human body and its organs, glassware for laboratory practice, science textbooks, etc., which were permanently available in the space. In addition, the room was configured as a science laboratory, with wet benches (that is, work benches with sinks) along three of the four walls on the room. The room also had a permanent computer and projector & screen set, as well as a TV set (see Figure 1). The Brazilian classroom, on the other hand, served as a general grade 11 classroom for that particular group of students, in which all disciplines that comprise the core national (compulsory) grade 11 curriculum were taught. As such, it contained only the student, the white board and a TV set.

The projector and the computer were brought in by the teacher, and as a result, the projector was set on one of the student desks, which considerably limited the size of the image projected (see Figure 2).

Regarding the affordances and constraints of the use of multimodalities during teaching, we highlight two findings from our analysis. First, because the students in the Brazilian context did not have any materials (textbooks or printed notes) to rely on, they needed to copy all the text and images from the slides projected on the screen during the lesson. This took away significant amount of time from the lesson, as the teacher needed to wait until students had finished copying it down. In addition, there was the potential for cognitive overload. Thus, the use of multimodalities in this particular situation, although important for the realization of meaning, could also be considered a constraint in the possibilities for meaning-making to occur, as students needed to choose between paying attention to the teacher and then copying down information or copying down information while the teacher was explaining the concepts, which would inevitably divert their attention from the teacher's speech and gestures. In the Canadian context, as the topic was spread out among several lessons, the teacher could better organize the use of multimodal resources; moreover, the students had printed notes to work from, limiting the amount of information they needed to copy down during the lessons. Second, the slower pace, multiple lessons, and the diversity of multimodal resources used in the Canadian context allowed for the reinforcement of key ideas and concepts, within a conceptually developmental sequence that afforded multiple opportunities for meaning-making to take place. For example, for explaining how the nervous impulse travels through the cells, the teacher used diagrams, computer animations, a simulation with a fixed domino set, speech, and gestures/body movements. All of these resources were employed repeatedly and in complementarity to each other, as new terms and ideas were presented to students throughout the several lessons on this topic.

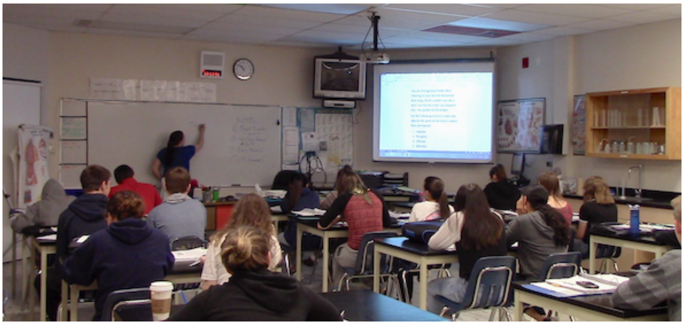

Fig. 1. The Canadian classroom

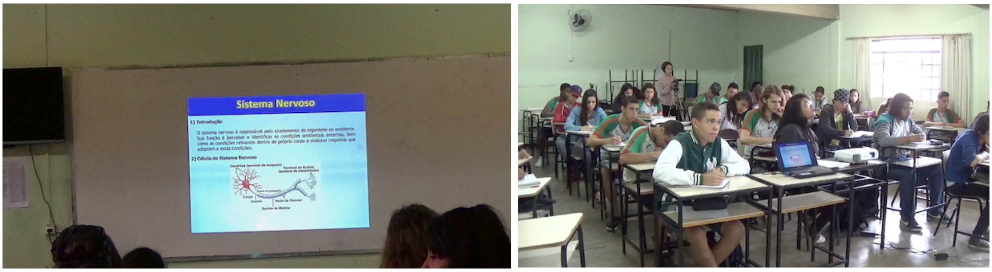

Fig. 2. The Brazilian classroom. (a) The white board with a projected slide. (b) View from the other camera

The type of analysis we conducted in this study affords the identification of important cues for what may be ordinarily referred to as effective explanations of concepts. In everyday interactions, people naturally use and interpret these cues, without even becoming aware of doing so [5]. However, if we are to teach science teacher candidates to be more effective communicators and to explain concepts more effectively, the exploration of these communicative and performative processes is a requisite first step to design strategies to teach these skills to future science teachers.

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Argumentation about Antibiotic Resistance in Secondary School Biology: The Role of Skills, Knowledge and Learning Environments

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Abstract

Science education aims at preparing students to participate in the social discourse and make informed decisions. Austrian science teachers shall encourage students to justify their positions and argue professionally and consistently. This work deals with secondary school students' (n=24; 16-17 years old) argumentation about antibiotic resistance. Qualitative data were collected by audio taping eight 20-minute small group discussions in a standard biology lesson. The students were prepared for the discussion in twelve biology lessons. In groups of three the students had 20 minutes to deal with the claim "antibiotic resistance is increasing worldwide" and four possible explanations. They should reason with the help of four short facts given to them as well as their expertise gained in recent biology lessons. The discussions were audio taped, transcribed and qualitatively analysed. The results show that the argumentations are mostly shallow and consist of few elements. Also, they argue rather intuitively than rationally. The students spend a lot of time with clarifying the meaning of the given explanations and facts. Many students seem overwhelmed by the task and don't recognise it's purpose. They experience difficulties in connecting knowledge as well as recognising errors in the given explanations. Poorly developed language skills and a lacking conceptual understanding of the content may have influenced the quality of students' argumentation.

Keywords: socioscientific issues, decision-making, reasoning, discourse, motivation

1. Introduction

Science education aims at preparing students to participate in the social discourse and make informed decisions. In Austria, science teachers shall encourage students to justify their positions and argue professionally and consistently.

Argumentation is an important facet of science. Learning the language of science is an essential part of science education and so every science lesson should encourage students to improve these language skills. However, scientific language is a major obstacle for many students in studying science. Improving the quality of science education, both in terms of the experiences it offers students and their cognitive and affective outcomes, requires the promotion of language, literacy and scientific literacy. [e; c]

According to the Toulmin's Argumentation Pattern, argumentations can be subdivided into the elements claim, data, warrant, backing, qualifier, and rebuttal. The basic argument consists of a claim that is in such a way supported by data or examples that the claim is a conclusion (syllogism). However, claims can be relativised by terms such as some, likely, and possibly. Warrants create links between the claim and the data, which can be underpinned by backings. Rebuttals are statements that contradict data, explanations and support. This form of argumentation is descriptive, logically inferential, and contains no normative premises. [3; 4; 5]

This work deals with secondary school students' argumentation about antibiotic resistance. The research questions are: Which argumentation structures do secondary school students (n=24; 16-17 years old) use when discussing the reasons for the worldwide increase of antibiotic resistance?

2. Research design

Qualitative data was collected by audio taping eight 20-minute small group discussions in a standard biology lesson. It seems to be important to prepare students in terms of language and content [6]. Thus, students learned about the immune system, vaccines, public health protection, pathogens, symbiotic bacteria, antibiotics, antibiotic resistance and strategies to avoid antibiotic resistance in eight 50-minute biology lessons. In two biology lessons (100 min) the teacher (first author) provided an argumentation training. The students practiced arguments, analysed argumentations and became acquainted with argumentation errors in general and specific in a biological context.

For the qualitative data collection the teacher developed a task similar to tasks used by other research groups [5; 10]. The task was designed to support students in recognising errors in the given explanations, reasoning with the help of lessons learnt in biology class as well as determining and discussing their own views and those of others. The students are expected to be able to argue well, because both in German lessons and in foreign language teaching argumentation skills are practiced in several grades.

In groups of three, students (n=24) were confronted with the statement "antibiotic resistance is increasing worldwide" and were offered four possible explanations.

The students were asked to discuss these explanations. They should reason with their expertise gained in recent biology lessons and with the help of four short facts provided on a worksheet. The groups which finished their task very quickly or felt that they can't get on with the discussion received two additional explanations. The students discussed for 20 minutes. After 10 minutes, they got four additional facts and were asked to reconsider their choice as well as to talk about why they reasoned for or against the four explanations. Finally, they were expected to adapt their choice and their reasons, if necessary.

Afterwards, the students had 20 minutes to write about pro and cons of a chosen explanation. Previous research conducted in the same biology class allowed the interpretation, that these students might need a little bit of extrinsic motivation [7]. An attempt was made to motivate students to deepen their knowledge in the discussion and to use argumentation skills and knowledge to write the essay. It was also stressed that such tasks are relevant to their final exams.

Prior to the data collection, the students were asked for their consent and informed about in writing and verbally why and how data is collected, how anonymity and data security is ensured and that they can retract their consent any time. The audio-taped 20 minute long group discussions (n=8) were transcribed by the second author, who changed the names and did not transcribe personal information to ensure anonymity.

Together, the authors analysed the students' argumentations qualitatively by following the work of Riemeier and colleagues [5], which is based on Toulmins Argumentation Pattern [3; 4].

3. Results

In general, the students argue rather intuitively than considerately and rationally.

The argumentations are mostly shallow and consist of a few elements. Most argumentations consist of single claims, however, many students don't give any facts or data to justify their claims. When students connect a claim with data, mostly this data is of poor quality. For example, a student chooses explanation number two because it just makes sense to her but gives no reasons for her choice. Warrants appear occasionally with very few students.

The students spend a lot of time with clarifying the meaning of the given explanations and facts or read the texts too fast and not careful enough. However, most students don't understand the task, the explanations, and the facts properly. An ongoing discussion is rare, because students have difficulties in understanding the content or expressing their views verbally.

In general, most students seem to have misunderstandings, e.g. many students think the human body develops an antibiotic resistance instead of bacteria. Many appear to have a shallow understanding of the content. Some students show basic scientific knowledge, but can't connect it with the task. Also, most students don't delve into the given explanations and facts deeply enough. Only few students recognise argumentation errors or incorrect argumentations. The facts offered in a extra work sheet are only used by very few students as data for their argumentation, instead most students discuss the content of the facts and try to understand them.

In the discussions most students don't focus on the correctness and logic when examining the arguments presented by their group members, but on fairness, e.g. by acknowledging the arguments of a classmate. Almost never students justify a counterclaim.

Many students seem overwhelmed by the task and/or don't recognise the purpose of the task. Some even utter being bored or annoyed. In almost every group there is at least one student who just wants the discussion to come to an end no matter if a meaningful outcome is achieved or not. Few students state that this kind of task is a positive change in classroom routine or show signs of ambition and joy in problem solving. However, most students give up as soon as they experience difficulties in solving the task. Individual students show even signs of frustration when the teacher and the assisting pre-service teacher refuse to help them to solve the task.

4. Discussion

Poorly developed language skills, a lacking conceptual understanding of the content and de-motivating conditions in general may have influenced the quality of students' argumentation.

The fact that students' arguments consist of only a few elements and that students merely justify their arguments is consistent with other research findings [5; 8; 9; 10].

Language seems to be a major obstacle for most students in studying science [1].

However, students practiced argumentation in German lessons as well as in foreign language lessons in several grades. Perhaps, the content-specific knowledge and thus the causal relationship and the logic of arguments is less important in these subjects than in science classes. However, it is possible that the students do not realise that they shall transfer skills gained in other classes, even though the teacher emphasised the interdisciplinary importance of the task.

This research results as well as other research results suggest that it seems to be important to prepare students for argumentation in terms of language and content [6].

Students need to understand the content of tasks, assertions, facts, data and explanations in order to argue correctly and consistently and thus enter into a well-founded discourse. Possibly, the teacher didn't succeed in her attempt of promoting a conceptual understanding of antibiotic resistance, because the learning environment has not been crafted thoroughly enough. A few lessons might not be enough to help students understand biological phenomena as complex as antibiotic resistance and/or the argumentation training given by the teacher was too short. It is also possible, that the students were not interested in the reasons for antibiotic resistance, at least not to the extent that would have motivated them to make an effort. It might be that students did not consider it important to engage in an argumentative discourse because this is not common practice in science education [5] in Austria. The results raise the question if the prevailing school conditions, under which teachers and students may deal with socioscientific issues, support enhancing argumentation skills in biology lessons.

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Changes in Students' Nature of Science Conceptions upon a HOS and NOS-Enriched PBL Intervention

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Abstract

History of Science (HOS) can be used as a successful strategy to discuss Nature of Science (NOS) themes in Natural Sciences classes [1]. The present study focused on improving students' views about the Nature of Science upon a short time length Problem-Based Learning intervention about the origin of life, using History of Science relevant episodes. The NOS learning objectives of the intervention were limited to the role of imagination and creativity in scientific investigations, the changing and provisional characteristics of scientific knowledge, and the understanding that the following conceptions are inadequate: unlike theories, scientific laws do not change, and research in Biology around the world is carried out the same way, because Biology is universal and independent of society and culture. Participants were 8th grade students, 13 to 16 years old (Mean=13.26 and SD=0.79), at a Portuguese state-funded school (N=34). The educational intervention occurred during the academic year 2017/2018 and its outcomes were evaluated using a pre-/post-test questionnaire and structured observations. The null hypothesis that there are no significant differences on students' epistemological conceptions was statistically rejected considering the results of a Likert scale questionnaire ministered before and after the intervention. The non-parametric Wilcoxon Signed Ranks Test of significance revealed that pre- to post-intervention gains were significant for the targeted objectives supporting the effectiveness of the intervention improving students' NOS understandings. Such results are in accordance with other studies (e.g., [2]) showing that shorter interventions may influence students' NOS understanding. Results also suggest that HOS and NOS-enriched PBL instructional units such as the one in the present study constitute a useful and valuable pedagogical method for Middle School students' learning curriculum contents and aspects of NOS.

Keywords: Nature of Science, NOS conceptions questionnaire, Origin of life, History of Science

1. Introduction

The promotion of scientific literacy faces several obstacles today, namely, the lack of informed insight about what one classifies as Nature of Science ([3]; [4]).

Nature of Science (NOS) refers to the epistemology of science, science as a way of knowing or the values and beliefs inherent to scientific knowledge and its development [5].

In this study we considered NOS including also the aspects of scientific inquiry, according to [6].

The present study focused on improving students' conceptions of NOS, through an instructional intervention that takes an explicit and reflective approach to promote NOS as a cognitive outcome; a strategy described as more effective ([2], [3]) and an integrative approach in which NOS aspects are embedded within the Biology contents [3]. We consider that methods that enhance questioning, communication, argumentation and collaboration are adequate, and we have chosen Problem-Based Learning (PBL) was chosen since we hypothesized that students' analysis of the designed resources, including the problem situation, can induce the cognitive conflict between their prior conceptions and the more informed conceptions of NOS [7] and because PBL is also described as developing skills such as questioning, communication, argumentation, collaboration, decision making, problem solving, critical thinking and autonomous learning [8].

The understanding of NOS is referred as views of the Nature of Science by some authors [9] scientific epistemological views or scientific epistemological beliefs [10], conceptions of the Nature of Science [11] and understanding of science and scientific inquiry [12]. In our study we use the term NOS conceptions, in accordance to [11].

In the present, the most used NOS assessment tool about views of NOS are, probably, the Views of Nature of Science, VNOS questionnaire [9], and the Views About Scientific Inquiry, VASI questionnaire [13]. These questionnaires are constituted by open-ended questions. However, in this study, due to time constrains to complete the questionnaires and the limited knowledge of NOS and writing skills of the students we decided to use a questionnaire for assessment of students' NOS views with Likert scale items and no open-ended items. We constructed some items, based in literature about the theme and used other items that were suggested and tested before by other authors (Liang *et al*., 2006; Liu & Tsai, 2008; Tsai & Liu, 2005).

We chose to focus this study on some general NOS aspects (Kampourakis, 2016), using History of Science relevant episodes about the origin of life, that constitute the learning objectives of the intervention unit: the necessity of the human imagination and creativity in the development of scientific knowledge (Lederman, 2007), the tentative feature of scientific knowledge (Lederman, 2007), the relationship between law and theory (Lederman, 2007) and the use of different methods by scientists (Lederman & Lederman, 2012).

The following research question was addressed: what are the effects of the Origin of Life learning unit in students' NOS conceptions?

The following null hypothesis was considered: There are no significant differences on students' NOS conceptions, in a Likert scale questionnaire, before and after the Origin of Life learning unit.

2. Research Design

2.1 Outline of the intervention

The intervention consisted of 3 PBL sessions (50 min each). Students were provided with a problem-situation and a learning scaffold related to several theories about the origin of life enriched with an historical perspective, and with NOS aspects.

Considering that students have access to considerable amounts of information and the short length of time available for the PBL unit, selected information about each theory was provided. This intervention occurred during the academic year 2017/2018 and was previously authorized by the National General Direction of Education.

2.2 Participants and settings

Participants in this study (N=34) were 8^{th} grade students in two different classes of a Portuguese state-funded school (Oporto region, Portugal). Ages 13 to 16 years old (Mean = 13.26 and SD = 0.79), 18 females and 16 males willing to participate in the study after the corresponding informed consent signed by the parent/person responsible for education. The first author was responsible for the intervention and taught the intervention unit to all the students. The Natural Science teachers of the two classes, as voluntary participants, observed all the lessons.

2.3 Data Collection and Analysis

The impact of the intervention was assessed using a mixed-methods approach using a pre-/post-questionnaire (with items in a Likert scale) and qualitative analysis about the observation of the classes.

The NOS conceptions questionnaire is under development, in which some items were adapted from other authors ([11], [12], [14]] that were contacted and authorized their use while others were constructed based on literature about the theme (e.g., [16]).

Previously, a panel of 4 experts (educational scientists, faculty professors and a middle school teacher) validated the content of the questionnaire. The adequate time for students to complete it was assessed and provided, and an adjustment to the vocabulary was performed. The quantitative responses were analyzed, using the software Statistical Package for the Social Sciences (SPSS), the Wilcoxon Signed Ranks Test (Z and p are presented in Table 1), and the effect size (r) was calculated according to [17].

We also designed an observation instrument regarding PBL facilitation, with a 1 (never) to 5 (always) Likert scale. Some items were of our own authorship and some were based on instruments designed by other authors [18] and [19] that were contacted and authorized their use; one instrument was applied for participatory observation (including observation of each group of students) and another one was applied to the teachers who observed the classes.

3. Results

3.1 Testing the null hypothesis: There are no significant differences on the students' NOS conceptions, in a Likert scale questionnaire, before and after the Origin of Life learning unit

A comparison of students' responses from the pre- and post-test showed improvement of student's NOS understandings regarding some NOS aspects.

Students showed the most change (r = 0.41) in the item 2 - Scientists do not use their imagination and creativity because this is contrary to their logical reasoning (Table 1).

Table 1. Changes in students' epistemological conceptions of each NOS item, using the Wilcoxon signed ranks statistical test results (Z) and effect size (r) for items with statistical significance.

Items	Z	r
1 – Scientists do not use their imagination and creativity because they can interfere with objectivity [12].	-3.178**	0.39
2 – Scientists do not use their imagination and creativity because this is contrary to their logical reasoning [12].	-3.340**	0.41
3 – Scientists use their imagination and creativity to collect data[12].	-3.229**	0.39
4 – Scientists use their imagination and creativity to analyze and interpret data [12].	-2.110*	0.26
5 – Unlike theories, scientific laws do not change [12].	-2.003*	0.24
6 – Current scientific knowledge can be changed or totally rejected in the future [14].	-2.302*	0.28
7 – Scientists, at different times, can use different theories and methods to interpret the same natural phenomenon [10].	-0.559	-
8 – Science is a form of knowledge that provides evidence-based explanations.	-0.384	-
9 – Science is a way of looking for answers to questions about natural phenomena (adapted [16]).	-0.500	-
10 – Scientists use different methods to conduct scientific investigations [12].	-0.465	-
11 – Scientific research around the world is carried out in the same way, because science is universal and independent of society and culture [12].	-0.179	-

*Note: *Statistical significance at $p \leq 0.05$; **Statistical significance at $p \leq 0.001$*

The difference between pretest and posttest was significant for several items (items 1, 2, 3, 4, 5 and 6, in Table 1) and in the overall mean classification of the total questionnaire, including some NOS aspects not explicit addressed in this unit, ($Z = -2.099$, $p = 0.036$ and $r = 0.25$); hence, the null hypothesis is statistically rejected. However, no statistical significance was found in other items that we would expect to find (e.g., item 7).

3.2 Analyzing the promotion of adequate PBL environment

Positive results were shown from the observation instrument for PBL facilitation.

Responses 4 (frequently) or 5 (always) for the majority of groups of students and 2 (rarely) or 3 (sometimes) for 2 out of 13 groups (in the participatory observation instrument) and responses 3 to 5 (in the instrument observation instrument filled by the other two teachers) about teacher support including encouraging students to apply prior knowledge, student responsibility, student interaction and collaboration, quality of problem and of resources provided and promoting self-directed learning (such as formulating and answering their own questions). Therefore, this Origin of Life unit was an effective PBL unit.

4. Discussion

The NOS aspect that students struggled the most are the distinction between scientific laws and theories, according to authors [2], and in our study showed an improvement on the post-test after the intervention. The NOS aspect about the role of imagination and creativity in science, in which students showed a naive view, had a significant change after our intervention.

Our claim is that the intervention was useful for improving certain aspects of students' NOS understandings, however this intervention may not be effective for all types of students. This study has certain limitations, such as the small size of the sample that was a sample of convenience, and the choice of the school was based on its proximity and collaboration to the university. And also, due to the timing of the authorization of the study and the school schedule, the fact that the teachers of the classes of this study provided a previous non-PBL unit (3 sessions), about part of the contents of this intervention, and a previous NOS-enriched PBL unit (3 sessions) (Sousa & Chagas, in preparation), which may explain not finding statistical significance in items we would expect to find (e. g., item 7) and in the overall questionnaire.

Another potential limitation of the study is the short length of this intervention; however, previous studies have shown that shorter interventions have positive effects on NOS views ([2]; [20]). The short length of time of the intervention can be seen as strength, as it is a cost-effective method for increasing student achievement [20].

NOS aspects are not found in the curricular objectives of the Portuguese curriculum for middle school students, so our PBL unit was intentionally designed to align with current content standards defined for 8^{th} grade students - learning goal "to argue about some theories of the origin of life on Earth" [21] – that was achieved by using an ill-structured problem, which leads students to the contents required in the curriculum.

5. Conclusions and Future Work

The intervention unit used in the current study was designed to address the role of imagination and creativity in scientific investigations, the understandings about theories and scientific laws, understandings of the changing and provisional characteristics of scientific knowledge and role of culture and society in Biology. This exploratory study using this Origin of Life unit seems to be useful for improving these NOS understandings planned.

The current study also provides support for the ability of shorter interventions to influence students' NOS understanding from immediately before to after the unit.

Presently, the questionnaire used in this study is under development and this study may contribute with useful information to achieve its improvement.

Taken together, the results suggest that this HOS and NOS-enriched PBL unit is a useful and valuable pedagogical method for teaching the Middle School curriculum contents and aspects of NOS. Given the lack of guidance documents with concrete proposals for NOS inclusion, our research is also relevant from the applied point of view since it includes the production of innovative educational resources to facilitate the integration of aspects of NOS in the curriculum, through PBL. More research is needed to provide a comprehensive picture of the role of PBL in student learning outcomes.

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Does Paired Mentoring Work? A Study of the Effectiveness and Affective Value of Pairing Students Aged 16 with Undergraduate Students in England

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Abstract

Within England there is a growing aim to improve the lives of secondary school students who are defined as disadvantaged as well as supporting these students' attainment and improving their attitudes towards secondary school science. This project was designed to support disadvantaged students who were taking their compulsory public General Certificate of Secondary Education (GCSE) science examination in their final year of secondary education in England (Year 11 – aged 15 to 16) by pairing them with undergraduate mentors from a university. The study, set up as a randomized control trial, involved 86 disadvantaged students across four secondary schools with half being involved in the intervention and half in the control – drawing on an inter and intra school comparison. The mentoring lasted for 23 weeks with an intensive six-hour mentoring session just prior to their GCSE examinations. Data was collected from the Year 11 students' mock and actual GCSE examinations results as well as questionnaires from both Year 11 and undergraduates. The results found that mentored students did statistically better in terms of their attainment both in mock and actual GCSE examinations as well as a statistically greater improvement in their attitudes to science than un-mentored students. These findings demonstrate the impact and value of academically asymmetrical paired mentoring projects.

Keywords: Paired Mentoring; attitudes; summative assessment; secondary school

1. Introduction

In England there is a growing need to improve the lives of disadvantaged students where their secondary schools obtain additional funding to "to raise the attainment of disadvantaged pupils of all abilities and to close the gaps between them and their peers" [1]. In England, a student is classified as disadvantaged if they are:

Pupils in year groups reception to year 6 recorded as Ever 6 FSM [eligible for free school meals (FSM) in any of the previous 6 years]: Pupils in years 7 to 11 recorded as Ever 6 FSM: Looked-after children (LAC) defined in the Children Act 1989 as one who is in the care of, or provided with accommodation by, an English local authority: Children who have ceased to be looked after by a local authority in England and Wales because of adoption, a special guardianship order, a child arrangements order or a residence order [2].

There have been numerous government initiatives to widen participation and increase the number of students continuing onto science related courses at further and higher education level. This need is greater, however, with regards to Pupil Premium students in comparison to their wealthy peers with statistics showing that the formers are far less likely to obtain high marks in their GCSE results [3] whereas the latter are twice as likely to pursue higher education [4]. Additional funding has been given to schools in order "to raise the attainment of disadvantaged pupils and close the gap between them and their peers" [3]. There has not been any specific initiative to address that issue of raising disadvantaged students' attainment in GCSE exams aiming, at the same time, to improve their attitudes towards studying post compulsory science and pursuing a science career.

Over the last 40 years, educators have examined strategies to improve and benefit the learning environment for all students of all backgrounds – and especially those whose background is deemed as disadvantaged. These approaches aim to either improve academic performance or help students develop skills and positive attitudes.

Inherent in much of the literature available on these strategies is an acknowledgement of the multiplicity of the terms used which is indicative of the intended outcome (academic improvement or attitude development) and the relationship between the students and the person who acts as the helper. Whilst we recognize the variation in the terminology used in the literature we believe that the most appropriate term to describe the relationship between a more experienced individual and a less experience one is that of 'mentoring' which includes helping mentees prepare for and achieve academic advancement (which is actually the focus of peer-tutoring) whilst at the same time mentees can also benefit from the mentors' help in developing an awareness of resource availability (which is what the role of a sponsor is all about).

We generally use the term mentoring here to refer to all the one-on-one or small group teaching activities in which a more experienced individual tutors a less experienced or younger student.

1.2 Mentoring: Its role and benefits

The cognitive processes involved in such a mentoring relationship have been investigated by various authors over the years and many of them have emphasized the value of the verbal communication and questioning [5]. The mentoring relationship could be more fully understood through a social and cultural constructivist view of cognitive development [6]. In this sense, it could be seen as an exploration through social interaction with a more knowledgeable and experienced person within the mentee's zone of proximal development (ZPD). Vygotsky defined the ZPD as "[t] he distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" [7].

Although the ZPD was developed as a way of viewing what children are coming to know, Vygotsky also noted that students become able to solve problems beyond their actual development level if they are given support and guidance in the form of prompts or leading questions from someone more advanced. We suggest that this more advanced individual could be a mentor whose help and support could make students able to internalize the new information and become more able to perform independently in a next similar situation. The student accesses knowledge and expertise through the mentor, whose role is more that of a facilitator rather than that of a teacher [8]. This view of mentoring focuses on a communicative nature of learning in which advancement is achieved through one-on-one communication and negotiation between the mentor and the mentee. In comparison to other, more traditional approaches paired mentoring enables students to become more actively involved in the teaching by having greater ownership of the learning process with opportunities to respond, make errors and be corrected being high. In Tinto's words: "Students who are actively involved in learning, that is who spend more time on task especially with others, are more likely to learn, and in turn, more likely to stay." [9].

1.3 Rationale of the programme

Although there is evidence in the literature regarding the effectiveness of mentoring programmes, most of such initiatives implemented in the past were self-evaluated by the participants (mentors, mentees and programme coordinators) with corroborative data not being available in terms of their effectiveness in improving academic skills and educational prospects of students [10]. Similarly many of the studies on the effectiveness of mentoring and tutoring projects for disadvantaged students implemented in the past lack the breadth, depth and rigor of data that would permit conclusions to be drawn in comparison with other types of educational interventions [9].

2. Methodology

The study was set up as a randomised control trial and involved 86 Pupil Premium students. These were students from low-income families who are eligible for free school meals, or had been looked after for more than six months, or whose parent(s) are currently in the Armed Forces. Four school were recruited. The schools were similar in terms of the proportion of free school meals, GCSE 5A*-C measures and value-added performance to reduce the likelihood of any effect being attributable to factors other than mentoring.

Secondary school students were recruited from four different schools and were randomly assigned to either the experimental or control group with half in each group.

The secondary school students in the experimental group were mentored for one hour per week for 23 weeks up until their GCSE examinations with an additional intensive six hour mentoring session just prior to those examinations. Data were collected from the Year 11's target (predicted grades) and actual GCSE examination results as well as questionnaires from Year 11 on their attitudes towards science.

3. Results

Using the test for independent samples, it was found (see Figure 1) that students who were mentored achieved better in their GCSE examinations ($M=5.95$, $SE=.143$) than predicted and also outperformed those in the control group ($M=5.30$, $SE=.161$).

The difference was significant $t\,(78) = -2.67$, $p < 0.001$ and the difference, according to Cohen [11] guidance, represented a medium-sized effect ($r=.3$).

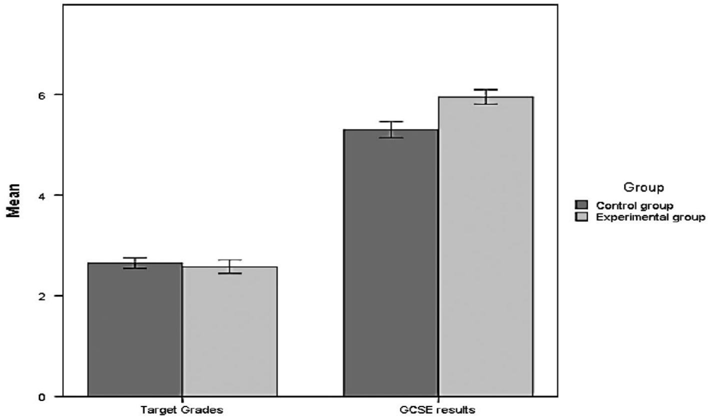

Fig. 1. Means of target/predicted and GCSE exam grades in science for both groups

The students who were mentored (experimental group) also showed a statistically significantly greater improvement in their attitudes towards science than un-mentored students. A dependent t-test was used to compare the two means of attitudes coming from the experimental group before and after students had been mentored. This approach was adopted to examine whether, except from any differences in students' achievement, there was any impact of the mentoring in terms of their attitudes towards science.

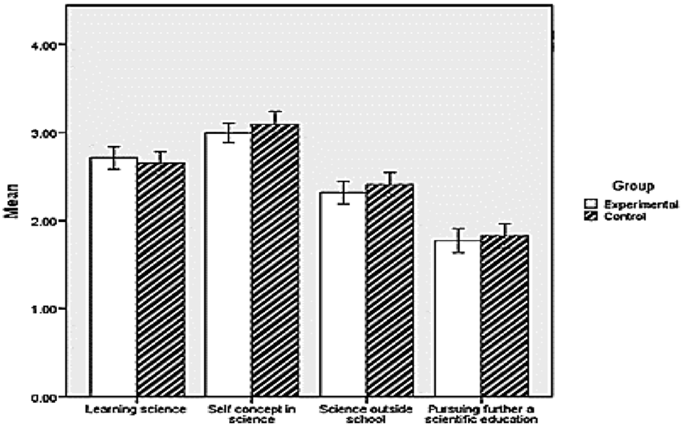

Fig. 2. Pre-intervention students' attitudes towards science from both groups

Figure 2 presents the results of the comparison between the control and experimental group before the intervention, while Figure 3 shows the pre and post intervention for mentored students' attitudes towards science. The results from the statistical analysis of the data are shown in Table 1.

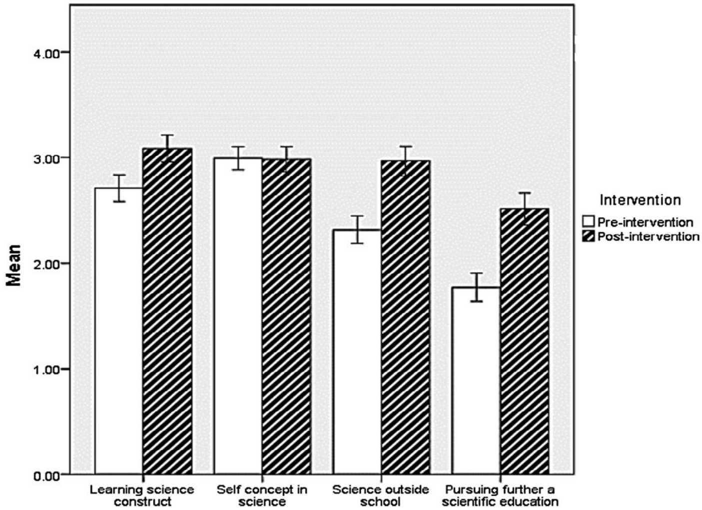

Fig. 3. Post-intervention mentored students' attitudes towards science

Attitude construct	Pre-and post-intervention	Means	Standard deviation	*t*-test	*p*-value
learning science	Pre	2.71	0.79	−2.25	0.031
	Post	3.09	0.78		
self-concept in science	Pre	2.99	0.69	0.07	0.946
	Post	2.98	0.73		
science outside school	Pre	2.31	0.80	−3.46	0.001
	Post	2.97	0.84		
Pursuing further a scientific education	Pre	1.77	0.84	−3.64	0.001
	Post	2.51	0.93		

note: a p value of less than 0.05 was considered statistically significant

Table 1: Means, standard deviation, *t* and *p*-value for the experimental group pre- and post-intervention.

4. Conclusion

In conclusion, the findings demonstrate the value of academically asymmetrical paired mentoring for disadvantaged students within secondary school science. The impact of the intervention was that in its entirety, statistically significant both in terms of increased academic attainment and in terms of attitudes towards science.

For school teachers and university lecturers, there is a potential exciting challenge of how to maintain and encourage such partnerships to benefit all students and not only those who are disadvantaged.

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Influence of Motivational, Attitudinal and Metacognitive Skills in the Academic Achievement of Freshman Science and Engineering Students

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Abstract

Research in science education has addressed as one of its main lines the proposal of several comprehensive models of the components of problem solving. These models coincide in distinguishing between the variables that relate to the structure of knowledge in memory and those that relate to the cognitive functions that operate on that knowledge, to prepare, control and monitor the execution of a solution in a new task. It also recognizes a third component related to the motivation, attitudes and beliefs of the subject that solves problems. The ability to solve problems in a particular domain results from the complex interaction of the knowledge structure, cognitive functions and beliefs about oneself and about the task. The differences observed during the process, from the interpretation of the problem to the persistence in trying to solve it, can be attributed to variations in aspects of these three cognitive constructs. The purpose of this research was to evaluate two affective variables, the achievement motivation, associated with the interest for academic success; and the attitude towards chemistry learning, associated with the conceptions about it; as well as a cognitive variable such as metacognition, necessary for the development of several of the scientist's own abilities, in freshman science and engineering students of a Peruvian university. The level of correlation between these variables and their influence on the academic achievement of the students was determined. The results obtained show the high degree of correlation between the selected variables, although only achievement motivation turned out to be a variable predictor of academic achievement.

Keywords: Achievement motivation, learning attitudes, metacognition, problem solving

1. Introduction

Undoubtedly, the development and strengthening of problem solving skills are the main objectives of Problem Based Learning (PBL). Therefore, it is necessary to review the dimensions that directly influence these skills. Several comprehensive models recognize as main dimensions the domain knowledge, the general strategies and the self-regulation and control skills. In addition, some models also recognize beliefs and affective variables as important dimension in the problem solver [1, 2].

Jonassen identifies external and internal factors that affect the problem solving process, the former are related to the nature of the problem (structuredness, complexity and abstractness) and the way in which it is represented to the learner.

The representation of the problem and the way it is perceived by the student depend on the context and the modality used in its design. The internal factors are related to the characteristics of the learner and imply, on the one hand, the previous knowledge, in particular the structural knowledge; the experience; reasoning skills and, the cognitive functions deployed for the planning and monitoring of problem solving process. The latter are strongly related to the development of metacognitive skills. Another component of internal factors is related to affective elements, such as attitudes and beliefs about problems, problem mastery and the learner's perception of his own problem solving skills. In this way, the motivational components, such as the engagement, both at the beginning and during the process; effort; persistence in the task and decision making will have a strong effect on problem solving achievements [3, 4].

he purpose of this research was to evaluate two affective variables, achievement motivation, associated with the interest for academic success; and the attitude towards the learning of chemistry, associated with the conceptions about it; as well as a cognitive variable such as metacognition, necessary for the development of several of the scientist's abilities, in freshman science and engineering students of a Peruvian university. The correlation level between these variables and their influence on the students' academic achievement were determined.

2. Methodology

2.1 Participants

The participants in this study were freshman science and engineering students from a Peruvian university, who were enrolled in a General Chemistry course. The study included only the students who answered the three instruments applied, therefore the number of participants was 38, the average age was 18 years and the range was between 16 and 20 years. 63.2% was male and 36.8% female.

2.2 Context of the study

The hybrid PBL model implemented involved the presentation of a PBL scenario at the beginning of each thematic unit (5 in total). Students, organized in groups of 4 members, must present their solution proposal at the end of the unit. Throughout the unit the groups developed collaborative learning activities with the teacher's mediation.

The evaluation of each unit considered 40% of the group work (PBL problem and learning activities) and 60% of individual assessment (problem solving). The final course grade considered two individual exams (problem solving), each weighed with 30%, the average of the evaluations of the thematic units, weighed with 20%, and the laboratory activities assessment weighed with 20%.

2.3 Instruments

Attributional Achievement Motivation Modified Scale (EAML-M) [5]. 30 semantic differential items valued on a gradient of 1 to 6 points. Highest scores in each item correspond to the most favorable sense of motivation for academic success. Total scale score reflects the level of achievement motivation in the learning context. The scale consists of six dimensions: interest and effort; interaction with teacher; task/ability; exam; collaborative interaction with peers; peer influence on learning skills.

The maximum score obtainable is 180 and the minimum is 30. Cronbach's alpha value is 0.9026.

Metacognitive Activities Inventory (MCAi) [6]. 27 items that use a five-level Likert scale with the purpose of exploring the use of the regulatory component of metacognition (planning, monitoring and evaluation) in the context of solving university chemistry problems. The MCAi score expresses the percentage of the maximum points that can be obtained in the inventory. Greater use of metacognitive strategies is associated with higher score values. Cronbach's alpha value is 0.85.

Colorado Learning Attitudes about Science Survey (CLASS) for use in Chemistry [7]. The original version consists of 50 items for which a Likert scale of five levels is available. A favorable score is considered as the percentage of responses that agree with the expert response, an unfavorable score is the percentage of responses that do not agree with the expert response. For the purposes of this study the instrument was adapted using only 36 items. In the pilot application four optimal dimensions were identified in terms of reliability and interpretability: personal interest (α: 0.633), conceptual learning and problem solving (α: 0.738), atomic molecular perspective of chemistry (α: 0,700), making sense and effort (α: 0,571) [8].

2.4 Procedure

The three instruments were administered during the last two weeks of class. The average time to answer each instrument is 30 minutes.

2.5 Analysis of data

The data were analyzed using Statistical Package for the Social Sciences (SPSS) 21 software®. Level alpha was established a priori in 0,05. A descriptive analysis of the instruments scores was performed. Correlation between the three variables was determined. Linear regression analysis was made, stepwise method. The dependent variable was academic achievement expressed as the final course grade. The possible predictor variables considered were MCAi, EAML-M and CLASS scores expressed as percentage.

3. Results

Table 1 shows descriptive statistics for total scores obtained in the three instruments used and the final course grade.

	M	SD
EAML-M score	65,512	11,513
MCAi score	69,830	9,024
CLASS score	49,268	23,567
Final course grade	60,000	7,352

Table 1. Descriptive statistics for EAML-M, MCAi, CLASS scores and final course grade (N=38)

Table 2 shows the Pearson correlation coefficients for the study variables total scores and the final course grade.

Variable	EAML-M	MCAi	CLASS	Final course grade
EAML-M	1			
MCAi	0,625**	1		
CLASS	0,414**	0,552**	1	
Final course grade	0,356*	0,039	0,058	1

** $p < 0,05$; ** $p < 0,01$*

Table 2. Correlation matrix of study variables and final course grade (N=38)

Significant positive correlation between the three study variables can be observed.

In particular, the relationship between motivation and metacognition has been widely discussed, recognizing its ambivalent nature. Metacognitive analysis of the activity itself can significantly influence the apprentice's motivational schemes. At the same time, achievement-oriented motivation is based on knowledge of one's own capacity, interest and effort invested in achieving a goal. Therefore, it can be expected that subjects with a high achievement motivation present a greater degree of metacognitive knowledge.

On the other hand, it is known that feelings and emotions have a direct influence on learning and behaviors. However, the affective aspect is complex since it implies a diversity of variables such as norms, values, opinions, beliefs, attitudes, etc. Attitudes imply a favorable or unfavorable predisposition towards the object of learning and, in this way; they could influence the motivational and metacognitive aspects of the process.

The results of the linear regression analysis indicated that the total score of EAML-M was a predictive variable for the final course grade, $F(1, 36)=5.211$, $p<0.05$. The R^2 value was 0.126, which indicates that 12.6% of the variance is explained by the total score of EAML-M. Table 3 shows the summary of the regression model applied following the stepwise method.

Variable	B	SD	b	t	p
Constant	45,124	6,614		6,823	< 0,001
EAML-M score	0,227	0,099	0,356	2,283	0,028

Table 3. Stepwise linear regression analysis summary in predicting final course grade

Linear regression analysis considering EAML-M total score as dependent variable and MCAi and CLASS as possible predictors showed that only the regulatory aspects of metacognition, evaluated by MCAi, were predictors of EAML-M total score, $F(1, 36)=23,127$, $p<0.001$. R^2 value was 0.391.

4. Conclusions

As indicated above, problem solving involves a series of complex and interrelated processes whose diversity and variability have a decisive influence on the learner achievements. In this study, the purpose was to analyze some of the most important aspects related to the student, that is, the internal factors associated with the problem solver.

The results show that, indeed, the influence of the variables studied on academic achievement is important, highlighting in a relevant way the achievement motivation.

It can be affirmed that motivation constitutes the triggering element of learning process, which allows the student to assume the challenge posed in the task and to be persistently engaged in the search for the solution. The influence of metacognitive activities on motivation has been proven with the results obtained. The aspect related to attitudes towards chemistry learning did not show a significant influence on academic achievement; however its relationship with motivational and metacognitive aspects was evident.

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Reconsidering Spontaneous Analogical Reasoning through the Knowledge in Pieces Mechanism

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Abstract

Much of the science education literature on analogical reasoning points to the benefits of analogies in helping students familiarize themselves with concepts, phenomena and situations they find abstract and difficult to understand. The conceptual benefits from such a use of analogies seem increasingly clear, as there is evidence from studies in which students were provided with an analogy, were taught how to use and, as a consequence, reached a better understanding of the concept, phenomenon, or situation they were unfamiliar with in the first place. This paper does not contradict the efficacy of such a use of analogies, but shifts attention to students' spontaneously self-generated analogies, as opposed to taught analogies where students do not generate the analogy but are asked to use and reason with. It discusses how the 'knowledge-in-pieces framework', according to which knowledge is viewed as a complex system composed of fundamental knowledge elements that are activated in response to a particular situation, can be used for viewing the relationship and interaction of students' knowledge with their spontaneous analogical reasoning. Data are drawn from small focus group discussions in which students of the same age group (9-10, 11-12, 12-13, 14-15, 16-17) were asked to explain predictions they made when presented with novel situations they had not seen before. The role of students' spontaneous analogical reasoning in these explanations is examined along with the knowledge they drew upon in order to make their predictions. The findings underscore the need to consider students' analogical reasoning and how their existing knowledge affects this reasoning which, in turn, impacts on their understanding of unfamiliar situations and phenomena.

Keywords: Spontaneous Analogies, Knowledge-in-Pieces, P-prims, Analogical Reasoning

1. Introduction

Analogical reasoning – the cognitive process of drawing similarities between domains, often between prior knowledge and novel situations considered for a very first time – has been suggested as a key process in human cognition [1] and an important factor in learning at all ages [2]. It is for these reasons that analogies, as tools for instruction, have been of interest to educators and philosophers ever since Aristotle, with extensive research in this area consistently suggesting that analogies can play a significant role in students' learning and facilitate the teaching of abstract concepts, like those involved in science education [3].

Reasoning on the basis of analogies allows students to draw relationships between domains (situations, objects, concepts, etc.) they are already familiar with and unfamiliar ones they have never experienced before. It enables students to extend their existing knowledge from the familiar domain (base) to the unfamiliar (target) even if the two domains differ in many respects, and draw, in this way, inferences, albeit potentially erroneous ones [4], from the former to the latter. For example, when young students are asked to think about how plants grow, some spontaneously extend their existing knowledge that they themselves need to eat food to grow erroneously to plants and, as such, generate the erroneous belief that plants take up their food with their roots – rather than understanding that plant make their food through photosynthesis [5].

Therefore, reasoning on the basis of spontaneously generated analogies can, in some situations, result in the generation of misconceptions, depending upon the appropriateness of the base analogy selected which, in turn, is influenced by the existing knowledge of the person – experts are more likely in this respect to recognise an appropriate base domain from which to draw an analogy than is a novice.

1.1 Prior research on analogical reasoning

Analogies and analogical reasoning have been studied using a wide variety of research methods and from a wide range of perspectives. Much of this research has examined the effectiveness of an analogy in terms of the degree to which students can transfer knowledge from a base domain they are provided with to a specific target domain and whether the similarities drawn from the one to the other lead to a scientifically correct inference to be drawn [6], [7]. Although the efficacy of such use of 'teacher provided' analogies finds support from that research, this paper considers the use of students' spontaneously, self-generated, analogies. The paper attends specifically to the interaction of students' prior knowledge with the analogical reasoning process through the Knowledge in Pieces (KiP) mechanism, where the term mechanism here is used to refer to the way a person reasons about and explains phenomena [8].

The following section presents a brief description of the KiP mechanism which is then used to interpret two students' analogical reasoning in a novel situation (situations they have not considered before being asked to make predictions about).

1.2 Knowledge in Pieces Mechanism

The KiP mechanism is based upon a Piagetian [9] constructivist tradition in which reasoning is perceived as a process of interpreting phenomena through existing knowledge. From a KiP mechanism, a person possesses a fragmented collection of independent, disconnected, knowledge elements named phenomenological primitives, or p-prims for short. P-prims are phenomenological in the sense that they are minimal abstractions, derived from experiences and closely tied to familiar phenomena, and are primitive in the dual senses of not needing further explanation and being evoked as a whole [8]. It is through p-prims that a person is enabled to explain and predict situations observed in the real world in a way that is consistent with the everyday lived experiences that these p-prims were abstracted from. In this reasoning process of explaining and predicting events, p-prims are activated only when the configuration of the contextual features of the situations under consideration fits the circumstances in which these p-prims originated [10].

2. Methodology

The paper builds on previous research [11] in which a total number of 166 students, from five different age groups (9-10, 11-12, 12-13, 14-15, 16-17), were provided with six novel situations. In these novel situations students were asked to make a prediction about the outcome of a future event (effectively what would happen in the event depicted in the novel situation) and then write or discuss, during focus groups, what led them to their predictions. The novel questions were all presented in a pictorial form so as to be accessible across this wide age range and also to avoid providing any kind of lead in terms of the selection of one particular option from those listed in the accompanying multiple-choice question.

3. Results

The analysis of students' responses in the questionnaire and the transcribed focus group discussions showed that their spontaneously generated analogical reasoning pervaded their thinking in making their predications and affected their understanding of the novel situations. Consider, for example, the responses given by a 12- and a 15-year-old student respectively in the weight and gravity novel situation (Figure 1) set out to probe students' understanding of the concept of gravity in conjunction with falling and weight.

I have answered B. It is the one under the box with the elephant [bulb A] that has to switch on first because it has greater mass than the other. If you cut the ropes then both boxes will fall and the one with the greater mass will fall down first. This is like holding a stone and a small marble in your hands and if you let them go, the stone will go faster. It always go faster because the weight is greater.

In my opinion bulb A will switch on first, because the left box has greater mass than the right and therefore it should fall down first. I think that this is like the example in which we let a dumbbell and a ball from a roof to fall. Once let, the dumbbell hits the ground first.

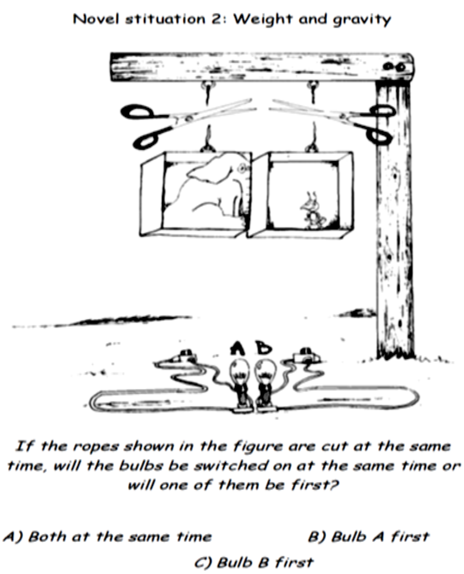

Fig. 1. Weight and gravity novel situation

From the KiP mechanism, p-prims are activated either alone or in combination with the analogies. In the above example when students see that the rope is cut the first p-prim that was found to be frequently activated was the 'supporting p-prim', according to which objects need to be supported in order not to 'fall downwards' [9]. Once this p-prim is activated, and students think of this situation as being analogous to their everyday observations of objects falling towards the ground, the next p-prim that was often observed, from their discussions, to be activated was the 'Ohm's p-prim' [9], according to which the stronger the agency the greater the effect. In this example the agency is the weight of the two objects, and by seeing this situation as analogous to one where two objects of different mass are set to fall downwards, the activation of the Ohm's p-prim leads students to the inference that the heavier object, in this case the box with the elephant, falls to the ground first.

4. Discussion

The results showed that students' analogical reasoning was dependant on the p-prims evoked by the novel situations (target domain). Once activated, the role of the p-prims was to provide a basis for the student to make comparisons between the base and the target domain [12] while the role of analogies was to drive the application of inferences from the one to the other. Many of the analogies students spontaneously self-generated were very similar and, in some cases, identical with those suggested [8] to be the sources of p-prims in the KiP mechanism.

The findings underscore the need to consider students' analogical reasoning and how their existing knowledge affects this reasoning which, in turn, impacts on their understanding of novel situations and phenomena and can often lead them to misconceptions. This could help in further examining the role of the knowledge students bring with them to learning events, in and outside the science classroom, and how this knowledge is likely to affect their ongoing reasoning which, as the study showed, is often influenced by their use of spontaneous, self-generated, analogies.

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Secondary School Students' Evaluation of Vaccination

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Abstract

In Austria, science teaching aims at encouraging students to develop decision-making competence and moral judgment by addressing socioscientific issues. This work considers how Austrian secondary school students evaluate ethical aspects of vaccinations. In biology lessons and a talk given by a medical scientist, students were confronted with the biological basics of vaccination, advantages for both the individual and society and the risk-benefit balance of vaccination. The students (n=17; aged 16-17) participated in semi-structured interviews, which mainly addressed their attitudes towards vaccination, responsibility to society and compulsory vaccinations. The interviews were audio taped, transcribed and qualitatively analysed. Most students showed an indifferent attitude towards vaccination. Students were mostly concerned with protecting the health of individuals and hardly with public health protection. Most students valued freedom of choice and thus rejected compulsory vaccination. They hardly addressed ethical or moral aspects of the issues discussed in the interviews. In general, students ignored recent lessons learned and argued rather intuitively and emotionally than rationally. Critically evaluating normative positions, e.g. compulsory vaccination, implies considering relevant knowledge as well as multiple points of view and balancing them. Most students seemed to experience difficulties in doing this. Perhaps they did not associate vaccinations with their personal life, socio-political responsibility or ethical considerations and/or felt that vaccination is not an issue that provokes discussion.

Keywords: moral judgment, decision-making, socioscientific issues, bioethics

1. Introduction

Scientific findings are essential for solving societal challenges, however, they can raise bioethical questions.

Vaccinations serve both to protect the individual and to protect the population.

Vaccinations protect the individuals' health by reducing their risk of contamination enormously. This is especially true for viral diseases because there is hardly any other specific treatment. In addition, adequate vaccination coverage can provide collective protection. The so-called herd immunity arises when enough people are vaccinated.

As a result, a pathogen can hardly circulate within the population. Herd immunity protects unvaccinated people, e.g. children with immune deficiency, and can prevent an epidemic spread of disease or even completely eradicate a disease. [2]

Individual vaccination behaviour may have a strong impact on the health of others.

Thus vaccinations constitute a public health goal. Herd immunity is a public good as it benefits all members of society. [3]

In Austria and other European countries, the vaccination coverage, especially against measles, was very high. It is currently declining and vaccination hesitancy is spreading [1].

There is no compulsory vaccination in Austria, however, the Ministry of Labour, Social Affairs, Health and Consumer Protection makes recommendations via the annual Austrian Vaccination Plan. Since 1998 there is a free child vaccination program in Austria. This includes important immunizations and booster vaccinations for children up to the age of 15 years. [2]

If we want people to analyse the issue of vaccination profoundly, to make informed decisions and to include its ethical significance in their decision-making process, they need to understand scientific basics as well as they need to practice ethical evaluation or moral judgment. These demands are included in the Austrian educational standards for secondary schools. In Austria, science education aims at encouraging students to develop decision-making skills and moral judgment by addressing socioscientific issues. Realistic, challenging and debatable socioscientific issues produce a social or moral dilemma and require scientific knowledge as well as ethical evaluation or moral judgment [4]. German science education literature [5; 6; 7] describes moral judgment via seven dimensions:

- Awareness of one’s own personal attitude,
- Awareness of the moral relevance of a situation,
- Assessment,
- Reflection of consequences,
- Change of perspective,
- Argumentation,
- Ethical knowledge [7, translation by: 8, pp. 179-180].

This work considers the research question: How do secondary school students age 16-17 years evaluate the bioethical issue of vaccination?

2. Research design

In spring 2018, qualitative data were collected through semi-structured interviews with students who visited a grade 10 biology class of a secondary school in Tyrol/ Austria. Because the first author of this paper was their biology teacher, a special focus was put on research ethics. The students were asked for their consent and informed about in writing and verbally why and how data is collected, how anonymity and data security is ensured and that they can retract their consent any time. A pre-service biology teacher (second author) who wrote her master thesis at the University of Innsbruck interviewed the students to ensure the anonymity of the transcripts.

In the first step, students were introduced to the scientific content necessary to understand vaccination and its meaning for society. In biology lessons (four times 50 minutes), students studied the immune system, the functioning of vaccines, herd immunity and the responsibility for the individual and society. In addition, the school doctor invited a medical scientist and vaccination expert to talk to all 10th graders attending the school. In his one-hour talk, the scientist emphasised the importance of vaccinations and their ethical significance. He talked about the functioning of vaccines, advantages for the individual and society, prejudice and arguments of those opposed to vaccines, safety of vaccines, the risk-benefit balance and possible long-term consequences of a measles infection. The scientist concluded that he is not in favour of compulsory vaccination enforced by law as he believes in the emancipation of citizens through education.

In the next step, students (n=17; aged 16-17) participated in semi-structured interviews, which mainly addressed the issues responsibility to society and compulsory vaccinations. These issues were discussed in local media because neighbouring Italy introduced certain mandatory vaccinations [1]. The interviews were audio taped, transcribed and qualitatively analysed [9]. The aim was to find out how 10th graders evaluate the subject of vaccination ethically and which aspects of moral judgment according to the literature [7; 8] are reflected in their statements. Together authors read and discussed the transcripts and arranged the students' statements in order to create a system by using codes, which have been deduced from the literature [7; 8].

3. Results

Most students show an indifferent attitude towards vaccination. For these students vaccinations seem to be normal practice, about which they do not worry much. Individual students strongly commit to vaccinations. Some students expressed concerns about side effects of vaccines.

Many students seem to have an egocentric perspective during interviews. These statements are concerned with vaccinations as an important source for individual health protection rather than a source for public health protection.

In general, students ignored scientific knowledge, which they compiled in class previously and argued rather intuitively and emotionally than considerally and rationally. Thus, they hardly justify their arguments and statements.

Most students address examples used during class activities and mention for example measles and chickenpox. However, hardly any students show the ability to transfer this knowledge to any other context when discussing aspects of vaccination.

For example, many students remember herd immunity only in the context of chickenpox, whereas few students explicitly address herd immunity in other contexts. Many students recognise the social relevance of vaccinations in terms of herd immunity implicitly. However, they rarely address it spontanoulsy.

When discussing ethical aspects of vaccinations, e.g., compulsory vaccination, most students express their opinion, however, it does not become apparent whether they reflect on their own opinion or position. For example, they do not explain how they arrived at this view. Only two students utter where their standpoint comes from.

Most students recognise the dilemma to restrict freedom of choice of individuals for public interests. Austrian society provides parents with free vaccines for their children in order to protect people who can't be vaccinated and for public health protection. However, forcing parents to intervene in the body of their children against their will can be questioned morally. Even though most students see the advantages of vaccinations, they value freedom of choice so much that they reject compulsory vaccination. Besides, students hardly address ethical standards or moral norms. For example, they didn't question that society has a responsibility towards children of parents who are opponents of vaccinations as well.

Only few students show the ability to reflect on consequences and to change their perspective. For example, when confronted with the ethical dimensions of vaccinations, many students remember that the medical scientist told the story of a local boy, who got infected with measles in a paediatrician's waiting room as a baby, suffered from severe complications and passed away. Those students blamed the parents of the child who passed on the measles for not vaccinating their child. It appears to be difficult for the students to change their perspective and think about those parents as people, who probably want the best for their children by setting different priorities.

4. Discussion

All participating students visit either the ethics class or the catholic religion class.

Presumably, students have practiced moral judgment in these classes, however, they probably don't realise to transfer skills gained in these classes and use them in a biological context. Perhaps students don't associate vaccinations with their personal life, socio-political responsibility or ethical considerations and, thus, feel that vaccination is not an issue that provokes discussion.

Critically evaluating normative positions, e.g., compulsory vaccination, implies considering relevant knowledge as well as multiple points of view and balancing them [10]. Most participating students seem to have trouble in connecting knowledge, anticipating consequences, showing empathy and changing their perspective. We argue that teachers need to react to these difficulties by helping their students to reflect on their decision-making process. In order to be able to do that, students need a profound body of knowledge. Teachers are facing the challenge of supporting their students to gain knowledge and practice evaluation and moral judgment in very little time. Besides, teachers need to reflect on how they present their own position in the classroom. A student who feels sceptical towards vaccinations might be afraid to ask controversial questions or take a standpoint against vaccinations. Indeed, some students expressed concerns about side effects of vaccines in the interviews but not in the classroom.

Teachers need to identify difficulties students face. They themselves need support in developing diagnostic as well as feedback skills.

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Situation and Structural Framework of Competence: Action Logic, Curriculum Logic, Logic of Education

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Abstract

This article analyzes the issue of "competences" from different perspectives: conceptual clarifications, situational and structural approaches, methodological and action. Emphasis establish the connections between different categories and types of competencies, but also on identifying mechanisms for designing competences specific to school subjects. The innovative approach of the proposed approaches is related to the three-dimensional conceptualization of competence (action logic, curricular logic, learning logic on the one hand, and two-dimensional logic of the priorities of the types of activities in relation to the personality development directions and/ personality development with types of activities within a domain of knowledge). Situations are the "source and criterion" of skills. A competence is the result of interaction between person-action-situation. The approaching of competence from the situational perspective also includes curricular logic (competence as the finality and form of manifestation) and is a curricular tool designed to provide the learning process (learning logic). At the same time, for all fields of activity a competence is the condition and indicator of performance and efficiency. Competences are therefore a transferable and multifunctional package of knowledge, skills, abilities, values and attitudes that allow the person to achieve his / her fulfillment and professional development, social inclusion and professional involving in the field.

Keywords: competence, teleological, key skills, transversal skills, specific skills, unit skills, activities, preprocurement, knowledge, skills, attitudes, taxonomy of skills

The competence issue remains the most current and controversial topic today.

In fact, all debates in this regard focus on the dimension of the transition from knowledge to action, from "know" to "know how to do", "know how to be".

Approaches focus on skills have origins in the professional and linguistic fields. In the first case – in response to the rational organization of work and ensuring its high profitability.

It is necessary to mention the existence of several disputable issues on the "competences" dimension: defining competence; structure of competence; operationalization of competence; gradual manifestation of competence; projection skills; training and assessment skills etc.

Competence: conceptual clarifications

Defining the concept of competence is a difficult task, and in the view of some authors it is impossible, because it is a “vague concept”. As a rule, the definitions of competency concept contain varied dimensions/substances and may have different theoretical positions depending on the context, the field of knowledge, the point of view of the competence conceiver.

Therefore, in this way the skills are transferable and multifunctional package of knowledge, skills, abilities, values and attitudes that enable the individual way to achieve the fulfillment and professional development, social inclusion and employment in the field.

This definition is coherent with the basic characteristics of competence formulated by J. Henry and V. Cormier [7]:

- is a complex – integrated knowledge, strategies, abilities, attitudes into a complex process of manifestations;
- is relative – although it is a finality of education, competence never gets a final formula, and it develops continuously throughout life;
- is potential – unlike a performance that competence can be designed and evaluated, the possibility of mobilizing it generating different performances in the future in different contexts of independent learning;

C. Delory proposed the following definition: “Competence is an integrated set of skills, habits and attitudes that allow the subject, in the face of a category of situations, to adapt, to solve problems and make projects.” “According to Guy le Boterf, competence does not consist of resources (knowledge, capacities ...) to mobilize, but in the mobilization of these resources itself. Competence is to know how to mobilize yourself (savoir-mobiliser).”

In Gillet’s view, a competence is “a system of conceptual and procedural knowledge, organized into operator schemes, which allow, within a family of situations, to identify a task-problem and solve it by effective action”.

Competence = (capacities × content) × situations = specific objective × situations. Learning is “at the same time a divergent process, at the level of capacities, and convergent at the level of competencies” [6, p. 71].

Linda Allal proposed a network of components (dimensions) that interfere in a competence: cognitive, affective, social and sensory-motor [10].

<table>
<tr><th>Components of a Competence</th></tr>
<tr><td>Cognitive Components:
• Knowledge
- Statements – rules, facts, laws, principles (knowledge);
- Procedures (good sense – savoir-faire);
- Conditional (contextual), which allows the subject to choose at a certain moment a certain strategy, a certain approach, to engage in a certain action (M.A. Broyon, 2001). This knowledge is responsible for the transfer of learning (Tardif, 1992).
• Meta-knowledge and Metacognitive and regulation.</td></tr>
<tr><td>Affective Components: attitudes, motivations ... Social Components: interactions, concerts ...</td></tr>
<tr><td>Sensor-motor components: Gestural Coordination ...</td></tr>
</table>

Table 1. Dimensions of competence

Situational and structural approach of competence

The situational approach to the concept of competence focuses on the triple logic; the action in the situation, the curricular logic and the logic of learning [13].

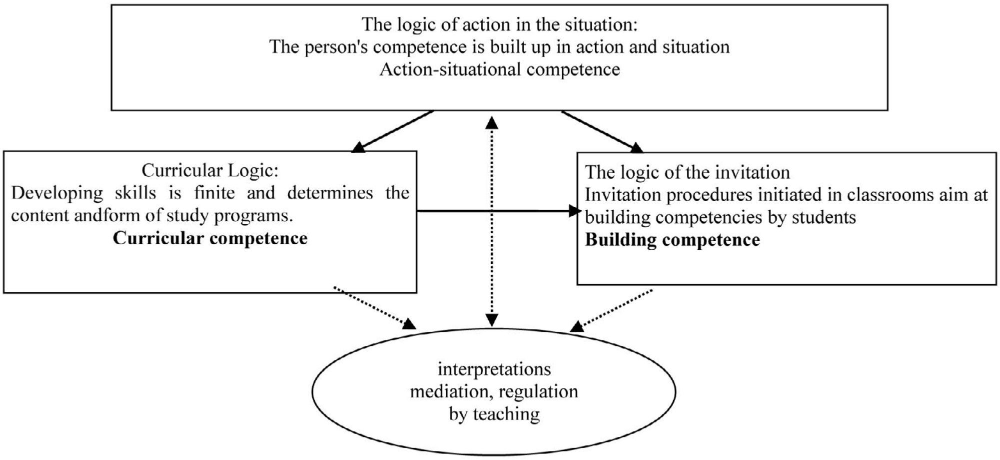

Fig. 1. The concept of competence in a triple logic

In other words, this process is organized around four frameworks: a situational framework, a framework of actions, a resource framework, and a framework for evaluation [13].

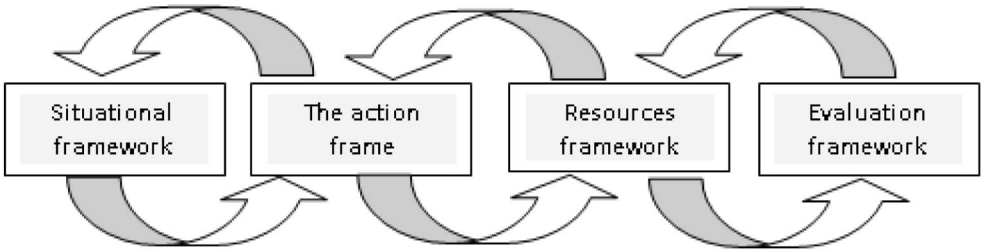

Fig. 2. Interdependence between the four frameworks: situational, action, resource, evaluation

This approach in the situation must lead to the formation of a competent person.

The competent action is based on several elements: understanding the situation; perceiving the goals of their own actions; has as effect of treating the situation; the possibility of using a plurality of resources, to adapt them and to build new resources etc. [8].

A similar approach to the competence structure is taken up in PISA documents.

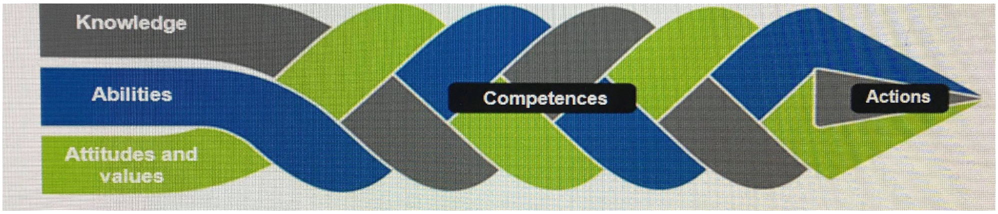

Fig. 3. Dynamics Competence Structure (PISA)

The advantages of this approach are: 1. Action – is the key element of competence. 2. Achieving the knowledge, skills, attitudes in dynamics and phases. 3. Correlation of global competences with disciplinary ones. 4. Focus on local, global and intercultural issues.

At the same time, it is important to establish the «place» of competence units (pre-requisites) in the competence structure (dynamics of competence formation).

The pre-acquisition of specific competences on university disciplines are defining in the disciplinary curriculum. It is worth to mention that there is a wide variety of connections/interconnections between different categories and types of competencies that provide a systemic approach to them.

Methodological aspects of the design of competences specific to university subjects

Designing the competences specific to the university discipline is a complex, difficult, creative and responsible procedure. Concepts of the competence system (or curriculum designers) will be able to use the following algorithm of actions and steps:

A. For general competences specific to university subject: identifying one or another skill taxonomy as a tool for designing them; identify the structure of competences: verb, in active form, domain/subject, level/modality/norm, context/outcome; establishing the formative valences of the given discipline, the action/typology of specific actions, for example: “Romanian Language as a Foreign Language” discipline has the vocabulary of listening, reading, writing, communication, and discipline “Anatomy” forming the perception of medical terms, skills training.

This concept can be presented graphically through the matrix, for example: based on the discipline “Romanian Language as a Foreign Language”.

	Hearing	**Reading**	**Speech**	**Writing**
Knowledgeandunderstanding	↓ →	↓ →	↓ →	↓ →
Applicationandoperation	↓ →	↓ →	↓ →	↓ →
Integrationand transfer	↓ →	↓ →	↓ →	↓ →

Table 4.Taxonomic framework for the design of competences specific to the academic discipline (variant 1)

	Knowledge/ understanding	Application/ operation	Integration/transfer
Hearing	↓ →	↓ →	↓ →
Reading	↓ →	↓ →	↓ →
Writing	↓ →	↓ →	↓ →
Speech	↓ →	↓ →	↓ →

Table 5 The taxonomic framework of designing the competences specific to the academic discipline (variant 2)

It should be noted that both approaches lead to the same goal – the achievement of an action/activity, but in different ways.

B. For competencies/units of competence specific to the discipline

As general competences for study subjects, designing the units of competence is a complex and difficult procedure. It should be noted that competence units could also be seen as ways of contributing to the (direct or indirect) formation of transversal competences. Their correct formulation must be consistent with the competencies and specific units of competence to the discipline given. Namely, by achieving operational objectives within a lesson, students assimilate initial pre-acquisition, constitutive competencies.

Some results of assessing the interconnection between different categories of competences in curricula at university subjects

The curriculum of the Romanian Language includes in its structure the following specific competencies:

1. *Competence* to use basic knowledge from the field of anatomy (medical terminology) in various communication situations regarding the development of the ability to receive the written and spoken word in Romanian
2. *Competence* and ability to form knowledge and skills designed in terms of functional insertion in the professional field;
3. *Competence* to apply linguistic means and a specialized lexicon.
4. *The ability* to express coherently in a simple manner to describe experiences, events, goals;

In this context, all specific competences derive from basic competencies in medical (medical), and each specific competence derives, in part, from other transversal/key competencies. Thus, the first specific competence also derives from communication skills in Romanian as a foreign language for international students, the second specific competence – from the competences to learn to learn, the third – the communication skills in Romanian as a foreign language and tangential from digital competences, fourth – from action-strategic competences and the fifth – from action-strategic competences and entrepreneurial skills (Figure 5).

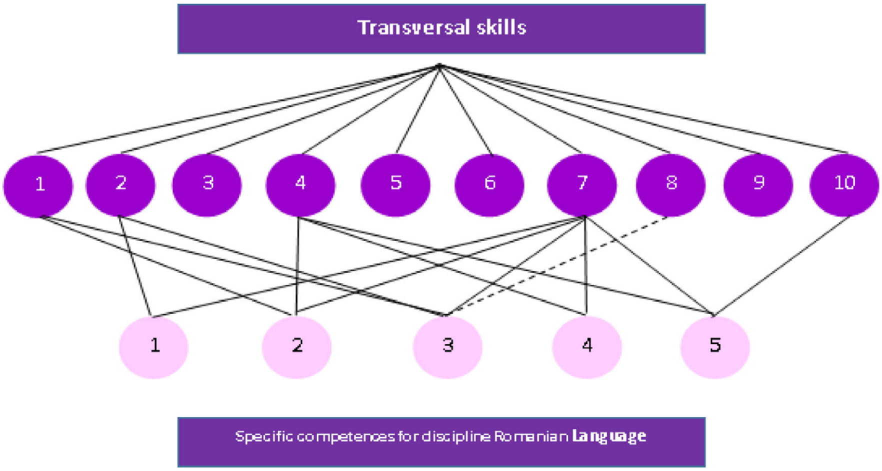

Fig. 5. The correlation scheme "Cross-cutting skills-specific competences" at the Romanian Language discipline

This correlation reflects a certain gradual correlation between transversal/key competences and specific competencies, which highlights the share of Romanian language contribution in the formation of certain transversal/key competences, namely:

- Basic skills in Anatomy, Histology. **3** points high
- Skills to learn/learn to learn. **2** points, average grade
- Communication skills in Romanian/State language **2** points, average grade
- Action-strategic competencies. **2** points, average grade
- Entrepreneurial skills. **1** point, low grade

The competences specific to the Romanian language as a foreign language are taxonomically designed as follows:

- Specific competence no.1 → category of competences-knowledge and understanding.
- Specific competence no.3 → competence category-application and operation.
- Specific competences no. 2, 4 and 5 → competency category-integration and transfer.

No. crt.	Taxonomic level of competence units (expressed by verb)	Number of records per module (eg, "Digestive System" module)	Number of records on all modules (7 modules)	Correlation with specific competencies (No. of specific competence)
	Defining		1	1
	Identification		6	1
	Determination		3	1
	Description		1	1
	Recognition		3	1, 2
	Comparation	1	1	3
	Interpretation	1	2	1
	Differentiation		1	1
	Application		1	3

	Establishing relationships		1	1, 2
	Analysis	1	4	1, 2
	Argumentation	1	5	1,5
	Proposal		1	5

Table 6. Correlation: Specific Competences – Competence Units in Romanian Language

Correlation of assessment the analysis data: Specific competencies - competence units demonstrate that there is a correlation between specific competences and competence units.

Conclusions

Focusing on competencies is asserting by the need to develop complex student skills that allow them to adapt better the social and cultural changing of environments. Competence means to act by mobilizing and effectively using a set of resources that the individual has at one time and in a given context. Addressing the concept of competence in this article does not claim to be exhaustive. At the same time, it attempted to re-conceptualize and argue a situational approach to competences from the perspective of the logic of action in concrete situations from the perspective of curricular logic and from the perspective of learning logic. In this context, a taxonomic design of the competency system was proposed, focusing on the degree of interconnection between different categories and types of competences, but also on the progressive framework for their development.

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Training of Science Teachers

Inter-University Project on Collaborative Physics Workshops: An Ibero-American Experience

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Abstract

One of the essential aspects in the initial training of science teachers is to deal with the design and planning of experimental inquiry-based activities. In addition, the participation and communication in networks that help solve derived professional problems – aspects included in the digital teaching competence – is also fundamental. This paper presents an investigation with the participation of future teachers from Spain and Peru, in the context of the Primary and Secondary Education degrees, respectively. The purpose was to develop school workshops about physics, based on sequences of inquiry-based activities. The sample consisted of two class-groups of students engaged in subjects that include physics education. The work groups designed and published experimental activities for the corresponding workshops, including videos to facilitate their resolution. Then, after an initial session of videoconference, future teachers went on to solve and analyze the proposals of their partners from the other country. Throughout the process, the participants exchanged their reflections through forums and documents in a collaborative platform. Later, in another videoconference session, they had the opportunity to communicate their critical analysis to the work groups of the other nationality. Finally, they completed an online Likert questionnaire (1-5), on the contribution of the project to their professional skills and technical and personal contributions in this process. The results indicate great satisfaction from future teachers, especially accused in aspects such as: self-reflection on the designed workshops (69% of «5» scores), interaction with other future teachers (66%) or the perception of variety of materials to design inquiry-based activities (72%).

Keywords: Preservice teacher training; Physics workshops; International projects; Scientific competence; Digital competence

1. Introduction

Nowadays, teacher training programs for any educational level are based on the promotion of professional competencies. Among them, it is necessary that future primary and secondary school teachers modify their teaching approaches, from the traditional ones focused on the teacher to other alternatives focused on student learning.

International institutions have highlighted the benefits of the «inductive approach» to promote students' interest in their learning and improve the quality of educational processes [1, 2]. These methods, which include Inquiry-Based Science Education

(IBSE), emphasize the construction of knowledge by students and the teachers' role of guiding, through an adequate «scaffolding». In this sense, the initial training of teachers must ensure their acquisition of skills to implement these methodologies and contribute to the desirable educational change. To that end, it is necessary to work on aspects such as sequencing and contextualizing the activities, or choosing appropriate laboratory materials, skills which are included in the idea of scientific competence [3].

Another training component would be linked to technological competence – fundamental in an interconnected world like ours –, which can be developed through collaboration in national or international projects, framed in initiatives such as eTwinning or Scientix [4].

The ultimate intention is that future primary and secondary school teachers have the opportunity to learn in a self-reflective way those knowledge, skills and attitudes that they will have to implement in their professional development [5]. Due to its relevance in the school classrooms, the design of «science workshops» – an approach encompassed in the IBSE model – would constitute one of the contents to be developed in the training programs.

2. Purpose

The purpose of the general inter-university project – focused on the initial teacher training – is "the design and analysis of school workshops on light and color and electrical circuits, based on programs of inquiry-based activities".

In this study, the research objective is to analyze the contribution of the didactic proposal to the professional skills of future teachers, and the technical and personal contributions during the development of the different stages and activities.

3. Theoretical framework

Science workshops make up a methodological resource that in this case is directed towards physics and its teaching. In general, workshops assume the implications of constructivist methodologies, centered on students and on the combination of theory and practice –i n many cases, experimental –. In this sense, they can be understood as a methodology of structured inquiry [6], where the topic is given and a sequence of questions is provided to guide and orient knowledge construction. For their development, polyvalent or flexible spaces, variety of materials and, what is more relevant, methodological changes are required [7]. From a logistical point of view, workshops require a set of class sessions for students to solve different activities in cooperative groups. During their implementation, it is important to promote the autonomy and self-reflection of students, through a scaffolding properly planned by the teacher. In this way, science workshops represent a methodology that promotes the students' interest towards science learning [2].

4. Methodology

Due to the characteristics of the study presented here, once the participants have been identified, a distinction will be made between the stages of the academic proposal and the project assessment by future teachers. The latter will be carried out in terms of the impact on their professional skills and in relation to technical and personal contributions in the development of the project.

4.1 Participants

The project has been implemented with two class-groups of Spanish and Peruvian future teachers who are enrolled in Primary and Secondary Education degrees, respectively. There are a total of 8 future teachers from Spain (average age 20.75, 6 female and 2 male, 2 work groups) and 21 from Peru (average age 20.57, 9 female and 12 male, 4 work groups).

4.2 Stages of the learning proposal

The project has been developed in different stages, which are represented in Fig. 1. The general idea is that, in addition to designing their own physics workshops – and face the associated challenges – the groups of future teachers can compare and assess the pros and cons of different workshop approaches for the same topic (electrical circuits or light and color). To this end, an exchange of workshops among the countries is promoted, as well as their resolution and feedback between peers, through forums on the platform – Schoology – and a final videoconference session. In this way, it is intended to provoke in-depth reflection on the design of the experimental workshops, while promoting digital competence (video editing, publication of materials, etc.) and communication skills of future teachers.

4.3 Analysis of the project assessment

The results we present here derive from an online questionnaire filled by the participants. It consists of 18 closed questions (Likert scale 1-5) which are organized in the following dimensions related to the project: *i)* pedagogical impact; *ii)* subject-specific impact; *iii)* human contributions; and *iv)* technical contributions. These questions are shown and analyzed (descriptive statistics) in Tables 1-2.

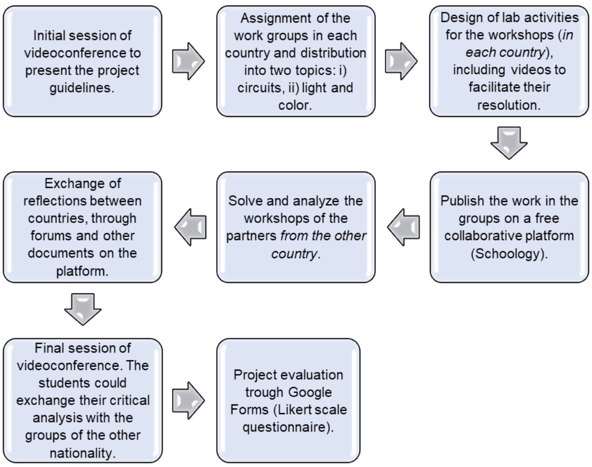

Fig. 1. Stages and activities of the inter-university project

5. Results

Tables 1-2 show the statistical results associated with the four dimensions of the Likert-type questionnaire (1-5). The first of them reflects that future teachers value in a very positive way the role of the people (work groups, professors, etc.) involved in the project. The technical and technological aspects also obtain high ratings, especially the final discussion activity through videoconference (item 8).

Table 1. Statistical results regarding human and technical contributions throughout the project

How much have the following aspects contributed to the proper development of the project…? (*N*=29)

Human aspects	**Min**	**Max**	**Mode**	**Mean**	**SD**
1. Your personal contributions to the different activities and work sessions.	3	5	4 (72%)	4.21	0.48
2. The contributions of co-workers – groups	2	5	5 (55%)	4.41	0.77
3. Professors from your own country.	4	5	5 (62%)	4.62	0.49
4. The associated groups – electrical circuits/light and color – of the other country.	3	5	4 (48%)	4.31	0.65
Technical aspects					
5. The design and tools of the Schoology platform.	2	5	4 (52%)	4.03	0.76
6. The videos made by the groups of the other country.	2	5	3 (41%)	3.62	0.96
7. The accessibility to the materials and tools necessary for carrying out the workshops.	3	5	4 (48%)	4.31	0.65
8. The final session of discussion about the workshops through videoconference.	3	5	5 (52%)	4.45	0.62

Table 2 includes the results on the pedagogical and didactic impact perceived by the participants. The second is slightly higher, highlighting aspects such as self-reflection on the design and selection of inquiry-based activities (item 7) or the diversity of materials to propose them (item 8). In any case, other transversal aspects (personal, technological or communicative) are also valued very positively.

Table 2. Statistical results regarding the perceived impact on future teachers' professional skills

To what extent do you consider that the project of school workshops between Spain and Peru has allowed you to…? (*N*=29)

Pedagogical dimension	**Min**	**Max**	**Mode**	**Mean**	**SD**
1. Work and interact as a team with a group of future teachers from another country.	3	5	5 (66%)	4.59	0.62
2. Independently assess workshop proposals designed by other groups on the same topic.	2	5	5 (59%)	4.52	0.68
3. Constructively communicate the evaluations of the workshops designed by the other groups.	2	5	4 (52%)	4.24	0.73
4. Reflect on the own workshops based on the evaluations of the other country (achievements, mistakes, possible changes, etc.).	2	5	5 (69%)	4.62	0.67
5. Use digital tools to record and communicate information (video recording and editing, cloud spaces, collaborative platform, forums, etc.).	3	5	5 (55%)	4.52	0.56
Subject-specific dimension					
6. Improve personal understanding about the contents of electrical circuits/ light and color.	2	5	5 (59%)	4.52	0.68
7. Reconsider the selection or design of lab activities to work on the contents of electrical circuits/light and color.	3	5	5 (66%)	4.62	0.55
8. Recognize that similar activities can be carried out with different materials (from everyday life, academics…).	3	5	5 (72%)	4.66	0.60
9. Recognize that the contents of electrical circuits/light and color can be sequenced in different ways.	3	5	5 (59%)	4.52	0.62
10. Identify and reflect on the inquiry-based or applicative – traditional – nature of the activities included in the workshops.	3	5	5 (62%)	4.59	0.56

6. Conclusions

The evaluation of the project supports its benefits to promote the development of professional competencies in future teachers, both those specific to science and others of a general nature, such as communicative or digital competencies. In addition, all of this is worked in a holistic way, through an authentic professional problem such as designing school workshops on physics.

Moreover, the perception of a variety of activities, materials or proposals to design inquiry-based activities is a clearly positive result, especially when, unfortunately, science workshops are still infrequent in school classrooms [1].

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Interactions between Learning and Emotions in Prospective Primary Teachers towards an Active Practice of Biology

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Abstract

Students experience a great diversity of emotions in academic settings: there is virtually no major human emotion not experienced in a classroom. These emotions are expected to have important effects on students' learning outcomes since control their attention, influence their motivation to learn and modify their learning strategies. Due to affective domain and cognition are integrated in the brain in critical areas for regulating the flow of information between regions, academic emotions and science learning are reciprocally conditioned. Therefore it is important to simultaneously look into affective and cognitive aspects in teaching-learning processes. This is particularly important in future Primary teachers, since the interplay between emotions and learning can determine their future professional performance. To deepen these interactions, in this contribution we analyse the relationships between the emotions experienced by a sample of 159 students of the Degree in Primary Education (University of Extremadura), before and after the implementation of an active practical intervention of Biology (based on guided research); and their level of Biology knowledge, both previous and acquired with the performed intervention. Emotions are assessed using a simple and quantitative self-report test which was validated in a previous research through factor analysis. This questionnaire measure ten academic emotions (5 positive emotions and 5 negative emotions), rated on a Likert scale from 1 "not experienced" to 5 "intensely experienced". Meanwhile Biology fundamental concepts are assessed through multiple-choice questions about common misconceptions in Secondary school as well questions extracted from TIMSS (Trends in International Mathematics and Science Study), which is designed to estimate science achievement in Secondary Education. Results reveal positive associations between the intensity of joy, enthusiasm, satisfaction and fun experienced during the practice and learning outcomes, as well as negative associations between them and the intensities of frustration and worry. Likewise, results indicate that low levels of previous Biology knowledge of Secondary Education are predictors of high intensities of boredom, frustration and worry, as well as that the previous intensity of enthusiasm can have predictive value in relation to learning.

Keywords: Emotions, learning, initial teacher training, Primary Education, guided research

1. Introduction

Classroom is an emotional place: all human emotions are experienced in different academic settings. Despite this diversity, academic emotions have been neglected by research in science education for decades [1]. Cognition and emotions are integrated in the brain in critical areas for regulating the flow of information between regions [2], being reciprocally conditioned [3]. Due to this interaction, academic emotions have important effects on students' learning outcomes since control their attention, influence their memory and modify their motivation to learn and their learning strategies [4, 5, 6].

Taking into account this influence, it is important to simultaneously look into affective and cognitive aspects in teaching-learning processes; particularly in future Primary teachers training, since the interplay between their emotions and their learning can determine their future professional performance [7]. To deepen these relations, in this research we analyse the interactions between the emotions experienced by a sample of future Primary teachers, before and after the implementation of an active practical intervention of Biology; and their level of Biology knowledge, both previous and acquired with the performed intervention.

2. Methodology

2.1 Sample

A sample of 159 volunteers (66% female, average age 22) was obtained from three groups of students enrolled in the Bachelor in Primary Education at University of Extremadura in its two campuses in Cáceres and Badajoz (Extremadura, Spain).

Students were informed about the goals of the research, duration, procedure and anonymity of their data. Participants answered two questionnaires before and after an active practical activity related to Cell Biology Education (developed under guided research): one on the emotions they felt towards the practice and one about core Cell Biology concepts. This practice has been described in a previous work [8].

2.2 Instruments

To determine academic emotions, we use a simple and fast quantitative self-report test measuring ten academic emotions (joyful, trusting, satisfied, enthusiastic, fun, worried, frustrated, uncertainty, nervous, bored), validated in a previous work through factor analysis [8]. Self-reported emotions measurement is among the most commonly method used, since it is easy to implement, it hardly affects the development of classroom's activities and provides measures of subjective and verbalized emotional experiences. In addition, academic emotions were assessed using single items since, compared to longer multi-item state measures, provide enough validity, require less time and are less intrusive with emotional responses of participants [1]. Emotions were rated on a Likert scale from 1 "not experienced" to 5 "intensely experienced".

Students reported their emotions before the intervention (how they thought they were going to feel with the implementation of the activity) and 2 weeks after its implementation (how they really felt during the activity). Cell Biology core concepts were assessed through multiple-choice questions about common misconceptions in Secondary school [9, 10, 11, 12] as well as questions extracted from TIMSS (Trends in International Mathematics and Science Study), which is designed to estimate science achievement in Secondary Education (age 12-16 in Spain) [13]. Students answered these questions before the intervention (pretest, with which to determine previous Cell Biology knowledge) and 2 weeks after its implementation (postest, with which to determine learning outcomes achieved with the implemented activity).

2.3 Statistical analysis

Due to data do not follow a normal distribution, Spearman correlation analysis are performed (SPSS program).

3. Results and discussion

Results reveal positive associations between the intensity of joy, enthusiasm, satisfaction and fun experienced during the implementation of the practice and learning outcomes, as well as negative associations between them and the intensities of frustration and worry (Table 1). These observations agree with several previous researches that revealed that emotional information is better remembered [4, 5, 6].

*Table 1. Coefficients of correlation between the intensity of emotions experienced with an active practice of Cell Biology and the Cell Biology learning outcomes achieved after its implementation (postest's mark). Bolds highlights significant correlations (Spearman, ***p-value<.001, **p-value<.01, *p-value<.05)*

Emotions felt with an active practice of Cell Biology	Correlation with Microbiology postest
Joyful	**.276*** **
Trust	.130
Satisfaction	**.278*** **
Enthusiasm	**.279*** **
Fun	**.213** **
Nervousness	-.056
Boredom	-.149
Frustration	**-.200* **
Worry	**-.196* **
Uncertainty	-.068

Regarding the predictive value in emotions-learning interactions, results indicate that low levels of previous Biology knowledge of Secondary Education are predictors of high intensities of boredom, frustration and worry (Table 2), as well as that the previous intensity of enthusiasm can have predictive value in relation to learning (Table 3). The predictive value of previous knowledge regarding present negative emotions has been described by several previous studies [1, 14]; although these researches also revealed predictive value regarding present positive emotions.

Concerning the predictive value of present emotions regarding future learning outcomes, the predictive value of enthusiasm regarding learning results has been displayed in previous researches [1, 15]; although these works revealed predictive value of negative emotions and other positive ones.

*Table 2. Coefficients of correlation between the intensity of emotions prior to an active practice of Cell Biology and the previous knowledge of Cell Biology of Secondary Education level (pretest's mark). Bolds highlights significant correlations (Spearman, **p-value<.01, *p-value<.05)*

Emotions prior to an active practice of Cell Biology	Correlation with Microbiology pretest
Joyful	.069
Trust	.079
Satisfaction	.071
Enthusiasm	.125
Fun	.121
Nervousness	-.062
Boredom	**-.157***
Frustration	**-.227****
Worry	**-.190***
Uncertainty	-.011

*Table 3. Coefficients of correlation between the intensity of emotions prior to an active practice of Cell Biology and the Cell Biology learning outcomes achieved after its implementation (postest's mark). Bolds highlights significant correlations (Spearman, *p-value<.05)*

Emotions prior to an active practice of Cell Biology	Correlation with Microbiology postest
Joyful	.114
Trust	-.089
Satisfaction	.067
Enthusiasm	**.157***
Fun	.062
Nervousness	.074
Boredom	-.078
Frustration	-.054
Worry	-.024
Uncertainty	-.015

4. Conclusion

Results show interactions between the emotions experienced by a sample of future Primary teachers, before and after the implementation of an active practical intervention of Biology; and their level of Biology knowledge, both previous and acquired with the implemented intervention. Due to emotions felt by teachers influence teaching-learning processes, these interactions should be taken into account in initial Primary teachers training.

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Levels of Teacher Self-Efficacy and Emotions Expressed by Teachers in Training STEM Areas

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Abstract

The stage of initial training of primary school teachers is particularly relevant to promoting science education for future generations. International reports alert that there is a decline in the choice of STEM (Science, Technology, Engineering and Mathematics) studies, as disinterest and negative emotions towards these subjects increase with age. Within the framework of science education, several studies have been developed analyzing the affective domain in its relationship with the cognitive domain in students of different educational levels. Some studies indicate that primary school teachers in training do not feel competent to teach scientific contents and are unsure about their teaching. This may be related to the emotions they have experienced and continue to experience towards scientific-technological areas. The general objective of this study has been to identify the levels of self-efficacy and the emotions that teachers in training express towards STEM areas. The design of the research has been exploratory and quasi-experimental, with pre-test and post-test to compare the influence of the implementation of external practices on the variables under study. The measuring instruments were designed to analyze their levels of competence for the teaching of STEM curricular contents, the memory of their emotions in their school stage, the importance of certain scientific-educational issues in their training and the emotions they experience during the teaching process of the selected contents. Statistical analysis reveals differences in emotional variables, with positive variables decreasing and negative variables increasing as the academic level increased. At the same time, there are statistically significant differences depending on the block of contents, both in the emotional variables and in the variable level of teaching self-efficacy. Likewise, the comparative analysis of the pre-test versus post-test data shows the existence of statistically significant differences in positive emotions and capacities, depending on the scientific content. Based on this, it is important to highlight the need to strengthen scientific, didactic and emotional competence in primary school teachers in training through methodologies that raise their levels of teacher self-efficacy and emotions towards STEM areas.

Keywords: STEM, Primary Education, Nature Sciences, Technology, Objects and Machines

1. Introduction

In the last decade there has been a great amount of research related to the importance of the competence domain in the teaching and learning of scientific-technological subjects [1]. The self-efficacy of the teacher is an important motivational construction that determines, in a certain way, the adequate learning of the students.

Some authors [2] define teacher self-efficacy as the level of confidence a teacher has in his or her ability to help children learn. Other research [3] has shown that teachers with a high level of self-efficacy are more competent in their teaching practice and do more to help students reach their potential. However, teachers with a low level of self-efficacy are less likely to strive to meet the learning needs of students.

These authors [3] also point out that the successful performance of a teacher leads to an increase in self-efficacy, while teacher failure creates a decrease in self-efficacy. Along these lines, it is necessary to consider research that has examined beliefs about the effectiveness of science teaching by teachers in training because it indicates that, once these beliefs are established, they are resistant to change [4].

Other authors [5, 6] revealed that solid prior experience was essential to improve levels of teacher self-efficacy. Specifically, they point out that teacher performance is the most powerful influence in providing authentic evidence of one's performance in a teaching situation. In addition, these authors suggest that positive self-efficacy is related to the acquisition of positive teaching experience and practical training. In other words, exciting and hands-on activities improve their self-efficacy as teachers [7]. In addition, active methodologies encourage and dynamize interaction in the classroom by facilitating student-teacher feedback. Working on problems linked to reality generates a motivating learning environment that modifies students' attitudes and emotions, preventing possible school failure [8]. Some studies [9] indicate that future teachers show low levels of teacher self-efficacy and little confidence in science teaching, showing negative emotions and attitudes [10]. For this reason, in initial teacher training it would be advisable to analyse levels of teacher self-efficacy in relation to both cognitive and affective domains, especially in STEM (Science, Technology, Engineering and Mathematics) subjects.

2. Methodology

The design of the research has been exploratory and quasi-experimental, with pre-test and post-test to compare the influence of the implementation of external practices on the variables under study. El objetivo general ha sido to identify the levels of self-efficacy and the emotions that teachers in training express towards STEM areas. The participating sample consisted of 71 students from the Primary Education Teacher Degree, teachers in training. It was selected by means of a non-probabilistic sample for convenience due to the ease of access to it.

Two questionnaires were used as a measuring instrument, one as a pre-test and the other as a post-test carried out before and after the teaching practices. In these questionnaires they are asked to evaluate in a first block the scientific areas of their school stage. Subsequently, they have to evaluate different subjects according to the level of importance they have for their training as teachers. In the third block, they must assess from 0 (low level) to 10 (high level) their level of competence and ability to teach subjects and blocks of content related to STEM areas. These contents have been extracted from the primary education curriculum. In the fourth block, they are asked about the emotions they experience as teachers depending on the scientific content and the level of the students to whom they have to teach it.

3. Results

Analysis of the data reveals that the teacher in training has low emotional and competency levels when teaching STEM content in the primary classroom. Figure 1 shows the average frequency rated from 0 (never) to 10 (all the time) of the memory of the emotions they experienced towards the Primary and Secondary Sciences during their school stage.

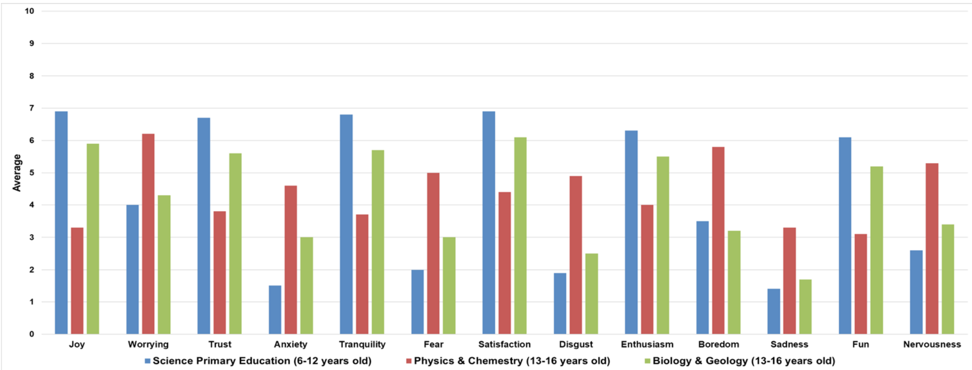

Fig. 1. Average frequency of memory of emotions in the pre-test

The pre-test results show that students remember positively the science subjects they studied during their primary education. However, the emotional results change when they reach the secondary stage. Students give high scores to positive emotions when they recall studying and working on biology-related content. In contrast, in physics and chemistry we can observe higher scores in negative emotions, with statistically significant differences (Sig. <0.05) between these subjects. When comparing these results with those obtained in the post-test, carried out after the practices, it is observed that positive emotions increase, and negative emotions decrease in biology.

However, in physics and chemistry, after the practices, negative emotions increase.

Subsequently, an emotional analysis of the blocks of curricular content of Nature Sciences was carried out. Figure 2 shows the results in two of the blocks.

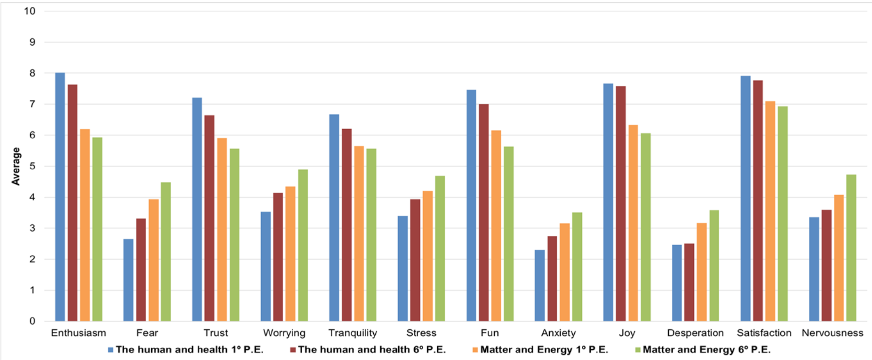

Fig. 2. Emotions experienced when teaching certain scientific contents at two educational levels

Figure 2 indicates that, prior to the practices, participants show positive emotions in the "Human Being and Health" block to a greater extent than in the "Matter and Energy" block. As a result, negative emotions occur more frequently in the latter block. After the development of teaching practices, the degree of manifestation of the emotions Fear, Worry, Stress, Anxiety or Despair increases in the blocks related to Physics/Chemistry such as "Matter and Energy", being this difference statistically significant (Sig. >0.05) with the pre-test data. It is also relevant to note that, in both cases, the scores of negative emotions are somewhat higher in the 6th grade than in the 1st and the positive emotions fall slightly when teaching science in the senior year.

Subsequently, the results referring to the level of teaching self-efficacy in science are shown. Figure 3 shows the results obtained.

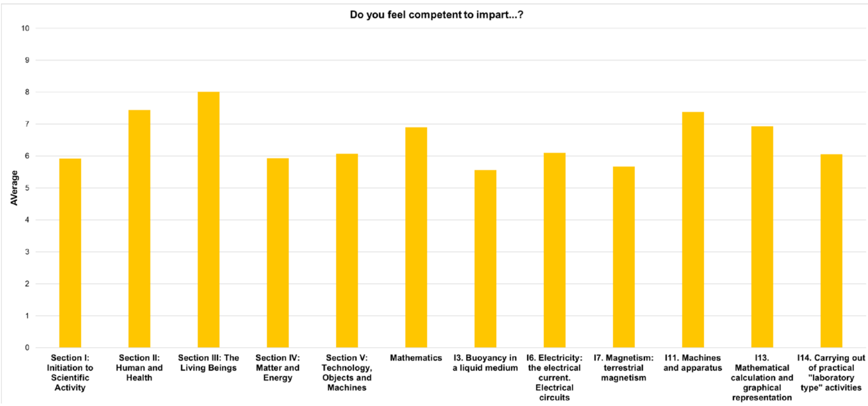

Fig. 3. Degree of competency to teach science in primary school

Figure 3 shows that those surveyed show greater competence in teaching blocks that are more linked to biology (BII and BIII) and feel more insecure in those related to Physics/Chemistry (BI, BIV or BV).

These results are reconfirmed by analysing the level of teacher self-efficacy in delivering a range of specific content. Figure 3 indicates that the trainee teachers consider that they have a medium-low level of self-efficacy when teaching primary scientific contents, but above all those more linked to Physics, such as in the case of I3, I6 or I7.

When analyzing the post-test, it was found that the level of teacher self-efficacy improved, although these results were far from being considered favorable.

Subsequently, the respondents assessed the level of importance of some training aspects in the teacher in order to ensure adequate teaching in the classroom (Figure 4). The analysis of these data revealed that future teachers consider these requirements to be important.

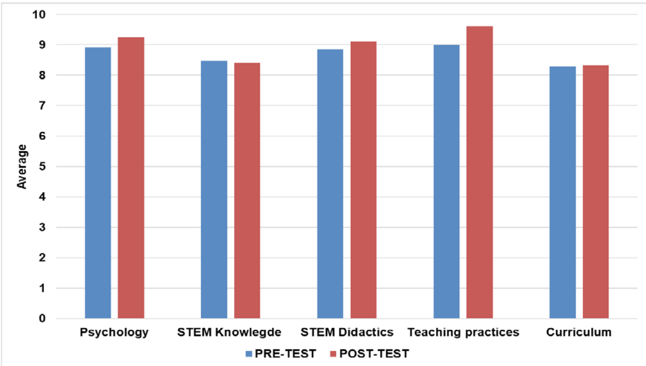

Fig. 4. Important aspects in teacher training

4. Conclusion

The previous results show the need to implement methodologies in the classroom that promote the acquisition of the scientific and didactic competence of the teacher in training, in order to improve the teaching of these contents in their future primary students [3]. However, self-efficacy is closely linked to the emotional variable, i.e., students will show higher rates of self-efficacy if they show concentration, control, happiness, participation and satisfaction during school work [11]. Likewise, the teacher's methodology and attitude influence the students' emotions [1]. Therefore, if teachers, when teaching scientific content, feel negative emotions, it is very likely that these negative emotions towards science will be transferred to students. Based on this, it is important to highlight the need to strengthen scientific, didactic and emotional competence in primary school teachers in training through methodologies that raise their levels of teacher self-efficacy and emotions towards STEM areas.

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Pre-Service Teachers' Challenges and Affordances in Implementing Inquiry-Based Science Teaching at Lower Primary

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Abstract

Our study is a designed-based research with our pre-service teachers as participants. We aimed at mapping pre-service science teachers' challenges and affordances when they faced the task of planning and implementing inquiry-based science teaching (IBST) at lower primary, followed by reflection on their experiences. Using thematic analysis framework, we looked for emerging patterns of challenges and affordances across our data set comprising of lesson plans, classroom observations, pre-service teacher focus group interviews, mentor teacher interviews and pre-service teachers' self-reporting. Our preliminary analysis suggests that given the carefully designed support, the pre-service teachers have managed to implement inquiry-based science teaching even with young students at first and second grade in primary school. A great range of scientific practices was implemented, including formulating hypothesis, making observation, constructing explanation and building argumentation. Some of the challenges dealt with insufficient age appropriate classroom management skills and in developing age appropriate scaffolding for leading inquiry work. However, despite the challenges, the affordances comprising of the usefulness of the 5E-model and the Nysgjerrigper method as teacher guide introduced by the teacher educators, and the children's natural curiosity have supported the pre-service teachers in the implementation of IBST.

Keywords: Inquiry, science, implementation, lower primary, pre-service teachers training

1. Introduction

Literature shows the intention from both the science educators' milieu and the policy makers to widespread the implementation of inquiry-based science teaching (IBST) and learning [1, 2]. IBST generally refers to student-centered ways of teaching in which students raise questions, explore situations, and develop their own paths toward solutions [3]. Since there is still no universally agreed upon definition of the term *inquiry*, we use the definition of IBST that we developed in the mascil project [4], which among others characterize inquiry tasks as meaningful, open and with multiple solution strategies. The teacher role is a guide that values and builds upon student's reasoning and reflections, and connects to student's experience [4].

IBST is considered a way to raise motivation, increase student performance and to provide students with the attitudes and skills in science necessary in society [5].

However, the inquiry approach is not implemented as widely as expected [3]. Thus, there is a discrepancy between the intention and the implementation of inquiry at the classroom level. The lack of inquiry enactment is also the case in Norway, despite the good systemic support. Some of the obstacles to teach science through inquiry comprise lack of teachers' knowledge and skills, lack of confidence and lack of ability to manage classroom and time [6]. As teachers are key stakeholders for whatever is happening in schools, one possible way to overcome these obstacles is by equipping pre-service teachers (PST) with appropriate pedagogical content knowledge (PCK) and pedagogical knowledge (PK) for inquiry in their training program.

What constitutes effective teacher professional development (PD) have been described in the literature [7], also when it comes to PD for implementation of IBST [8].

There is also a strong field of literature around the practicum in pre-service teacher education. However, there has been a limited focus on how PST themselves perceive their development during this learning period and little is known about how initial teacher education (ITE) enable them to implement IBST.

From literature, we know that being a novice teacher, challenges are connected to eg. classroom management, meeting special needs, classroom resources, long-range planning, time for preparation, and mentorship [9]. Teacher training should strive to meet and prepare PST for these challenges. The role of teaching experience and reflection in science teacher education is a way of better understanding the complex entities that constitute a knowledge base for teaching [10]. We know that practice is essential for PST to generate their own practical schemes of action. Reflection in and about practice allows PST to analyze their classroom behavior and contrast it with their previous conceptions, and with that of their companions [11]. Since PST learning includes personal, social, and professional development [12], support from university instructor, mentor teacher and fellow students is also fundamental for their educative process [11]. PST practicum intend to bridge the gap between theory and practice [13], but the relevance of coursework in preparation for practicum has shown to be low during the first two years of ITE [14]. In our study, we provided PSTs with methodologies for IBST during their second year of ITE, eg. the 5E-model [15] and the Nysgjerrigper method [16]. Our research question was: *What are the challenges and affordances PST face in implementing IBST at lower primary school during their practicum?*

2. Method

We followed the design-based research principle involving cycles of design, enactment, analysis and redesign [17]. We have done three cycles within three consecutive school years, one cycle per year. This paper gives an overview of the results of the data accumulated during these years.

2.1 Participants and Setting

The main participants of this study were primary school PST at the second year of their ITE. We worked with a new batch of PST each year. First, the PST worked in the university where we (researchers) introduced them to IBST and to teacher guide on planning inquiry lessons, e.g., the 5E-model [15] and the Nysgjerrigper method [16].

Then, we assigned them the task of planning and implementing IBST in the topic of their choice, at 1st or 2nd grade of primary school where they had their practicum [13].

During the practicum, the PST worked in groups, and each group was supervised by a mentor teacher (MT) from the placement school. After the practicum ended, the PST came back to the university and we asked them to reflect on what went well or not and why, and about the challenges and affordances in the IBST implementation [10, 11].

In total, we have worked with 60-70 PST in 18 groups, having two-three week practicum in 12 different primary schools, and taught more than 250 6-8 year old students. The chosen topics consisted of: “senses”, like sight, hearing, taste, smell and touch (6 groups), “digestive system” (3 groups), “floating and sinking” (3 groups), “autumn” (2 groups), and the topics “sound”, “day and night”, “windmill” and “oil in water” with 1 group each.

2.2 Data Collection and Analysis

We collected the lesson plans and the reflections from all 18 groups after the PST came back to university from the practicum. The reflections were audio-recorded. In addition, we distributed open-ended questionnaires to PST and MT and conducted semi-structured interviews. The PST interviews were done in-group, and the MT interviews were individual. Only those who were available and gave consent were interviewed. Eight questionnaires or group interviews of PST and nine questionnaires or MT interviews were collected. All interviews were audio-recorded.

We also conducted at least two classroom observations per cycle to see directly the implementation of the planned lessons. Together with the MT interviews, the classroom observation served as validation of the data from the PST, enhancing reliability beyond self-reporting.

The collected data were analyzed qualitatively using thematic analysis [18]. We looked across our data set for emerging patterns of challenges and affordances for IBST implementation.

3. Results and Discussion

Our preliminary analysis suggests that given the carefully designed support, the PST successfully implemented IBST even with young students at first and second grade in primary school. A great range of scientific practices was applied, including formulating hypothesis, making observation, constructing explanation and building argumentation [19]. These were confirmed by classroom observations.

Moreover, we saw that the PST acquired a good understanding of IBST. From the interviews, when asked about what inquiry means, most of them came up with the characteristics of inquiry approaches as presented in [3,4]. They also viewed IBST approaches as engaging and motivating. Some also thought that students would learn better, when they were taught using IBST approach.

Despite a good understanding of IBST and the fact that the PST managed to implement a great range of scientific practices, they met challenges, see Fig. 1.

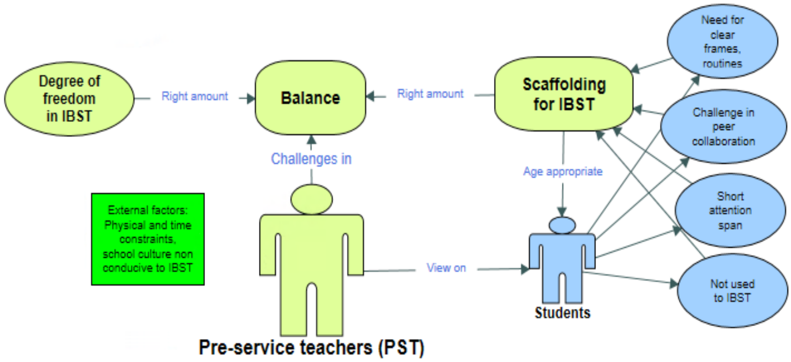

Fig. 1. Challenges in IBST implementation at 1st and 2nd grade primary school

The PST understood that IBST is a student-centred pedagogy, as opposite to traditional approach. They also knew that young children need guidance and clear boundaries for instance on accepted behaviour. The most challenging factor for the IBST implementation was to get the right balance between giving the children enough space for doing the investigation, and providing enough scaffolding of the activities, like step-to-step, detailed enough instructions for the children to understand. They were worried that giving the children too much space would lead to chaos and a loss of control over children's behaviour. Giving them too much scaffolding would lead to no or almost no degree of freedom, and the activities that initially were planned to be open or inquiry-based [3, 4], ended up being "closed", or teacher-centred like in traditional approach. Many of our PST successfully stroke the balance by giving the children the appropriate type of scaffolding in an appropriate amount, but some did not. Even those who succeeded still acknowledged scaffolding young children for inquiry work in a balanced way as challenging.

Recurrence themes emerging from the MT interviews were "relationship with students" and "knowledge of students" which both came under "classroom management". The fact that the PST were still novices influenced how successfully they familiarized themselves with the students and understood their needs [9].

For instance, the students had a relatively short attention span; hence, the lesson sequences should be of appropriate length. Some had limited writing and reading skills, hence alternatives like drawing should be offered. Moreover, terms had to be explained, like what "*collaborating*" means in a group work. Some of the PST managed well, while some others struggled. The mentor teachers considered the lack of classroom management skills of some PST as a challenge.

However, despite the challenges the affordances comprising the usefulness of the 5E-model and the Nysgjerrigper method as teacher guide introduced by the teacher educators, and the children's natural curiosity supported the pre-service teachers in the implementation of IBST, see Fig. 2.

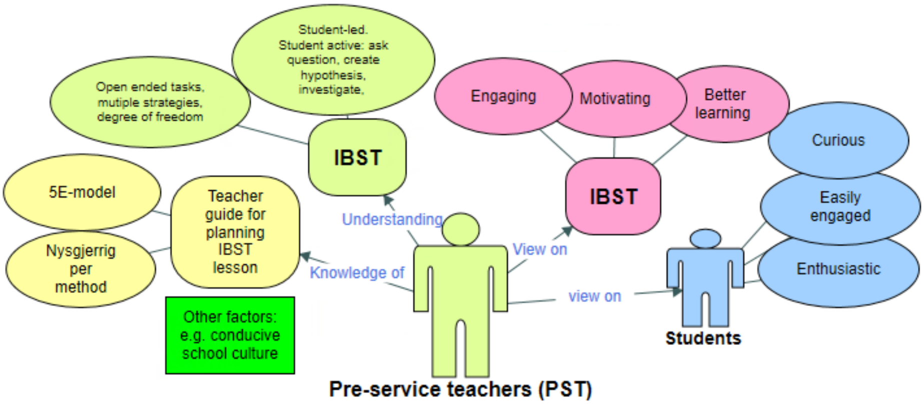

Fig. 2. Affordances in IBST implementation at 1st and 2nd grade primary school

Children's curiosity and engagement were indeed the recurring themes emerging as main affordance. This result was validated by MT's perspective. Although sometimes the children could be overly excited and resulted in rushing the inquiry steps (e.g., jump over the hypothesis), it was encouraging for the PST to see the students easily engaged, enthusiastic and highly motivated: *"It doesn't required much to engage the students, really!"* (PST, interview). The students were also very curious and asked questions, such as *"Why do we have one eye on each side of the nose?", "Why is the poop brown?*", etc.

Besides, the PST considered the 5E-model and the Nysgjerrigper method as being useful teacher guide in planning the lesson, although in the implementation they often had to make adjustments based on the students and the external factors such as time and physical constraints, like room availability, limitation of resources, etc. We considered the PST's good understanding of IBST and their view of IBST as affordances for implementation of IBST, because without a good understanding of IBST and a belief that IBST would enhance motivation and engagement, the implementation would be impeded. From the MT's perspective, the PST's ability to know well the students' needs and limitation and to provide adequate support within a clear frame were considered as affordances.

4. Conclusion

In conclusion, the pre-service teachers managed to implement IBST at lower primary. However, due to the young age of the students, it is important that the PST acquired age-appropriate classroom management skills combined with skills for developing age-appropriate scaffolding (in type and amount) that enable them to lead inquiry work of the students. Although more PST training is commendable, our intention to equip the PST with appropriate PCK and PK in their training program was achieved at least for some PST.

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Professionalization of Tutors in Chemistry: Conceptual Perspectives for the Design of a Tutor School

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Abstract

Tutorials substantially support university teaching in Germany. In chemistry their purposes vary from providing students with mentored settings, in which the contents of previous lectures are recapitulated in small groups, to supervised seminars with the focus on laboratory work. This academic form of teaching is usually led by students of higher semesters as group leaders, so-called tutors. The design of the learning arrangement lies in the hands of the tutors, who usually have little teaching experience and at most basic knowledge regarding chemistry didactics. Hence the problem arises, that most tutors often lack learning-effective and student-centered methods as well as an understanding of their own role as tutors. As a result, the imitation of a lecturer-centered form of teaching can be observed, although the tutorials should rather focus on active knowledge processing and practice. It becomes clear that the tutors need to be prepared for their particular work in order to avoid reality shock in teaching as well as strengthen their role as learning guides.
The purpose of this paper is therefore to introduce a concept for the training of tutors and an according basic unit. This basic unit includes the following targets: (1) clarifying the understanding of the tutors' roles (2) facilitating a change of perspectives between the different roles (3) getting to know and experiencing student-centered teaching/ learning methods (4) imparting relevant didactic aspects (such as the Johnstone Triangle) (5) refining the ability to analyze characteristic types of students to highlight the importance of classroom management.

Keywords: Tutor School, Professionalization, University Teaching, Learning Guide, Student-Centered Methods

1. Introduction

Learning processes at the university are significantly supported and fostered by tutorials. In this article, a tutorial is understood as the following [1]: A tutorial is an academic teaching form in which like-minded people, such as students attending the same lecture, learn together in small groups under the guidance of tutors. Typically, they accompany classical lectures by promoting specialist competencies in peer-to-peer learning arrangements. They are intended to encourage students to actively engage with the material taught in the lecture and to support exam preparations. It becomes clear that learning processes become easier for young students, the better the tutorials are designed [2]. Thus, the quality of the tutorial is mainly influenced by the appointed tutors, mostly students of higher semesters, who are largely selected on the basis of their specialist competencies [1, 3]. This is often based on the assumption that someone who has extensive specialist knowledge is also able to communicate this comprehensibly [4]. It is often neglected, however, that in most cases the tutors are not aware of the didactic, personal and social skills they need to initiate, accompany and support student learning processes [1].

In preparation for their work, the tutors are not being adequately qualified by the university and the faculties, which leads to them oftentimes perceiving their teaching assignment as a major didactic challenge [1]. As a result, the tutors adapt the lecturer-oriented teaching style of their professors, leading to tutorials dominated by “chalk-and-talk” settings instead of the intended active application of the lecture contents [1, 4]. Students can thus be deprived of the opportunity to independently design their own learning processes and actively process new knowledge. This partly has a negative impact on exam results and could lead to longer study periods and higher dropout rates [1, 4]. In addition to these possible negative consequences, professors see certain risks in the assignment of tutors. A main risk is the unequal quality of the tutorials, which is expected to be counteracted by a qualification of the tutors [5].

In order to be able to increase the quality of the tutorial teaching through the adequate support of student learning processes, the tutors should be prepared more specifically for their tasks. Therefore, the present contribution concentrates on the concept for the training of tutors as well as the construction of a basic unit.

2. Concept for a Tutor School

The concept of training tutors considers three key points (see Figure 1). These three points include:

(1) **Basic Unit:** The basic unit should be attended obligatorily by all tutors to ensure a general understanding of teaching and learning at the university. Thus, the basis for an increased quality for the tutorials is laid on the one hand and on the other hand the basis for the advanced units is created.

(2) **Advanced Units:** The advanced units are designed to deepen the understanding about teaching and learning settings, allowing tutors to achieve professionalization in various fields. Above all, the advanced units should ensure direct apllication based on specific tasks.

(3) **Tutorial:** The tutorial is the highest level above the individual training units. Here the trainees should apply their acquired knowledge from the individual training units directly in their own tutorials.

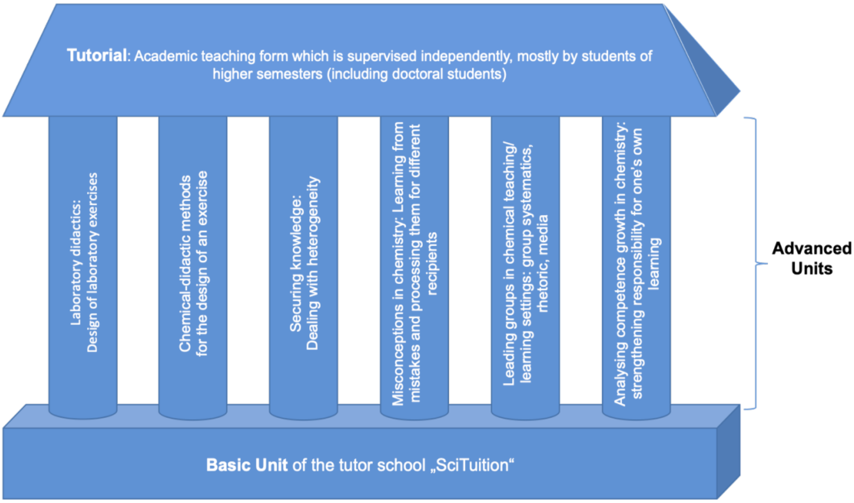

Fig. 1. Concept of a tutor school for university education in chemistry

3. Construct of a Basic Unit

The basic unit of the tutor school "SciTuition" aims to pursue the primary learning objective of changing the role perception of tutors, in this case from the knowledge mediator to the learning guide. As described above, this is the main challenge, so that a student-centered teaching style can be developed instead of imitating the lecturer-oriented teaching style. In order to ensure this, the basic unit was planned in individual modules in order to customize the course concept adaptively according to the learning group, such as the training of students with teaching experience as well as those with little to no experience. In addition, the modular design makes it easier to pick up contents of the basic unit during the advanced units.

The basic unit is currently being tested with five modules (see Figure 2). The individual modules are pursuing the following goals:

(1) Clarifying the understanding of the tutors' roles.
(2) Facilitating a change of perspectives between the different roles.
(3) Getting to know and experiencing student-centered teaching/learning methods.
(4) Imparting relevant didactic aspects (such as the Johnstone Triangle).
(5) Refining the ability to analyze characteristic types of students in order to highlight the importance of classroom management.

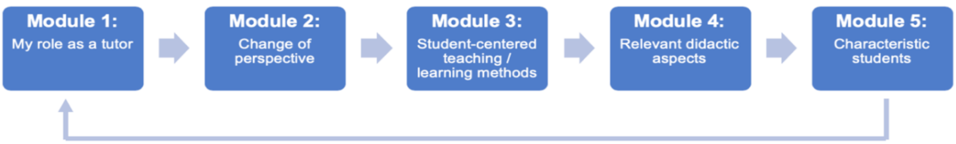

Fig. 2. The schematic structure of the basic unit for the tutor school "SciTuition"

All in all, the five modules are to be understood in a circular process, whereby at the end of the course the understanding of the role should be taken up again. This is intended to provide a concluding reflection on the student's own understanding of tutoring and their significance as a learning guide. In order to induce this process of understanding, the participants should first deal with the role of a tutor (module 1).

Afterwards, the participants should broaden their perspectives by becoming aware of problems and difficulties that students may face in the tutorial (module 2). In order to counter these problems, student-centered teaching and learning methods should be presented, which the participants can use in their tutorials (module 3).

Via these methods, the tutors can guide the students in their process of learning more effectively, thus stimulating a more sustainable learning success. In addition, basic didactic aspects, such as the Johnstone Triangle, are brought to mind to highlight the subject-specific challenges of teaching in chemistry (module 4). These are supplemented by further challenges through addressing various characteristic students which may occur in a tutorial (module 5). The participants should develop possible options which they can apply to deal with the characteristic students in their own tutorials. The developed ways of handling such students should dispel fear of difficult situations and enable tutors to appear more self-confident in the tutorial.

During the course of the training, various evaluation tools are used to provide feedback on the individual modules and to encourage participants to reflect. The instruments used include, for example, the ticking of statements concerning the individual modules or show of hands regarding the use of methods to collect quantifiable data. Furthermore, open questions are asked in order to generate ideas for the further development of the training, but also to identify and discuss the concerns and fears of the participants. In the following, exemplary statements of the evaluation of the primary learning objective (changing the role perception of tutors à from knowledge mediator to learning guide) are presented.

Mentioned characteristics of a tutor **before** the course	Modification to characteristics of a tutor **after** the course
Preparation of tasks	Promote group dynamics
Respond to and answer questions	Ask students questions
Motivated	Recognize and counteract problems
Specialist knowledge	Person of trust
	Adaptability

Table 1. Exemplary evaluation results for the primary learning objective

It can be seen that, especially after attending the course, the mentioned characteristics are supplemented by aspects which take up the perspective of the students. This reinforces the assumption that taking on the role of learning guide can be simplified and promoted. For example, the specialist knowledge mentioned before the start of the course is supplemented with adaptability, which makes it clear that the specialist knowledge should be adaptively taught.

4. Conclusion and Outlook

During the course it became clear that the participants often assumed that they have to act as knowledge mediators. The course topics can help to ensure that the tutors perceive themselves as learning guides instead. The individual modules can help the participants to better understand their role as tutors and to broaden their perspectives. Both becoming aware of individual competencies and experiencing student-centered methods can help participants to better implement learning at eye level in a peer-to-peer environment. Both didactic as well as group-specific challenges can be worked out during the course and constructive approaches to solutions can be developed.

In follow-up studies, further evaluation data will be collected and examined in order to be able to clarify quantifiable statements regarding the change of the role understanding of tutors through training as well as the expectations of students towards the tutors. In addition, advanced units will be evaluated in order to guarantee a holistic concept regarding the professionalization of the tutors.

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Prospective Primary School Teachers' Difficulties when Dealing with Multiplying Fraction Word Problems

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Abstract

The connections between the learning of a concept and its teaching are a source of great concern to our Mathematics Education Department teachers, particularly in the case of fraction word problems. The TPACK framework provides appropriate tools for the study of this topic. We presented to 47 couples of prospective primary school teachers a multiplying fraction word problem in an equal sharing context. The problem was supposed to be solved in two ways: using graphic strategies (with a GeoGebra applet) or arithmetically. Additionally, our trainees were asked about the indications they would give to their future pupils in order to solve similar problems. All the tasks were assigned to one of the TPACK sub domains, and analyzed according to it. The most important findings were related to the predominance of the arithmetic-based methods over the computer-based ones. Moreover, a high percentage of the couples did not check the necessary coincidence of the results when solving the same problem in a different way. When comparing solving results and indications for pupils, we found that many couples with a mathematically correct answer delivered poor indications to their future pupils.

Keywords: TPACK, fraction teaching difficulties, fraction learning difficulties

1. Introduction

Our prospective primary school teachers are used to work with different technological instruments in their everyday life. However, these instruments rarely become an essential part of their learning/teaching processes. Furthermore, they have been taught through traditional methods that included limited interpretations of the rational number. The goals of our work are: i) to analyze if they are willing to include technology in their teaching activities and ii) to study if they are prepared to overcome these interpretations of the rational number.

2. Theoretical framework

Firstly, we briefly introduce the basic concepts of TPACK (technological pedagogical content knowledge) framework. It shows the general domains our prospective primary school teachers' should cover in our course, and the interpretations of the rational number, which is the specific content of our work.

2.2 The TPACK framework

TPACK is the framework that we use to study the prospective primary school teachers' knowledge for technology integration, as explained in Koehler & Mishra [1].

This framework builds on Lee Shulman's construct of pedagogical content knowledge (PCK) to include technology knowledge. The acronyms in Figure 1 mean:

CK: Teacher's knowledge of the mathematical content, including concepts, theories, ideas, organizational frameworks, etc.

PK: Teacher's knowledge of the processes, practices and methods involved in the teaching and learning of mathematics.

PCK: Teacher's knowledge of the possible adaptations of the mathematical content to its teaching.

TK: Teacher's knowledge that permits him/her to do different tasks using IT and to find different ways of solving a given task.

TCK: Teacher's knowledge of the mutual influences and limitations of technology and content.

TPK: Teacher's knowledge of the changes that technology generates in learning and teaching.

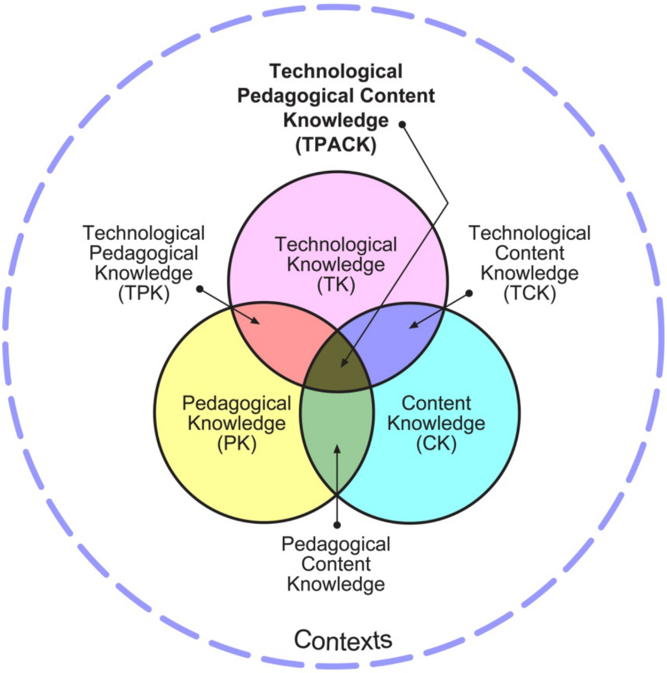


Fig. 1. TPACK diagram. Source: http://tpack.org

2.2 The interpretations of the rational number

Five different constructs or interpretations of the rational number are classically accepted by Kieren [2]: part-whole, measure, quotient (division), operator and ratio. Following the explanations in [3]:

- Part-whole interpretation is related to the partition of a continuous quantity in equal-sized subparts.
- Measure interpretation is related to the parts in which the unit is divided

(denominator) and the number of these parts considered (numerator) taking into account the fractional representation of the number.

- Quotient interpretation is related with the idea of equal sharing *a* objects or units with *b* persons if we consider the fractional representation of the number.
- Operator interpretation is related with the idea of multiplying the rational number by another number (possibly rational too).
- Ratio interpretation is related with the idea of comparing the sizes of two sets or two measurements.

Although our course covered all five interpretations, the part-whole interpretation is the most frequent in Spanish text-books. Freudenthal [4] explains how restricted this interpretation is, both phenomenologically and mathematically. Moreover, students are forced to believe that "½ times means the same as ½ of" and learn arithmetical rules that build the concept of rational number. These facts, among others, lead to a mechanical understanding of the algorithms, but no to a true understanding of the concepts.

3 Methods and sample

In January 2017, a four-task questionnaire (a, b, c and d) was presented to 47 couples of prospective primary school teachers who had previously followed up the course "Teaching of the rational number in primary school":

Antonio had pizza for lunch with his friends on Monday and Thursday. On Monday they were 5 friends and shared 3 pizzas. On Thursday, they were 8 friends and shared 5 pizzas. On Monday, he gave one fourth of his food to his sister Sara, eating the rest of his lunch. On Thursday Antonio decided to eat all the food he received, but he dropped one fifth of it on the ground. Which day did Antonio eat the most? (Note: all the pizzas are alike.)

(a) Solve the problem without using arithmetic operations, but using the graphic support of the given applet (available at https://www.geogebra.org/m/b3XaeVVV). Justify your answer. (You can use as many screenshots as you want to clarify the resolution.)
(b) Considering your previous justifications, what could you say about the graphics used?
(c) Solve the problem without using any graphic strategy, just by using arithmetic operations.
(d) Imagine that you are preparing a mathematics class for your primary school pupils to teach them how to solve problems about comparing quantities coming from the application of operators. Describe step by step the mathematical instructions you would give to your students to teach them how to solve the given problem.

This activity was designed to connect the quotient, the operator and the measure interpretations. All of these interpretations had been previously studied by our students.

Each task has its corresponding sub-domain in the TPACK framework as follows: a (TCK), b (TCK), c (CK) and d (TPACK).

4. Results

In this work we show only the results corresponding to task 'd' (42 couples answered) due to the limited space that we have.

- 3 couples (out of 14) used the given applet in their instructions, even if they have used previously the applet to solve the problem.
- 2 couples considered in their instructions that the problem can be solved in more than one way.
- None of the couples suggested that the answer of the problem could be checked by solving it by a second method.
- 14 couples based their instructions in the measure interpretation of the rational number.
- 10 couples gave no interpretation to the fractions in their instructions.

In Table 1, we present the references given in the instructions to the main mathematical topics (the operator interpretation and the comparison of quantities) and the contextualization level of the instructions, (classified as T-theoretical, A-abstract, Cn-concrete, Cm-complete). The number of corrects answers in each box is in brackets.

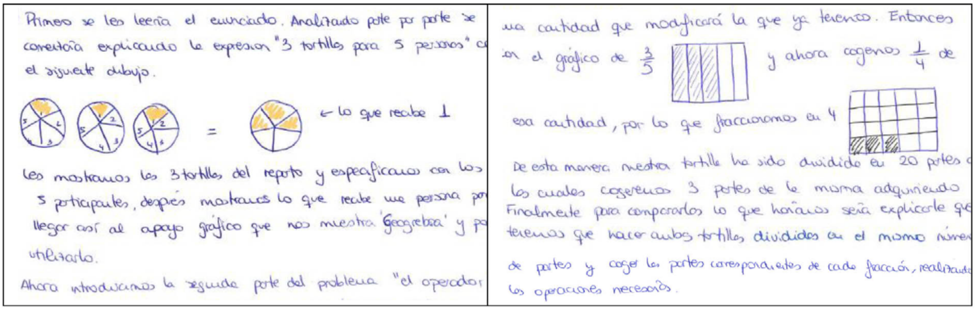
	T	A	Cn	Cm
No reference in the instructions to the operator interpretation nor the meaning of the comparison	1 (0)	1 (1)	1 (1)	
References only to the operator interpretation	2 (2)	1 (0)	9 (6)	
References only to the meaning of the comparison	5 (5)	0 (0)	2 (0)	
References to both of the concepts	7 (3)	2 (0)	5 (3)	6 (3)

Table 1. Mathematical topics and contextualization level

Results about contextualization level and mathematical content in the instructions:

- 20 out of 42 couples considered both mathematical aspects in their instructions. These couples are divided in three almost balanced groups: T, A/Cn and Cm.
- 27 couples considered the meaning of the comparison in their instructions.
- 32 couples considered the operator interpretation in their instructions.
- 68% of the couples did not consider both mathematical aspects have correct mathematical answers.
- 45% of the couples considered both mathematical aspects have correct mathematical answers.

To illustrate our findings, we show in Figure 2 part of the instructions written by a couple with an incorrect mathematical answer but complete instructions.



Primero se les leería el enunciado. Analizando parte por parte se comentaría explicando la expresión "3 tortillas para 5 personas" c
el siguiente dibujo.

= ← lo que recibe 1

Les mostramos las 3 tortillas del reparto y especificamos con los 5 participantes, después mostramos lo que recibe una persona por llegar así al apoyo gráfico que nos muestra 'Geogebra' y p
utilizarlo.

Ahora introducimos la segunda parte del problema "el operador,

una cantidad que modificará la que ya tenemos. Entonces en el gráfico de $\frac{3}{5}$ y ahora cogemos $\frac{1}{4}$ de esa cantidad, por lo que fraccionamos en 4

De esta manera nuestra tortilla ha sido dividida en 20 partes d
los cuales cogeremos 3 partes de la misma adquiriendo
Finalmente para compararlas lo que haríamos sería explicarle que tenemos que hacer ambas tortillas divididas en el mismo númer
de partes y coger las partes correspondientes de cada fracción, realizando las operaciones necesarias.

Fig. 1. Complete instructions

5. Discussion

Very few couples decided to use technology, which could be due to the traditional instruction received during their school days. In this sense, they did not modify their approach to mathematics, and gave more value to a traditional/numeric answer over a technological/graphic one.

Only two couples considered solving the problem in two different ways, and none proposed to check the answer by solving it in two different ways. These heuristic strategies have been considered very important to learn mathematics in previous studies [5]. Moreover, these facts make a great contrast with the approach we take in our course, where we solve problems with rational numbers by using different interpretations that imply different solving techniques.

Ten of the couples in our sample missed any interpretation of the rational number when writing instructions in task d, and focused them in a formal explanation of the arithmetic operations. This fact could be related with the preponderance of the part-whole interpretation of fraction [6].

The prospective teachers emphasized the most difficult mathematical aspects, mainly the operator interpretation and the meaning of the comparison. From this point of view they may have thought that comparison is easier to be understood by a primary school kid than the operator interpretation. Moreover, instructions about comparison are shown to be more theoretical than the ones about the operator interpretation.

We observed that couples with more complete instructions have had worse mathematical answers than couples with incomplete instructions. We link these facts to the pedagogical difficulties shown by others with a better domain of the mathematical content, probably due to the fact that many preservice primary school teachers think that traditional school mathematics content is not difficult and, hence, it needs few explanations [7, 8].

6. Consequences for the teaching training in mathematics education

Some ideas could be taken into account for the design of future activities in Mathematics Education for prospective primary school teachers:

- To include tasks covering all the TPACK subdomains.
- To combine different interpretations of the rational number.
- To promote the use of one technique by making more difficult the use of the others. It means, for example, we have to to use higher figures in the activities to promote the use of GeoGebra by making more difficult for them the use of other techniques.
- To include actual answers of primary school kids to analyze errors and give tips to correct them by using different techniques.
- To ask for an analysis of the mathematical content before writing the instructions.
- To include role-playing activities with prospective teachers to make them understand better that, when designing instructions, they should focus in pupils' troubles rather than in their own ones

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Training Pre-Service Teachers to Connect Biology Teaching to Daily Life: Role of Positive Emotions

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Abstract

Since Primary Education ending, students describe science as an irrelevant discipline to their daily lives. Given this situation it is necessary to promote in classrooms the development of motivating activities of science, highlighting its connection with everyday life. Practical activities have this motivating role but do not provide satisfactory learning outcomes due to their traditional approach. Against this background, it is necessary to train future teachers to develop practical activities under non-traditional approaches as well as to include the interrelationships Science, Technology and Society (STS). This contribution shows the results of the implementation, with a sample of 149 pre-service Primary teachers, of an active intervention of Cell Biology (based on guided research and in which STS relations are highlighted through Biotechnology). The objective is determine if the positive effect of activities linked to daily life is mediated by emotions. For that purpose, we estimate, using a quantitative self-report test, the intensity with which participants experience a set of emotions. This questionnaire measure 8 positive emotions and 8 negative ones, rated on a Likert scale from 1 "not experienced" to 5 "intensely experienced". Cell Biology contents are assessed through questions about Secondary common misconceptions and TIMSS (Trends in International Mathematics and Science Study) questions. Results show positive associations (Spearman correlation, p-value<0.05) between learning outcomes and the intensities of all examined positive emotions (joy, satisfaction, trust, fun, enthusiasm, gratitude, pride, awe), as well as a negative association between learning results and the intensity of uncertainty. These observations suggest that participants who learn more Biology during the implementation of the active intervention based on STS, are those who feel greater intensities of positive emotions. This interplay between cognitive domain and positive emotions may result key to foster prospective teachers´ learning of science as well as significant to improve their future teaching action.

Keywords: Emotions, Science-Technology-Society, active learning, practical teaching, initial teacher training

1. Introduction

Since Primary Education ending, students describe science as an irrelevant discipline to their daily lives, being a field associated to negative emotions such as boredom, frustration and worry [1]. This situation is really worrying, due to academic emotions have important effects on students' learning outcomes. Research has shown that emotions felt by students control and modify cognitive aspects like attention, memory, learning strategies, language or problem solving [2, 3, 4]. Given this situation, it is necessary to promote the development of motivating activities of science, implementing active practical approaches (based on guided research) and highlighting the connection of science with students´ everyday life (including the interrelationships Science, Technology and Society, STS) [5, 6]. This is particularly important in future Primary teachers training, since the interplay between their emotions and their learning can determine their future professional performance [1]. To deepen these interactions, in this work we analyse the interplay between the emotions felt by a sample of future Primary teachers with the implementation of an active practical intervention of Biology; and the learning outcomes reached with this activity.

2. Methodology

2.1 Sample

A sample of 149 participants (67% female, average age 21.5) was obtained from groups of students enrolled in a Natural Sciences Education subject of the Degree in Primary Education (University of Extremadura, Spain). After the implementation of the practice, participants answered two tests: one on the emotions they felt during the implementation of the active practice, and one about core Biology contents. Students were informed about the goals of the research, procedure, duration and anonymity of their data. Participation was voluntarily and it was possible to withdraw participation at any time.

2.2 Description of performed intervention

Designed intervention is based on DNA extraction using household materials. It is an active practical activity since:

- It is developed under guided research: students research, guided by teacher, and elaborate its own extraction´s protocols
- STS relations are highlighted through Biotechnology applications such as prenatal diagnosis, gene therapy, paternity tests, forensic investigation, food quality control, generation of genetically modified organisms…, including the discussion about their social and ethical aspects.

This practice has been deeply described in a previous contribution [7].

2.3 Instrument to estimate academic emotions

To determine students' emotions towards the practice, we use a simple and fast quantitative self-report questionnaire measuring 8 positive emotions (joyful, trusting, satisfied, enthusiastic, fun, pride, gratitude, awe) and 8 negative ones (worried, frustrated, uncertainty, nervous, bored, fear, shame, disgust). This test was validated in a previous research through factor analysis [7]. Self-reported tests are the most commonly method used, since they are easy to implement, they hardly affect the development of educational activities and provide measures of subjective and verbalized emotional experiences. Emotions were rated on a Likert scale from 1 "not experienced" to 5 "intensely experienced". Students reported their emotions 15 days after the implementation of the intervention.

2.4 Instrument to assess basics of Biology

Biology concepts were assessed through questions about common misconceptions in Secondary school [8, 9, 10, 11] as well as questions extracted from TIMSS (Trends in International Mathematics and Science Study) for Secondary Education [12].

Students answered these questions 15 days after the implementation of the intervention.

2.5 Statistical analysis

Due to data do not follow a normal distribution, Spearman correlation analysis are performed (SPSS program). For the extraction of the factors were used generalized least squares and oblimin rotation.

3. Results and discussion

Results show positive associations (Spearman correlation, p-value<.05) between learning outcomes (measured through Biology test) and the intensities of all examined positive emotions (joy, satisfaction, trust, fun, enthusiasm, gratitude, pride, awe); as well as a negative association between learning results and the intensity of uncertainty (Table 1). These observations agree with several previous researches that revealed that emotional information is better remembered than neutral information [2, 3, 4], especially for positive emotions [13]. These observations suggest that participants who learn more Biology contents with the implementation of the active intervention based on STS, are those who feel greater intensities of positive emotions. This interaction can be observed in Figure 1, which represents the linear regression between test's mark and a factor calculated for all positive emotions. This interplay between cognitive domain and positive emotions may result key to foster prospective teachers' learning of science, as well as significant to improve their future teaching action.

However, this interplay does not allow us to establish a cause-effect interaction; although suggest that positive emotions encourage learning and/or learning improve positive emotions. Then, future researches are required to deep in this interplay and determine a possible causality. Even so, results show that positive emotions felt by a sample of future teachers, during an active activity based on STS, are related to learning outcomes; suggesting that Biology learning may be fostered by raising active practical activities that connect Biology concepts to students' daily lives (using STS relations).

*Table 1: Coefficients of correlation between the intensity of emotions experienced during the implementation of designed intervention and Biology learning outcomes (mark of Biology test). Bolds highlights significant correlations (Spearman correlations, ***p-value<.001, **p-value<.01, *p-value<.05)*

Positive emotions	Correlation with Biology test	Negative emotions	Correlation with Biology test
Joyful	**.198***	Nervousness	-.084
Trust	**.277*****	Boredom	-.134
Satisfaction	**.235****	Frustration	-.103
Enthusiasm	**.241****	Worry	-.060
Fun	**.238****	Uncertainty	**-.163***
Pride	**.239****	Fear	-.076
Gratitude	**.229****	Shame	.087
Awe	**.169***	Disgust	-.069

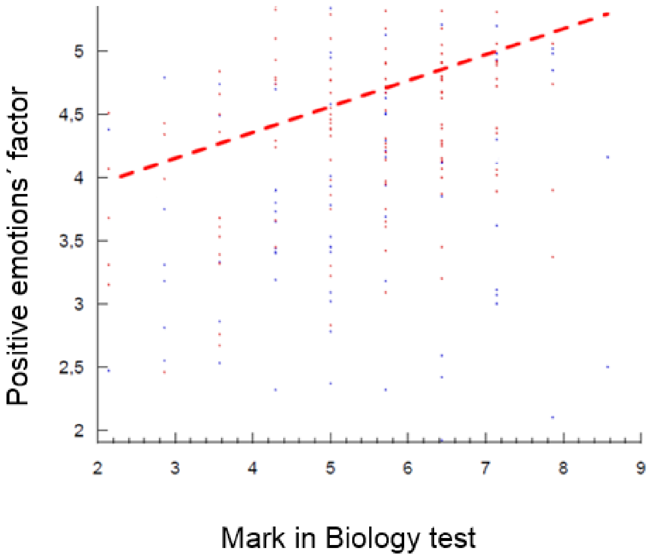

Fig. 1. Linear regression between positive emotions' factor and Biology learning outcomes (Biology test's mark).

4. Conclusion

Results reveal that positive emotions (namely: joy, satisfaction, trust, fun, enthusiasm, gratitude, pride, awe) felt by a sample of future Primary teachers, during the implementation of an innovative active activity based on STS; are related to students' learning outcomes. Due to emotions felt by Primary teachers influence teaching-learning processes, these interactions should be taken into account in initial teachers training.

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Using Video-Based Methods to Teach Rational Number to Prospective Primary School Teachers

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Abstract

The connections between the pedagogical approaches based in the use of video and the didactical models to teach the rational number are a source of great concern to the teachers of our Mathematics Education Department. The TPACK framework provides the appropriate domains and tools needed for the study of this topic. We present activities based in the use of the flipped classroom pedagogical model where the videos are well adjusted to the didactical models based in measure or in quotient. Our prospective primary school teachers were asked to design videos to present different contents to their future pupils or to watch some videos before taking the corresponding lessons. The main findings are related to the difficulties, pedagogical-technical and mathematical, showed by the students on their videos. On the one hand, they used to move from one type of activity to another with not enough explanation or presented too long videos. On the other hand, they presented activities different from the ones they were told. We have found that this video-based activities are related to problem solving strategies and bring out conceptual misunderstandings.

Keywords: TPACK, part-whole, rational constructs, Rational number

1. Introduction

Our prospective primary school teachers are used to work with different technological instruments in their daily life, but these instruments rarely become an essential part of their learning/teaching processes. In some areas, they have been taught about the potential of the use of video-based methods or strategies. Moreover, they look for videos in websites such as youtube, but rarely with a didactic point of view. Thus, the goal of our work is analyse pros and cons that arise when introducing different video-based methods to teach rational number problems. In particular, we use rich and poor video sequences to show didactic issues to our students.

2. Theoretical framework

In this section, we introduce the basic concepts of our framework: the TPACK shows the general domains that our prospective primary school students should cover in our course and some basic facts about the use of internet videos in mathematics.

2.2 The TPACK framework

TPACK (technological pedagogical content knowledge) is the framework that we use to study the prospective primary school teachers knowledge for technology integration as explained in Koehler & Mishra [1]. This framework builds on Lee Shulman's construct of pedagogical content knowledge (PCK) to include technology knowledge. The acronyms in Figure 1 mean:

CK: Teacher's knowledge of the mathematical content, including concepts, theories, ideas, organizational frameworks, etc.

PK: Teacher's knowledge of the processes, practices and methods involved in the teaching and learning of mathematics.

PCK: Teacher's knowledge of the possible adaptations of the mathematical content to its teaching.

TK: Teacher's knowledge that permits him/her to do different tasks using IT and to find different ways of solving a given task.

TCK: Teacher's knowledge of the mutual influences and limitations of technology and content.

TPK: Teacher's knowledge of the changes that technology generates in learning and teaching.

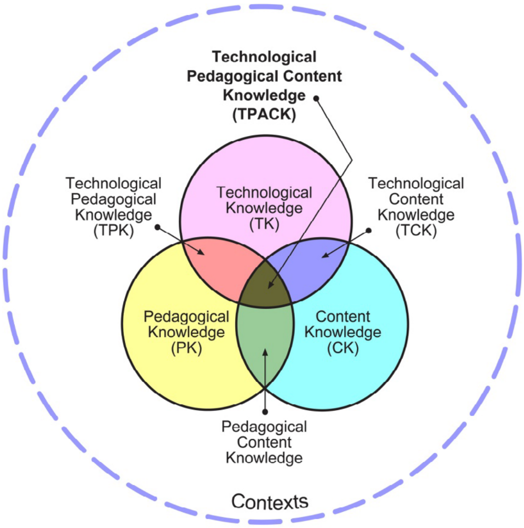

Fig. 1. TPACK diagram. Source: http://tpack.org

2.2 Video in mathematics

There are two different types of videos according to its focus [2]: Recordings of a class, including images of the teacher and digitalized writing systems. In the second group we can find interesting examples: Khan Academy (www.khanacademy.org), an international platform, mostly in English and AINTE Academia a youtube channel of a

Spanish mathematics teacher.

Some previous studies have discussed on the effectiveness of these kind of resources. Our goal in this work is to comment on the didactical approaches of them.

Following the idea explained in [3], our activities (see Figure 2) try to integrate four different types of activities, watching videos, reading documents, participating in on-line debates and writing reports. All of these activities were designed to promote a deeper understanding of the concepts based both in reflection and in mathematical communication.

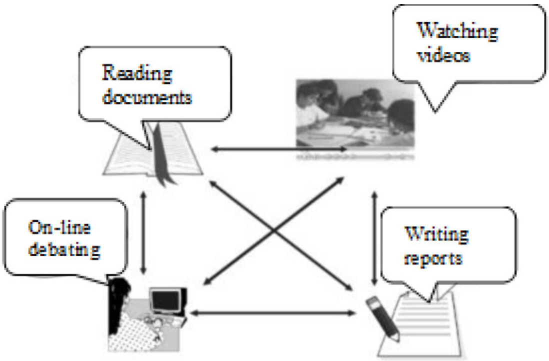

Fig. 2. Methodological structure for the use of video sequences in Mathematics

3. Results

In this section, we present some findings obtained during the experimentation phase. To show them, we describe the use of two video sequences used in our course, corresponding to different approaches: The first approach consists in the viewing of a video sequence, before or after the lesson, it works as an introduction or as a revision of the teachers' explanations. The second approach consist in the recording a video sequence by the prospective primary school teachers after attending the lesson, it promotes a deeper understanding since they have to design the appropriate explanations, activities.

3.1 Using a YouTube video

Many academies have recorded brief explanations as support to their classes and uploaded them to their youtube channels. Our example is a mathematics academy with more than 27.000 followers. In particular, we focus in the video "La fracción como reparto Matematicas 5º Primaria AINTE." designed to support explanations about the interpretation of the fraction as a quotient sub-construct [4] in an equal sharing context (https://.youtube.com/watch?v=M9jsNiGcQiA).

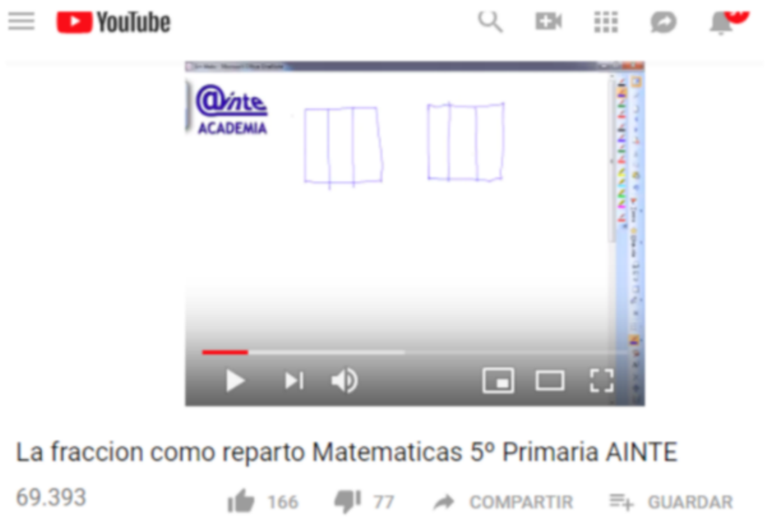

Fig. 3. fractions presented in an equal sharing context video

The author is suposed to explain to his students fractions in an equal sharing context. Students are told that two cakes are evenly distributed among three people.

He divides each cake in thirds. He asks to the students about the fraction of cake that corresponds to each of them. With this question he is isolating the numerical solution from the magnitude involved (weight or area in this case). Thus, the author is asking only for a number, not for the quantity of magnitude that corresponds to each person.

Finally, to solve the problem, the author changes the unit from «cakes» to «parts», where each part corresponds to one third of cake. To give the answer, he counts the number of «parts» and he divides it by the number of people, (see Fig 4, left) being his final answer «two parts».

Instead of this process, he should have used a one-phase technique, giving one third of each cake to each of the three persons, (see Fig. 4, right). The answer, would be given in terms of the original unit «cake» 1/3+1/3=2/3 of cake.

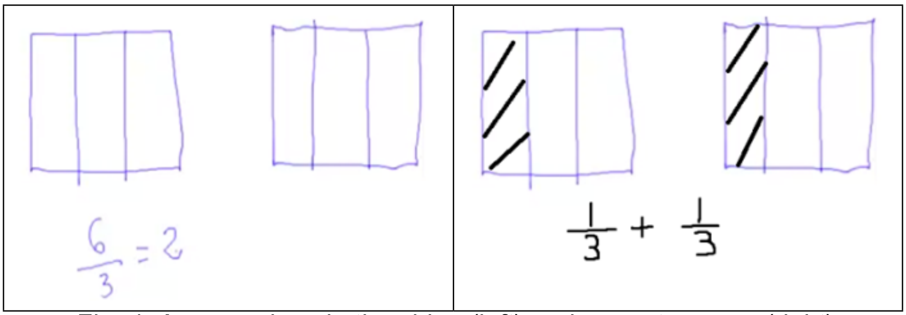

Fig. 4. Answer given in the video (left) and correct answer (right)

Afterwards, the author poses similar problems using the same technique and using the "part" as a unit. This unit corresponds in the following problem with one fifth of the cake, generating a bigger confusion since the same name corresponds in the new problem with a different unit.

Along with the viewing of this video some questions were posed by using the Edpuzzle software (https://edpuzzle.com/). See Figure 5 as an example of an intermediate question, posed right after the teacher in the video asked to their students: what fraction of cake corresponds to each person? instead of how much cake...? (Pedagogical Content Knowledge)

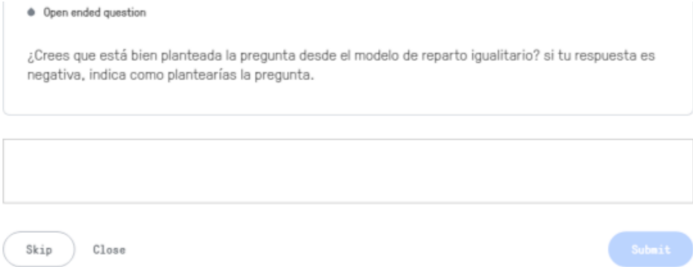

Fig. 5. Example of an open ended question (Do you think the question is well formulated according to the quotient/equal sharing sub-construct? If not, write an alternative question)

37% of our prospective primary school teachers gave correct answers.

After considering the correctness of the question, we asked about the actual solution of the problem (Content Knowledge) with the same percentage of correct answers. Considering the errors, some students answered "2/3" without any reference to the unit or "1/3 of each cake, thus 2/3 of both cakes" changing the unit from one cake to the whole.

3.2 Recording a new video

Once the researcher explained in class the different measurement situations that guide the teaching of the measure of magnitudes in primary school, prospective primary school teachers were asked about recording a 3 minutes video with examples of one of the studied situations.

Fig. 6. Student A Calculates the measure of the area of a rectangle using an arbitrary unit.

In the analyzed videos, prospective primary school teachers used a wide range of easy-to-handle materials and they use to propose easy situations to explain different measurements situations.

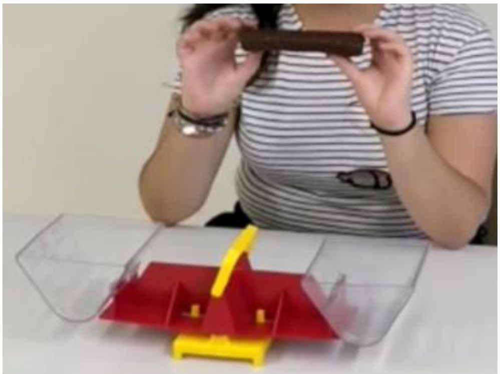

Fig. 7. Student B Constructs two modeling clay blocks that weight half of the given block

We also observed a great trend to use a traditional teaching model: before explaining the measurement situations and activities, they gave a series of theoretical explanations they were not suppose to deliver. The fact is that most of them seemed uncomfortable teaching even simple activities without these previous explanations.

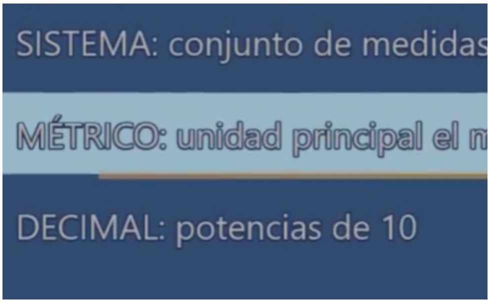

Fig. 8. Student A Previous explanations about the Metric System

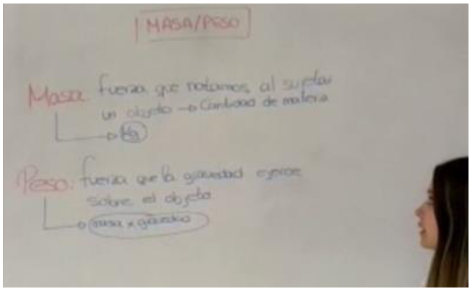

Fig. 9. Student B distinguish between mass and weight magnitudes

4. Conclusion

From a pedagogical-technological point of view (TPK): Our prospective primary school teachers found very pleasing these activities. They considered very interesting to watch and analyze the way actual teachers deliver their lessons. Specially, the possibility of watching them many times paying attention to different details. On the other hand they complain about not being possible to ask for details to the teacher in the video. Considering the Mathematical parts of the activity (CK), they indicate that teacher's explanations lead them to incorrect answers since they got convinced by them. The use of video-based activities has permitted to our prospective primary school teachers analyze their professional practices when explaining concepts related to rational numbers.

Our analysis of these activities points out to the following conclusions: watching actual teaching sequences enables our students to acquire some analysis strategies. These strategies could be used for the analysis of its own professional practice. In particular, they can realize how the part-whole sub-construct limits the use of other sub-constructs.

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