International Conference

NEW PERSPECTIVES IN SCIENCE EDUCATION

9th Edition

Florence, Italy

19 - 20 March 2020

Conference Proceedings

Edited by Pixel

International Conference New Perspectives in Science Education

filo diritto editore DAL 2008

PIXEL

INTERNATIONAL CONFERENCE PROCEEDINGS

NEW PERSPECTIVES IN SCIENCE EDUCATION
9th Edition

(19-20 March 2020)

FILODIRITTO INTERNATIONAL

filo diritto editore DAL 2008

Log in to find out all the titles of our catalogue
Follow Filodiritto Publisher on Facebook to learn about our new products

ISBN 978-88-85813-90-8
ISSN 2384-9509
DOI 10.26352/E319_2384-9509

First Edition March 2020

filodirittoeditore.com
inFOROmatica srl, Via Castiglione, 81, 40124 Bologna (Italy)
inforomatica.it
tel. 051 9843125 - Fax 051 9843529 - commerciale@filodiritto.com

Publication Ethics and Malpractice Statement

The New Perspectives in Science Education Proceedings, edited by Pixel and published by Filodiritto Editore, is a collection of international peer reviewed Conference Proceedings committed to upholding the highest standards of publication ethics. In order to provide readers with Proceedings of highest quality we state the following principles of Publication Ethics and Malpractice Statement.

1) Editorial Board

Pixel, the Chief Editor, coordinates the Editorial Board whose members are recognized experts in the field of innovation in education. The Editorial Board members are the experts involved in New Perspectives in Science Education' Conference Scientific Committee. The full names and affiliations of the members of the Editorial Board/Scientific Committee are provided in the related section of the Conference Web Site. The Editorial Office is based at Pixel, Via Luigi Lanzi 12, I-50134 Firenze, Italy.
Email: science@pixel-online.net

2) Authors and Authors responsibilities

Authors are obliged to participate in the papers' peer review process, responding to the reviewers' feedback and making the requested corrections, retractions, modifications and/or integrations.

All authors must have significantly contributed to the research work for the paper's production providing real and authentic data.

Authors must have written original papers and are aware that it is forbidden to republish the same paper.

Authors must provide the list of references and disclose all sources of financial support.

Fees required for manuscript processing and publishing are stated on the Conference Registration page.

3) Peer-review process

Pixel, as the Chief Editor, ensures a fair double peer-review of the submitted papers for publication.

Peer-review is defined as obtaining advice on individual papers from reviewers' expert in the field.

Papers submitted to New Perspectives in Science Education Proceedings go through, first of all, an internal review and if they meet the basic requirements, they are sent out for review by experts in the field, who are members of New Perspectives in Science Education Scientific Committee. The Peer reviewers evaluate and give advice on the papers.

The paper review process is clearly described below.

The reviewers evaluate the submitted papers objectively and present their opinions on the works in the Review Form. Reviewers evaluate papers based on content without regard to ethnic origin, gender, sexual orientation, citizenship, religious belief or political philosophy of the authors. A reviewer who feels unqualified to review the research reported in a manuscript notify the Editor and excluses herself/himself from the review process.

The Chief Editor strives to prevent any potential conflict of interests between the author and the reviewers. Reviewers should identify relevant published work that has not been cited by the authors. If a reviewer finds any substantial similarity or overlap between the submitted manuscript and any other published works, she/he should inform the Chief Editor. Private information or ideas obtained through reviewing the paper must be kept confidential by the reviewers and not used for personal advantage. Papers received for review must be treated as confidential documents. Without any authorization by the Chief Editor, the information of the submitted paper must not be shown to, or discussed with, others.

4) Publication ethics

The Reviewers must report to the Chief Editor any identified plagiarism, research fabrication, falsification and improper use of humans or animals in research. The Chief Editor strives not to allow any misconduct.

In the event that there is documented misconduct the following sanctions will be applied:

- Immediate rejection of the infringing paper.
- Immediate rejection of every other paper submitted to in New Perspectives in Science Education Proceedings by any of the authors of the infringing paper.
- Prohibition against all of the authors for any new submissions to New Perspectives in Science Education Proceedings, either individually or in combination with other authors of the infringing manuscript, as well as in combination with any other authors. This prohibition will be imposed for a minimum of three years.
- Prohibition against all of the authors from serving on the Editorial Board (Scientific Committee) of New Perspectives in Science Education Proceedings.

In cases where the violations of the above policies are found to be particularly outrageous, the Chief Editor reserves the right to impose additional sanctions beyond those described above.

Guidelines for retracting articles are the following:

- Retracting article will be considered if there is clear evidence that the findings are unreliable, either as a result of misconduct, honest error, plagiarism, or if the paper reports unethical research.
- The main purpose of retractions is to correct the literature and ensure its integrity.
- Notices of retraction will be promptly published on the online version of the Proceedings available on New Perspectives in Science Education Conference website and linked to the retracted article, accurately stating the information of the retracted article and the reason(s) for retraction.
- Articles may be retracted by their author(s) or by the Chief Editor (Pixel). The Chief Editor has the final decision about retracting articles. The Chief Editor will retract publications even if all or some of the authors refuse to retract the publication themselves in case of unethical behaviour.

Authors who wish to enquire about publication of a correction for their article, or who have serious concern that they believe may warrant retraction, should contact the Chief Editor.

5) Copyright and Access

Copyright and licensing information is clearly described in New Perspectives in Science Education website at Release for Publication.

The electronic version of the Conference Proceedings will be shared to all the registered participants who paid the registration fee.

6) Archiving

New Perspectives in Science Education Proceedings books are digitally archived on **Google Scholar** and **Academia.edu**

7) Ownership and management

New Perspectives in Science Education Proceedings are managed and edited by Pixel and published by Filodiritto Editore.

8) Website

New Perspectives in Science Education Conference website demonstrates that care has been taken to ensure high ethical and professional standards. It does not contain any misleading information, including any attempt to mimic another journal/publisher's site.

9) Publishing schedule

New Perspectives in Science Education Conference Proceedings are published yearly.

10) Name of journal

The proceedings' name New Perspectives in Science Education is unique and cannot be easily confused with another journal. These proceedings have ISSN code from CNR.

INDEX

Biomedical Science and Health

The HOPE Online Course on Oncogenetics

Anca Colibaba[1], Irina Gheorghiu[2], Ovidiu Ursa[3], Anais Colibaba[4]
Grigore T. Popa University Iasi/EuroED Foundation, Romania[1]
Albert Ludwigs University Freiburg, Germany[2]
Iuliu Haţieganu University of Medicine and Pharmacy Cluj, Romania[3]
Trinity College Dublin, Ireland[4]

Abstract

The article is based on the open online course promoted by the Hope project. The project is funded by the European Commission (under the Erasmus+ programme) being implemented within an international partnership from Bulgaria, France, Hungary and Romania. The main objective of the HOPE project (2018-1-RO01-KA202-049189) is to highlight the role of oncogenetics, a medical branch, in the early detection and prevention of cancer. The article gives insights into the open online course on oncogenetics which will definitely enable students to acquire advanced knowledge, competences and professional experience in the field of oncogenetics. Following the successful experience of other projects, a MOOC has been used as a way of conveying information and implementing it on a larger scale. Students will get training in theoretical and practical clinical, epidemiological and biological oncogenetics. The joint efforts of all partners involved (healthcare centres, universities, non-governmental educational organisations and IT centres) will also contribute to the collaboration between oncogenetics specialists, departments and medical specialists and family doctors and medical centres for the benefit of patients and their families.

Keywords: oncogenetics, cancer, detection and prevention, MOOC, students

1. European Context

Every day worldwide millions of people fight cancer going through therapies that hugely impact their quality of life. Over the next 2 decades, the number of new cases is expected to rise by about 70% [1]. Oncogenetics is a new branch of medicine that can change this future scenario by monitoring the genetic predispositions of people with mutations or family histories of cancer. The objective of oncogenetics is to understand genetic predisposition to cancers and care for persons at risk. The purpose of a genetic consultation is to determine the share of family history and possible predisposition.

Genetic tests, seldom practiced, sometimes confirm a hereditary origin. If an alteration is identified in a family, it can be sought in its relations. This makes it possible to reassure those having no predisposition and following up those at risk.

2. The HOPE Project

The HOPE project (2018-1-RO01-KA202-049189) raises awareness about the importance of oncogenetics and the role it can play in the early detection and prevention of the disease.

The project aims to:

- do research on situations, strategies, best practices of oncogenetics at Central and East European level
- create profiles of specialists in oncogenetics
- devise a training guide to advanced high-specialized intervention in oncogenetics
- create an Open Online Course on Oncogenetics
- create HOPE Mobile APP (iOS & Android), which will keep people informed about cancer risk.

The project's target groups are medical specialists: specialists in oncogenetics, oncogenetics advisers, psychologists, oncologists, gynaecologists, epidemiologists, geneticists, surgeons, specialists in molecular biology, bioethics specialists and medical management, patients and their families at risk of hereditary or familial cancer, medical institutions, lecturers in medicine (Medical Universities) – educational centres and public at large [2].

3. The HOPE MOOC

3.1 Main principles of a MOOC

Since 2000 the development of technology has significantly impacted every field of education, highlighting the need for openness and accessibility in education. The innovative online courses, MOOCs, have met this need. The MOOC of the Hope project tries to meet academic needs of the medical universities. The Hope MOOC relies on the pedagogical principles underlying any MOOC [3]:

Competence-Based Design Approach. The Hope MOOC focuses on outcomes of learning and addresses what the learners are expected to do, what competences they are expected to develop.

Learner Empowerment. The MOOC design favours a learner-centred approach, where students are active participants.

Learning plan and clear orientations Students are given a study plan and details as to how to carry out the activities of the MOOC.

Collaborative learning. Students are encouraged to collaborate with their peers in teamwork activities and discussion forums.

Social networking Social interaction and frequent contact between students are encouraged.

Peer assistance is also valued through peers' support and comments.

Quality criteria for knowledge creation and generation Quality criteria for content development and content selection are provided. Creation of knowledge is appreciated.

Interest groups. The approach provides opportunities for small group discussion and exchange.

Assessment and peer feedback Participants are provided with objective and precise criteria and explanation, rubrics, scales, and explanatory automatic answers.

Media-technology-enhanced learning Students are offered a variety of rich-media for capturing their attention and retention.

3.2 The Hope MOOC: General Elements; Oncogenetic monitoring

The Hope MOOC provides students and those interested with a training guide for highly specialized interventions in oncogenetics. Its main topics are as follows: cancer epidemiology, risk factors, essential clinical elements in hereditary cancer, the basics of human genetics, molecular oncogenetic diagnosis, psychological and ethical issues, selection criteria, bioethics issues, psychological counselling in oncogenetics monitoring, clinical practice etc.

3.2.1 Cancer epidemiology

The paper gives a few insights into descriptive epidemiology of cancers.

Cancer epidemiology is the study of the distribution, determinants, and frequency of malignant disease in specific populations in order to define causative factors (including preventable/ avoidable causes and inherited tumour susceptibility) and to formulate preventive strategies for the disease control [4].

3.2.2 Risk factors of cancers

Any factor that increases the likelihood of an event to occur, the cancer in this case, is called risk factor and the factors that decrease the chance of developing this event are called protective factors. According to IARC (International Agency for Research on Cancer) and World Cancer Research Fund (WCRF)/American Institute for Cancer Research (AICR), the risk (RF) or protective (PF) factors for cancer can be divided into the following categories depending on the type of evidence identified in the specialty literature [5]:

- factors that increase the risk (sufficient or convincing evidence);
- factors that could increase the risk (limited or probable evidence);
- factors that reduce the risk (sufficient or convincing evidence);
- factors that could increase the risk (limited or probable evidence).

Factors known to increase the risk of cancer include: smoking, infections, radiation, immunosuppressive drugs, etc.

Factors that could increase the risk of cancer include: diet, alcohol consumption, physical activity, obesity, carcinogens in the environment, etc (Table1).

Also, some of these risk factors can be avoided, while the action of others cannot be influenced, thus the risk factors are divided into modifiable risk factors (smoking, diet, number of births, etc.) and unchangeable (genetic factors, age, sex, etc.) [6].

Table 1. *Cancer Risk factors*

Tobacco • Smokeless tobacco, environmental tobacco smoke	*Radiation* • Ionizing and ultraviolet radiation, radon and its by-products
Alcohol	*Medications*
Diet • High animal – fat intake; aflatotoxins; deficiencies in vitamins A and C and beta-carotenes	*Infection* • Bacterial *(Helicobacter pylori)* • Parasites *(Schistosoma haematobium, Clonarchissinensis)* • Viral (Epstein-Barr virus, hepatitis B and C viruses, HIV, HPV, human T-lymphotropic virus type 1)
Occupational exposures • Aromatic amines, arsenic, asbestos, nickel, pesticides, polycyclic hydrocarbons, vinyl chloride, wood dusts, others	*Genetic susceptibility*

3.2.3 Protective factors for cancers

Diet. A person's diet may contain foods that increase the risk of cancer and foods that reduce this risk. Some studies support the hypothesis that diet rich in starch-free vegetables and fruits can provide protection against oral, oesophageal and gastric cancers. Also, fruit consumption can protect against colorectal cancer [7].

Physical activity. Research shows that there is a strong relationship between physical activity and decreased risk for colorectal cancer. There is scientific evidence that sustain the protection of physical activity against postmenopausal breast cancer and endometrial cancer. Among the protective factors for breast cancer are: breastfeeding (the risk decreases by 4% for every 12 months of breastfeeding); physical activity; celiac disease; regular intake of aspirin or nonsteroidal anti-inflammatory drugs (NSAIDs); diet (consumption of fruits and vegetables; fiber; carotenoids; soy; mushrooms; coffee); hysterectomy with ovariectomy (performed before menopause reduces the risk by 24-41%).

Regarding the ovarian cancer, risk-lowering factors include: multiparity; breastfeeding (decreases risk by 24%); the use of OC (reduces the risk by 25-28%); hysterectomy (decreases risk by 27-31%); ovariectomy; tubal ligation (30% risk reduction); the use of statins (decreases risk by 21%); the presence of erythematosus systemic lupus (decreases the risk by 34%); consumption of starch-free vegetables.

Protective factors for colorectal cancer include: physical activity; hormone replacement therapy (decreases risk by 16%); the use of OC (decreases risk by 14%); daily use of aspirin (a period of 5 years or more decreases the risk by 32-49%); Parkinson's disease (decreases risk by 24%); diet (rich in fiber, garlic, milk, calcium) is a factor that is likely to decrease the risk for colorectal cancer.

The European Code Against Cancer suggests 12 ways to reduce cancer risk:

Do not smoke. Do not use any form of tobacco.

Make your home smoke-free. Support smoke-free policies in your workplace.

Take action to be a healthy body weight.

Be physically active in everyday life. Limit the time you spend sitting.

Have a healthy diet:

- Eat plenty of whole grains, pulses, vegetables and fruits.
- Limit high-calorie foods (foods high in sugar or fat) and avoid sugary drinks.

If you drink alcohol of any type, limit your intake. Not drinking alcohol is better for cancer prevention.

Avoid too much sun, especially for children. Use sun protection. Do not use sunbeds.

In the workplace, protect yourself against cancer-causing substances by following health and safety instructions.

Find out if you are exposed to radiation from naturally high radon levels in your home.

- Take action to reduce high radon levels.

For women:

- Breastfeeding reduces the mother's cancer risk. If you can, breastfeed your baby.
- Hormone replacement therapy (HRT) increases the risk of certain cancers.
- Limit use of HRT.

Ensure your children take part in vaccination programmes for:

- Hepatitis B (for new-borns)
- Human papillomavirus (HPV) (for girls).

Take part in organised cancer screening programmes for:

- Bowel cancer (men and women)

- Breast cancer (women)
- Cervical cancer (women).

4. Conclusions

The project aims at optimising students' access to the real medical situations by connecting students' academic knowledge and skills with real medical activity. The HOPE MOOC meets a vital need in monitoring the genetic predispositions of people with mutations or family histories of cancer. It is based on well documented and generally accepted educational tools and establishes a unitary system of medical education in oncogenetics across Europe. The project encourages the flow and exchange of knowledge between higher education institutions and stimulates the collaboration between higher education institutions and the world of work (hospitals and clinics).

In addition, by developing the MOOC course the project enhances the ICT component of the teaching and learning process, which will increase the prestige and the profile of the medical universities from Europe internationally. Through international cooperation between education and training providers and other stakeholders (such as hospitals and clinics) the project generates and promotes innovation, at the level of medical education institutions.

Acknowledgements
This paper is based on a study of the HOPE project (Erasmus+ programme/ 2018-1-RO01-KA202-049189/ Field: Strategic Partnerships for vocational education and training), funded by the European commission.

REFERENCES

[1] *** International Agency for Research on Cancer. GLOBOCAN 2018. *Globocan cancer observatory.* Retrieved from: http://gco.iarc.fr (10 January 2020).
[2] The Hope project, Retrieved from https://hope.projects.umfiasi.ro/ (20 January 2020)
[3] Guàrdia, L., Maina, M., Sangrà, A., (2013). MOOC Design Principles. A Pedagogical Approach from the Learner's Perspective, Retrieved from https://www.researchgate.net/publication/239608003_MOOC_Design_Principles_A_Pedagogical_Approach_from_the_Learner's_Perspective
[4] Matei M, Azoicăi D. Epidemiologia cancerelor. În: Prisecari V: *Epidemiologie specială*. SA “Tipografia Reclama”, Chişinău, 2015, pp. 369-392. ISBN 978-9975-58-024-3.
[5] International Agency for Research on Cancer. GLOBOCAN 2018. Retrieved from (http://gco.iarc.fr./today/data/factsheets/cancers/39-All-cancers-fact-sheet.pdf).
[6] dos Santos Silva I. *Cancer epidemiology: principles and methods*. International Agency for Research on Cancer. Lyon, France, 1999. Retrieved from: https://publications.iarc.fr/Non-Series-Publications/Other-Non-Series-Publications/Cancer-Epidemiology-Principles-And-Methods-1999.
[7] Huxley RR, Ansary-Moghaddam A, Clifton P, *et al.*, The impact of dietary and lifestyle risk factors on risk of colorectal cancer: a quantitative overview of the epidemiological evidence. Int. J Cancer 2009; 125 (1): pp. 171-180.

Chemistry Education

Catalysis for Sustainability: (Electro)catalytic and Electrosynthetic Processes for Science Education

Christoph Weidmann[1], Felix Maiwald[2], Tim Will[3], Philipp Lanfermann[4], Thomas Waitz[5]
Institute of Inorganic Chemistry, Georg-August-University Göttingen, Germany[1,2,3,4,5]

Abstract

In this work, we present facile experiments for the introduction of electrocatalysis and organic electrosynthesis in science education. In particular, electrocatalytic waste water treatment using the Electro-Fenton reaction is discussed as well as the electropolymerization of non-hazardous aniline derivatives. Thereby, we show exemplified applications for their use in electrochromic windows and as an organic battery electrode.

Keywords: Electrochemistry, electrosynthesis, electrochromism, polymerization, battery

Introduction

Our society is currently facing increasing challenges regarding sustainable production, use of resources and the clean and efficient supply of energy. The scientific community is addressing these issues in various ways, ranging from fundamental research to applied sciences and engineering. However, these efforts are often not sufficiently visible for and communicated to the interested public.

One promising approach to develop sustainable and energy efficient processes on laboratory and industrial scale is the use of electrical energy to drive chemical reactions.

The increasing share of renewable power sources available on the grid, will let such processes directly benefit from the ongoing transition of the energy sector from fossil fuels to CO_2-neutral sources.

In order to develop opportunities for teaching the use of electrical energy in science and industry, the possible applications can be classified into three main categories:

(a) The in-situ generation of an active species instead of adding it from external sources (electrocatalysis), (b) the electrochemical synthesis of a specific product (electrosynthesis) and (c) electrically switchable functional materials. This work is therefore divided into two parts. The first about experiments regarding electrocatalysis for waste water treatment and the latter focusing on categories b and c, demonstrated by the synthesis and electrochromism of an organic polymer as well as a copolymer-based rechargeable battery.

One well-known example for an electrosynthetic process is the electropolymerization of aniline, yielding a conductive organic polymer. However, the use of aniline may be prohibited or at least not favourable for school experiments due to its high toxicity and carcinogenicity. Therefore, we present experiments based on less harmful derivatives to demonstrate electrosynthesis and the unique features polyaniline can provide for chemical education.

1. Waste Water Treatment by Electrocatalysis: The Electro-Fenton Reaction

Waste water can be contaminated with a variety of inorganic and organic pollutants, both either from industrial and household sources. Apart from more or less physical separation processes (filtration, precipitation of heavy metal ions) and adsorption on activated carbon, the removal of organic pollutants is mostly carried out by oxidation processes, yielding less harmful products than the original biocide or pharmaceutical residue. To achieve this oxidative decomposition, chemicals like ozone have to be added to the waste water. One very reactive and efficient oxidant is the hydroxyl radical which can be *in-situ* generated from hydrogen peroxide by catalysis with Fe (II) ions, commonly known as the Fenton reaction. Since the electrochemical generation of hydrogen peroxide is also possible (known as the Electro-Fenton reaction), is considered to be used for waste water treatment on industrial scale [1], [2] we present an experiment demonstrating this potential application with food colorant dye as a model pollutant.

1.1 Decomposition of organic dyes via Electro-Fenton reaction

300 mL of 0.1 M sodium sulphate solution were adjusted to pH 3 using sulphuric acid and a small amount of model dye (most suitable are non-toxic food colorants) was added.

After dissolving 5 mg of Iron (II) sulphate, a voltage of 1 V was applied between two graphite electrodes using a laboratory power supply and the solution was continuously stirred. After 20 minutes, it could clearly be observed, that the solution has been decolorized significantly due to the electrocatalytic oxidation.

The occurring reaction can be described as follows. Hydrogen peroxide can be generated by reduction of oxygen on the cathode and via oxidation of water on the anode:

$$O_2 + 2\,H^+ + 2e^- \rightarrow H_2O_2$$
$$2\,H_2O \rightarrow H_2O_2 + 2e^- + 2\,H^+$$

Fe (II) ions react with hydrogen peroxide to give hydroxyl radicals and Fe(III). The iron ions can be reduced afterwards to Fe (II) again, either electrochemically or by reaction with hydrogen peroxide:

$$\mathrm{Fe^{3+}(aq)} + e^- \rightarrow \mathrm{Fe^{2+}(aq)}$$
$$Fe^{3+}(aq) + H_2O_2(aq) \rightarrow Fe^{2+}(aq) + HO_2^{\cdot}(aq) + H^+(aq)$$

The oxidative decomposition of the dye is then caused by the mentioned hydroxyl radical, destroying the delocalized electronic system (and thereby bleaching the dye).

This simple experiment can be easily extended in order corroborate the proposed mechanism. First of all, the addition of hydrogen peroxide to the solution without applying voltage leads to the same decolorization as observed before, giving hints for the important role of hydrogen peroxide in this reaction. On the other hand, both the addition of hydrogen peroxide as well as the *in-situ* generation of this oxidant does not lead to decolorization without using the Fe (II) catalyst, suggesting the hydroxyl radical as the active oxidant

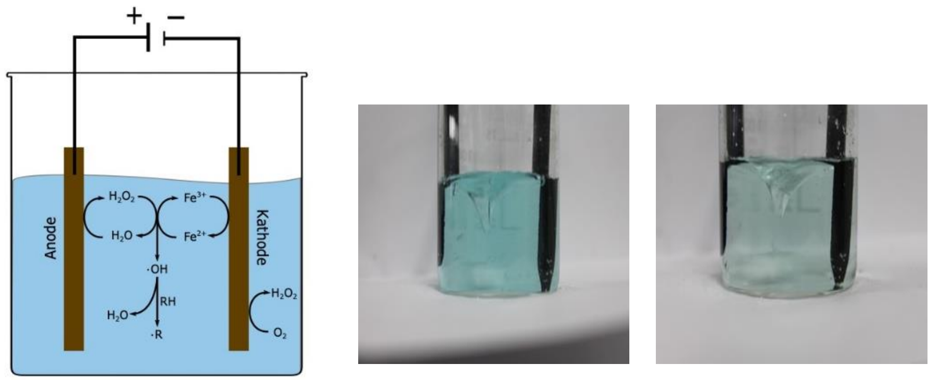


Fig. 1. *Schematic diagram of the Electro-Fenton reaction (left) and image of dye solution before applying voltage and after 20 minutes (right)*

The presented experiment offers the opportunity to demonstrate that electrosynthetic methods can be developed to help protecting the environment. The usage of electrical energy directly without the need to store chemicals like ozone, hydrogen peroxide or other potentially hazardous substances can emphasize the future importance of such processes. Furthermore, by understanding the reaction mechanism, the students can learn, that such processes are often a chain of several reactions, were one significant step can be promoted via electrochemistry. In this case, it is the generation of hydrogen peroxide, which then undergoes a conventional Fenton reaction, ultimately leading to oxidation of the model pollutant.

2. Electropolymerization of Aniline Derivatives

The electropolymerization of aniline derivatives is known in the scientific literature but was not yet discussed in context of science education. Although the additional functional groups may alter the properties of the resulting material and lead to a more complex system, we believe that poly (*m*-aminophenol) and poly (*p*-aminobenzoic acid) are very favourable systems for demonstrating electropolymerization, electrochromism and electrochemical activity in rechargeable model batteries.

The electropolymerization will be carried out in acidic aqueous solution with a graphite counter electrode and conductive FTO-coated (fluorine-doped tin oxide) glass slides as the working electrode. This allows an easy observation of the coloured thin polymer film as well as its change during electrochemical experiments.

3. Electropolymerization of *m*-aminophenol, *p*-aminobenzoic Acid and Aniline Copolymers

0.82 g *p*-aminobenzoic acid (7.5 mmol) was dissolved in 75 mL 0.5 M sulphuric acid.

Both the graphite and the FTO-coated glass electrode were thoroughly cleaned with water and acetone and connected to a DC power supply (working electrode as anode, graphite as cathode). The electrodeposition was carried out for 10 minutes using a voltage of 3.0 V under vigorous stirring.

After several seconds, the formation of a dark thin film consisting of poly(*m*-aminophenol) can be observed which continuously grows in thickness as the electrodeposition proceeds.

The electropolymerization of *p*-aminobenzoic acid can be carried out according to the same procedure. However, due to the lower solubility, the concentration of monomer was only 0.01 M. Therefore, 0.1 g of *p*-aminobenzoic acid (0.73 mmol) was dissolved in 75 mL 0.5 M sulfuric acid.

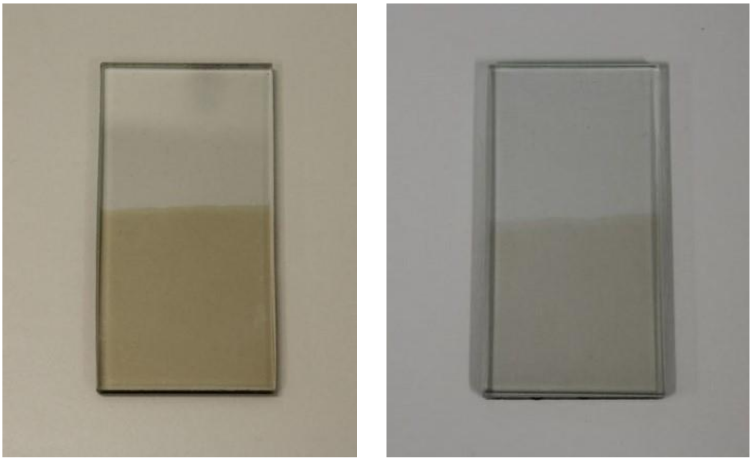


Fig. 2. *Poly (m-aminophenol) (left) and poly (p-aminobenzoic acid) thin films on FTO-coated glass slides*

The electropolymerization of a polyaniline/poly (*p*-aminobenzoic acid) copolymer was carried out according to an identical procedure with a molar ratio of 1:1 of aniline and *p*-aminobenzoic acid.

3.1 Determination of electric conductivity

For measuring the electric conductivity of the polymer film, we suggest to use an AC power supply combined with an amperemeter since DC measurements do not yielded reproducible result. Most likely this is caused by the measurement voltage, leading to oxidation and reduction of the polymer film, respectively and thereby changing its conductivity.

Both polyaniline derivatives subject to this study, exhibit a significantly lower electric conductivity than polyaniline itself. However, the lower toxicity avoids hazardous substances and allows the application of this experiments in chemistry classes.

3.2 Demonstration of electrochromism

A polymer-coated FTO-electrode was placed in a 100 mL beaker filled with 0.05 M sulphuric acid and a graphite counter electrode. The polymer electrode was connected as the cathode to a power supply and electrochemically reduced. For *p*-aminobenzoic acid films, a potential of 3.0 V vs. graphite was applied, while the electrochromism of *m*-aminophenol could be observed already at a potential of only 1.2 V. The reversibility of this process can be easily shown multiple times by simply reversing the polarity.

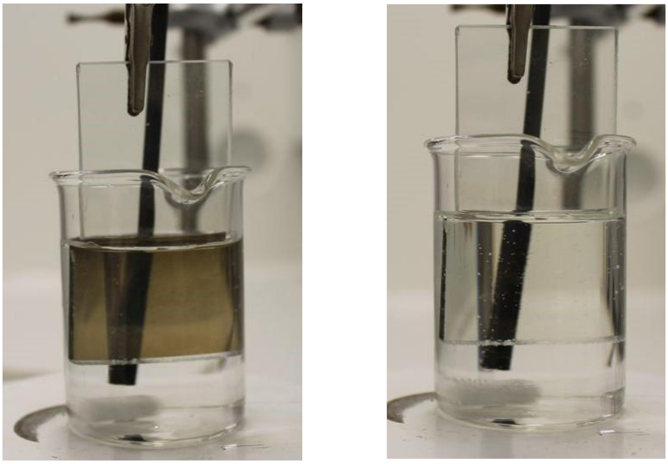


Fig. 3. *Poly (p-aminobenzoic acid) on FTO-coated glass slides after reduction (left) and oxidation (right), both by applying a potential of 3.0 V*

3.3 Poly (p-aminobenzoic acid)/Polyaniline-Zinc-battery

Both aqueous and nonaqueous polyaniline batteries are known and for providing a simple experiment, we chose to use an aqueous system using a zinc counter electrode which was reported in [3] for a similar copolymer.

The FTO electrode coated with polyaniline/poly (*p*-aminobenzoic acid) copolymer was placed in a 100 mL beaker filled with 75 mL of a 0.5 M ammonium chloride and 1.0 M zinc chloride solution. A Zinc rod was cleaned using abrasive paper and used as anode, while the polymer film was connected as cathode, resulting in an open cell voltage (OCV) of approx. 0.9 V. The cell was charged by applying 1.7 V for 15 seconds.

After disconnecting the power supply, the OCV reaches an equilibrium potential of approx.

1.25 V and can be used to drive a small electric motor. The connection of two cells in series (either in a common or separated electrolyte) allows the operation of a red LED as well. Since the battery operation is based on oxidation and reduction of the polyaniline-copolymer, a colour change can be observed during charge and discharge, allowing to determine the state of charge visually.

By regulating the charge/discharge voltage to maintain a low constant current, a charge and discharge curve can be recorded as shown in Figure 4.

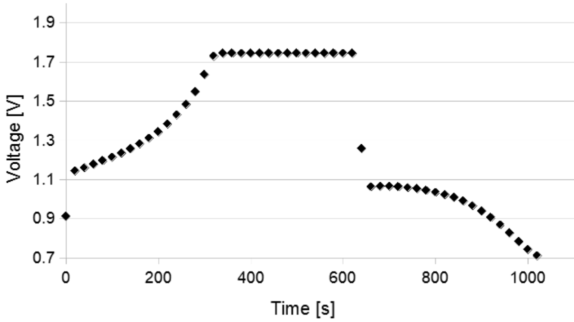


Fig. 4. *Voltage profile of a polyaniline/poly (p-aminobenzoic acid)-zinc-battery during charge and discharge (I = 0.1 mA, charge termination when I = 0.01 mA, discharge cut-off voltage 0.7 V)*

We believe the presented set of experiments to be a very valuable system to teach the fundamentals of electrosynthesis and electrochromism.

First of all, the polymerization can essentially be understood as an oxidation process of aniline or its derivatives, which can be easily determined via calculating oxidation states of the involved atoms in the monomeric and polymeric structure. Furthermore, the resulting polymer exhibits electrical conductivity which might seem to be counter-intuitive for the students but allows to communicate an easy to understand model of a conduction mechanism additionally to metallic and ionic conduction processes described by Banerji *et al*., [4] This mechanism explains the conductivity as a two-step process: The transport of charge through the delocalized π-system and a hopping mechanism from one polymer chain to the next one. Therefore, it is easily understandable, that the conductivity should improve with a higher molecular mass of the polymer since less hopping processes have to occur. This may also be the reason for the lower conductivity of the polyaniline derivatives, which are described to be consisting of shorter chains when compared to polyaniline.

Polyaniline itself can be oxidized and reduced to various states which can be distinguished by their colour. This allows to transfer the student's knowledge that altering a delocalized π-system results in changes of the adsorption properties (known from pH indicators) to this oxidation and reduction processes in the polymer. Additionally, the observed electrochromism can be used to connect this insight to real world applications like electrochromic windows used for example in the Boeing 787 Dreamliner and to introduce the term "functional material".

The reversible oxidation and reduction of polyaniline also offers the opportunity to use it as an electrode material in rechargeable battery systems which are gaining more and more importance for portable electronics, electromobility and grid storage of renewable energy.

REFERENCES

[1] J. Casado, *Journal of Environmental Chemical Engineering,* 7, Nr. 1, pp. 1-15, 2019.

[2] E. Brillas, I. Sirés, M. Oturan, *Chemical Reviews,* 109, Nr. 12, pp. 6570-6631, 2009.

[3] M. S. Rahmanifar, M. F. Mousavi, M. Shamsipur, *Journal of Power Sources*, 110, pp. 229-232.

[4] A. Banerji, M. W. Tausch, U. Scherf, CHEMKON, 19, pp. 7-12

Chemistry for Medical Students: How to Foster Students' Engagement?

Ingo Mey[1]
Georg-August-University Göttingen, Institute for Organic and Biomolecular Chemistry, Germany[1]

Abstract

Teaching chemistry as a minor subject at universities is often cumbersome as the students' engagement is generally low due to low acceptance of the discipline combined with high barriers such as a formalized language. Here we present an approach to improve medical students' engagement and participation in chemistry classes, which uses digital strategies based on the ILIAS open source e-Learning platform to improve teaching and learning within lectures, seminars and lab courses. It specifically addresses problems in lectures arising from the heterogeneity of pre-knowledge within a cohort. Before each lecture students are given an electronic pre-test to check on prior knowledge regarding the lecture topics and specific misconceptions about these topics. The results of these tests are evaluated, and each lecture is designed specifically to address these misconceptions and even out differences in prior knowledge among all students. Within the lecture several concept checks using clicker systems are included to test if the misconceptions were resolved during the lecture. These clicker-system based tests allow for breaks of the frontal teaching phase within the lecture and encourages students to discuss the topics with each other and the lecturer. Afterwards, the test prior to the following lecture is designed to check again for the already identified misconceptions as well as new misconceptions about the upcoming topics.
After each test, the students' gain access to a short instructional unit which includes very fundamental content of the upcoming lecture. By independently studying the instructional unit in ILIAS familiarity with the "language of chemistry" is generated leading to a lower barrier and compensation for the large heterogeneity in pre-knowledge. Within these units' text, images and especially animations are used to visualize e.g., the lewis concept and the connection of different chemical notations.
In addition to the test for misconceptions, exercises for the self-assessment of the students are provided for each topic, including best practice examples and tutorial videos for several rather complicated exercises.

Keywords: digitalisation, just in time teaching, concept checks, animations

1. Introduction

It is well known that representations in Chemistry are one source for students' conceptual errors [1]. In addition, the representations are often an obstacle itself and lead to students trying to understand a kind of representational chemistry language instead of the discussed topics intended by the lecturer. The problem is quite prominent when chemistry is taught as a minor subject in German universities, as most lectures are not designed with problems of "reading chemistry" in mind and lecturer are often not well enough trained in methods and didactics. [2] This is one of the reasons leading to very negative perception of basic STEM courses. [3] It is often assumed, that the students dislike the difficult to understand scientific disciplines which are not a direct part of their major subject, but studies showed that it is not the difficulty, but rather missing methodology in teaching and missing links to the major subjects which lead to a very negative perception.

It was already implied, that a change in methodology, especially using new media and digitalisation in combination with classical lecture formats allow to improve the acceptance of chemistry as a minor subject. [4], [5] Here I present a fully digital supported strategy for a 1st semester course chemistry for medical students, comprised of a lecture proceeding practical lab courses and seminars.

Prior to the changes in course design the lecture was comprised of a classical frontal lecture using PowerPoint. Evaluation of this lecture showed that 7 of 10 students found chemistry to be the most complicated pre-clinical subject. 2014 we evaluated the dropout rate of the lecture and found that 76% (175) of the first-year medical students participated in the first non-mandatory lecture whereas only 9.5% (25) attended the last lecture.

Having these numbers in mind, it is obvious, that most students attended the succeeding seminars with little to no knowledge. Only roughly 30% of the students affirmed to have done independent studies to prepare for seminars and lab courses in chemistry.

Here I present a course design which addresses the great heterogeneity within a cohort, guides the students to independent studies, reduces the students preparational time and fosters the students' engagement.

2. Course Design

The basic idea is: Every student should be able to follow every lecture and lectures should address misconceptions of the students, giving a better preparation of the students for the upcoming seminars. Therefore, the measures to be developed needed to: 1. Allow students of every proficiency level to prepare for the lectures in a minimal amount of time, 2. Establish a double feedback mechanism, where students are allowed to do self-assessment and evaluate their progress where at the same time the lecturer gets feedback on the students' progress misconceptions. As students at the University Göttingen are generally familiar with eLearning platform ILIAS, it was used to establish the digital support for the lecture.

In a first step the idea was to design each lecture according to the predominant misconceptions and problems in understanding chemistry within the cohort. Therefore, students were asked to voluntary answer very short (3 to 8 questions) tests prior to each lecture.

2.1 Cohort specific lectures

To allow all students to follow and participate in the lecture, the information in the tests prior to the lectures was used to redesign the lecture according to the problems identified but also allowed to identify concepts which didn't need further explanation (Fig. 1).

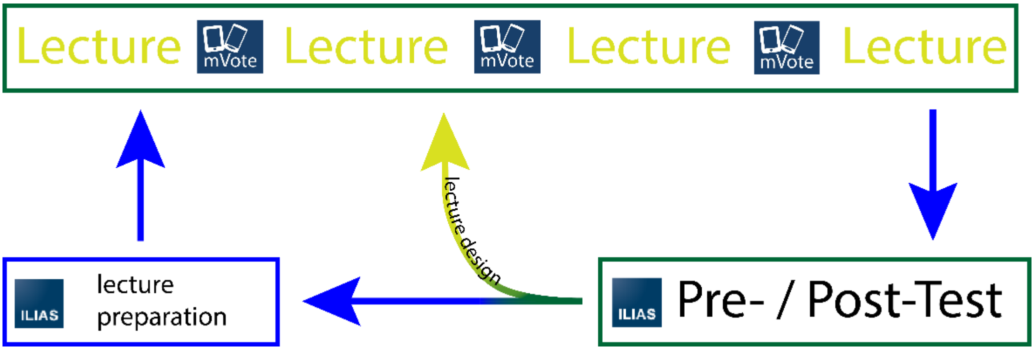


Fig. 1. *A cycle of Pre-Test – preparational eLearning – lecture for the students shown in blue + green. Students' feedback is used by the lecturer to design each teaching unit (shown in yellow). Lectures are supported by concept checks done with mVote*

In addition, students were able to assess their progress in chemistry based on the pre-/post-test results themselves. Examples for typical questions of the organic lecture part are given in figure 2.

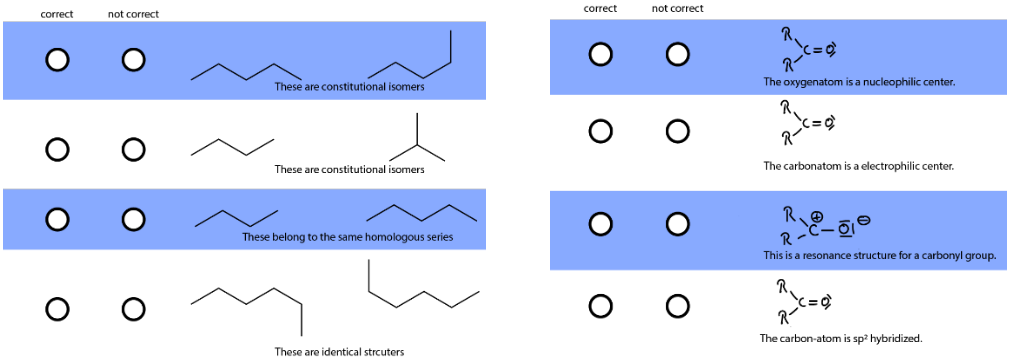


Fig. 2. *Two examples for typical T/F-questions used to check for the pre-knowledge of the students*

These questions address some very basic ideas of chemistry, visual representations and the ability to read and interpret them and was asked after these concepts were introduced in the previous lecture. 122 students answered the question, only 58% of the students were able to answer more than 2 of these statements correctly. Since lectures generally have a low level of redundancy in topics and the ability to read and interpreted chemical structures is a key skill in understanding and learning chemistry, it must be assumed that only half of the students might be able to follow the upcoming lectures. Of course, the chemical syntax and representations are part of the curriculum, but looking at German universities the complexity of reading chemical representations is not discussed in great detail, in contrast to educational science dealing with chemistry in school *curriculae*. [6], [7] Furthermore, observations like this were made for every concept introduced within the lecture, e.g., in the case of identification of electrophilic/nucleophilic centres of reactions only 50% of 70 students were able to identify these correctly using compounds like carbonyls and amines. Very interestingly all major barriers are somehow related to reading and interpreting the chemical syntax.

While 80% students were able to give the correct definition of nucleophiles and electrophiles only 50% could relate this to chemical structures in carbonyls.

2.2 Guided independent studies

To help the students in understanding chemical representations electronic learning modules in ILIAS were developed, which focused on the very basic principles necessary to follow the upcoming lecture. A key feature was using animations of chemical representations in combination with typical written explanations and images. Fig.3 shows a sequence of such an animation explaining mesomeric structures for benzene.

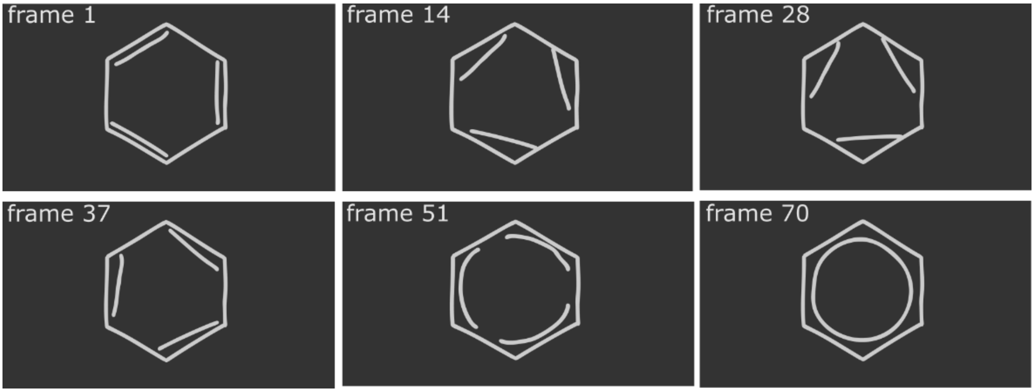


Fig. 3. *A Typical sequence used in an animation to explain mesomeric structures of benzene and the different representations. The movement of the π-electrons is explained by the structure of the π-orbitals in the aromatic system*

The eLearning modules for the preparation of the lectures were designed to be done in 20 minutes, and the pre-tests are mandatory to access the eLearning module. While more than 50% of the students carried out tests and preparations in the first lectures, this was reduced to 33% in the last lecture.

First evaluation of the eLearning module showed, that it seems to be most effective in reducing the barrier to approach the topic, leading to a kind of familiarity with the representations used in the lecture, shifting the students focus from reading the structures to using the structures. In addition, the visualized movement of bonds and electron pairs was described by most students as very descriptive. [4] Evaluation of the effectiveness of these animations is still to be done.

In addition, concept checks using the clicker system mVote, which utilizes students' smartphones, were introduced within each lecture. Each lecture is designed in four parts of teaching using PowerPoint and the black board, followed by a concept check (Fig. 1).

These breaks in lecture helped the students to recover after a phase of high cognitive load and allowed the identification of misconceptions within the lecture. Furthermore, besides direct discussion with the lecturer, also discussions between students were fostered, leading to situations where students explained solutions to problems given in the concept checks.

2.4 The resulting effects

Derived from free-text evaluations of the lecture, the several possibilities of communication to the lecturer, direct and indirect, lead to a feeling of taken seriously, which greatly enhanced the student's engagement. In combination with the easy to access preparational eLearning modules students were empowered in the ability to independently study chemistry. This feedback was partly or in total given in 78 of 152 evaluations. Furthermore, the amount of questions asked within the lecture increased greatly and student's remarks by email to the lecturer about problems they have when learning raised from typically none to roughly 2 per lecture.

The dropout rate of the lecture reduced dramatically, while the first lectures were attended by over 200 students, which is more than 90% the last lecture was still attended by more than 100 students. These numbers are estimates based on the students taking part in the concept checks, we did not count the numbers. The resulting tests to pass the class, did not change in overall pass rate (76%) but the discrimination between students that passed and such that did not increase greatly.

The total amount of time to prepare the lecture tripled roughly for the lecturer, but instead of just slowing down the lecture topics could be intensified by reducing the barrier to access and understand the topics and focusing in students' needs.

REFERENCES

[1] H.-K. Wu and P. Shah, 'Exploring visuospatial thinking in chemistry learning', *Sci. Educ.*, vol. 88, no. 3, pp. 465-492, 2004, doi: 10.1002/sce.10126.
[2] M. Hofer, M. Jansen, and S. Soboll, 'Verbesserungspotenzial des Medizinstudiums aus retrospektiver Sicht von Facharztprüflingen', *DMW – Dtsch. Med. Wochenschr.*, vol. 131, no. 8, pp. 373-378, 2006, doi: 10.1055/s-2006-932527.
[3] N. Kohler and H. van den Bussche, 'Je schwieriger, desto beliebter. Nutzen, didaktische Qualität und Schwierigkeitsgrad des vorklinischen Lehrangebots aus der Sicht von Hamburger Medizinstudenten', *Ann. Anat. – Anat. Anz.*, vol. 186, no. 3, pp. 283-288, Jun. 2004, doi: 10.1016/S0940-9602(04)80018-9.
[4] G. Boeck, B. Rost, and A. Schunk, 'Multimediale Materialien in der Lehre', *Nachrichten Aus Chem.*, vol. 53, no. 6, pp. 653-655, 2005, doi: 10.1002/nadc.20050530614.
[5] E. Germer, H. J. Bader, G. Boeck, and A. Schunk, 'Mediziner und Chemie – motiviert, aber wenig Vorwissen', *Nachrichten Aus Chem.*, vol. 50, no. 7-8, pp. 838-840, 2002, doi: 10.1002/nadc.20020500715.
[6] P. Laszlo, 'Towards Teaching Chemistry as a Language', *Sci. Educ.*, vol. 22, no. 7, pp. 1669-1706, Jul. 2013, doi: 10.1007/s11191-011-9408-6.
[7] C. L. Habraken, 'Integrating into Chemistry Teaching Today's Student's Visuospatial Talents and Skills, and the Teaching of Today's Chemistry's Graphical Language', *J. Sci. Educ. Technol.*, vol. 13, no. 1, pp. 89-94, Mar. 2004, doi: 10.1023/B: JOST.0000019641.93420.6f.

Enhancement of Metacognitive and Scientific Practice Skills through the Use of Gowin's V Diagram

Patricia Morales Bueno[1], Rosario Santos Rodas[2]
Pontificia Universidad Católica del Perú PUCP, Perú[1,2]

Abstract

The need to prioritize the development of scientific competences is a globally recognized point, since it is important for any citizen to have the capacity to integrate in a context markedly influenced by science and technology. However, progress in this objective is very slow, especially in the case of Latin American countries. This situation reaches the profiles of the students who come to university education and this fact generates a critical situation, in particular for the training of new scientists, for which the development of their skills for scientific practice is essential. These skills require the coordination of different higher order cognitive skills that include heuristic processes, inductive and deductive reasoning, mainly. In the case of experimental sciences, such as chemistry, laboratory experiences constitute a propitious space for the development of these abilities in students. In that sense, Gowin's V diagram is a heuristic resource, which is oriented towards the nature of knowledge, as well as that of learning, which allows it to be used both as an analysis strategy in the construction of scientific knowledge, as in its reconstruction or learning. The shape of the diagram makes it possible to make explicit the relationships that exist between the conceptual aspects and the methodological procedures, based on questions that integrate theoretical aspects with empirical or observational aspects. This paper reports the implementation of a strategy that uses the Gowin's V diagram in a Chemistry Laboratory course for first year students of Basic Sciences, in a Peruvian university. The purpose of the study was to determine the effect of the strategy implemented on their scientific practice and metacognitive skills. The results obtained showed a significant level of positive correlation between the variables, proving that the strategy was a predictive variable of the students' metacognition skills.

Keywords: Gowin's V diagram, metacognition, scientific reasoning, scientific skills

1. Introduction

There is a broad consensus that the education of any person should include the skills development for the understanding of science [1]. According to the OECD, scientific knowledge involves not only the content of science, but also its procedural and epistemic aspects. Scientific competence then implies the ability to explain scientific phenomena, interpret data, as well as evaluate scientific research and design forms of research [2].

The skills related to these competencies need to be taught and explicitly modelled.

The Gowing's V diagram is a tool designed by the American Professor B. Gowing, from Cornell University, which interrelates the conceptual, procedural and attitudinal competences of scientific activity and allows the integration of everyday knowledge with science. It includes the phases of the scientific method and allows to demonstrate the specific knowledge of the concepts, principles and theories that guide the investigation.

The diagram promotes that students be aware that knowledge is a product of research and that this occurs as a result of the interaction between the conceptual structure they have and the methodologies they choose, in the task of building knowledge [3], [4].

This study reports the use of this strategy in a general chemistry laboratory course with the purpose of promoting the development of skills for scientific practice and metacognitive skills.

2. Methodology

2.1 Participants

The participants in this study were first year students of Basic Sciences (Physics and Chemistry) from a Peruvian university. They were enrolled in a General Chemistry Laboratory course. The study included only students who responded to the metacognitive skills instrument applied (pre and post-test). Thus, the number of participants was 11 whose ages were between 17 and 25 years. The average age was 19 years. All participants were male.

2.2 Context of the study

The students were organized in permanent groups of three members. The design of the laboratory course considered three stages:

a. Pre-laboratory stage: individual preparation stage that consisted of preparing an approach to Gowing's V diagram and developing some short activities, such as reviewing some concepts related to the work session, looking for some physical properties of the substances to be used in the laboratory, as well as to do some simple calculations.
b. Development of the experimental session: Students developed the laboratory experience following general guidelines that promoted inquiry and efficient management of the data collected. The teacher was a facilitator during this stage and, promoted the academic discussion of what was being worked on. To do this, he used the structure of Gowing's diagram V and formulated the questions associated with it so that, the working groups could elaborate proposals based on the evidence found in the experience and use of their reasoning. The groups could briefly discuss their proposals, thus providing opportunities for the use of their argumentation skills.
c. Report preparation: The working groups prepared their work report after the end of the laboratory session. This should be sent for review a week later. This report should include a Gowing's V diagram reviewed and agreed upon by the members of the working group.

2.3 Variables of study

Gowing's V Diagram: Figure 1 shows the model used in the study. The students had to elaborate a first approach to this diagram, individually, as part of the stage prior to the laboratory session. For this approach, cell 6 should show the organization planned for the data collection and the way in which calculations would be performed. In cell 8, expected results must be placed.

The final diagram, reviewed and agreed by the working group, worked with the scheme as shown in figure 1. This diagram was evaluated with a rubric, table 1 shows the description of the expected result for each item.

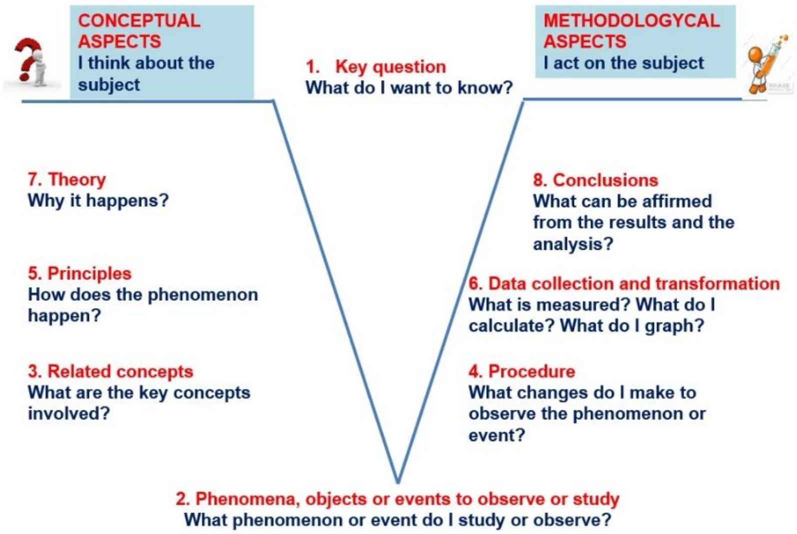


Fig. 1. *Model of Gowin's V diagram used in the study*

Scientific practice. This variable was constructed from the achievement's assessment in the three stages of the laboratory course design. For this evaluation a rubric was used.

For both variables, the maximum score according to the rubric applied was 24 points.

For the purposes of this study, this score has been expressed as a percentage.

Metacognitive skills. This variable was evaluated with the Metacognitive Activities Inventory (MCAi) [5], 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. The instrument was applied as pre and post-test.

Table 1. *Description of the expected result for each item in Gowing's V diagram*

Item	Description
1. Key question	It relates to the activity to be carried out, addresses the main topic and expresses clearly
2. Phenomena, objects or events to observe or study	The object of study is correctly identified and reported in a concrete and concise manner
3. Related concepts	All reported concepts are supported by theory, related to the key question, procedure/data/results
4. Procedure	The relevant stages of the procedure are correctly reported
5. Principles	Correctly report the principles and laws applicable to the phenomenon studied including a brief explanation of their application
6. Data collection and transformation	Report correctly: the collected data organization, calculation examples, graphics organization
7. Theory	The theory underlying the studied phenomenon is clearly identified and correctly expressed
8. Conclusions	They relate to the key question, the data and the results. They include a critical judgment of the experience. They are expressed correctly and clearly

2.4 Analysis of data

The data were analysed using Statistical Package for the Social Sciences (SPSS) 21 software ®. Level alpha was established a priori in 0,05. A descriptive analysis of the variables scores was performed. Correlation between the three variables was determined. Linear regression analysis was made. The dependent variable was MCAi post-test score. The likely predictor variable considered was Gowin's V diagram score.

The Wilcoxon Signed Rank test for related samples was used to verify differences between MCAi pre-test and post-test scores.

3. Results

Table 2 shows descriptive statistics for total scores obtained in the three variables of study.

Table 2. *Descriptive statistics for Gowin's V diagram, Scientific Practice and MCAi (pre and post-test) scores (N=11)*

	M	SD
Gowin's V diagram score	76,1209	7,55726
Scientific Practice score	84,2236	7,22649
MCAi pre-test score	76,8355	8,65789
MCAi post-test score	81,4800	8,66977

Table 3 shows the Pearson correlation coefficients for the study variables. Only MCAi post-test scores were considered.

Table 3. *Correlation matrix of study variables (N=11)*

Variable	MCAi post-test	Scientific practice	Gowing's V diagram
MCAi post-test	1		
Scientific practice	0,592	1	
Gowing's V diagram	0,646*	0,739**	1

** p<0,05; ** p<0,01*

There is a positive and significant correlation between the Gowing's V diagram score and both MCAi post-test and Scientific Practice variables. This result proves that the strategy used had relevant effects on the improvement of metacognitive skills, since it promotes the students to use their skills and strategies for scientific experimentation in a reasoned and conscious way, especially those that allow the regulation of metacognitive activity. The correlation between the Scientific Practice variable and MCAi post-test score does not become significant (p=0,055), this may be due to the sample size as well as to the fact that the first one considers aspects that do not have a direct relationship with the metacognitive skills evaluated, such as those related to the format of the written report, the performance of previous activities, etc.

The results of the linear regression analysis indicated that Gowing's V diagram score was a predictive variable for the MCAi post-test, F (1, 9) = 6,435, $p<0.05$. The R^2 value was 0.417, which indicates that 41,7% of the variance is explained by Gowing's V diagram score. Table 4 shows the summary of the regression model applied.

Table 4. *Stepwise linear regression analysis summary*

Variable	B	SD	β	t	p
Constant	25,096	22,327		1,124	0,290
Gowing's V diagram score	0,741	0,292	0,646	2,537	0,032

The difference between the MCAi pre and post-test scores was significant (p=0,008), so the strategy used had a significant positive effect in improving the student's metacognitive skills.

4. Conclusions

The results obtained in this study are quite encouraging since it has been proven that a teaching and modelling strategy for the development of relevant scientific skills can have positive and significant achievements. The Gowing's V diagram could be an effective tool in this purpose if it is complemented by a facilitation work, since the use of this resource is difficult for the student with little experience. Further intervention by the facilitator is necessary at the beginning of the process, which will become less frequent as the student becomes more familiar with the use of the diagram. As shown, the strategy also promotes the development of metacognitive skills that constitute an essential component for the training of students, particularly in the training of future scientists.

REFERENCES

[1] Pedrinaci, E. (coord.), Caamaño, A., Cañal, P., and Pro, A. "11 Ideas Clave: El desarrollo de la competencia científica", Barcelona, Grao, 2012.

[2] OCDE. "Marco de Evaluación y de Análisis de PISA para el Desarrollo: Lectura, matemáticas y ciencias, versión preliminar, Paris, OECD Publishing, 2017, pp. 91-123.

[3] Novak, J., Gowing, B. "Aprendiendo a aprender", Madrid, Martínez Roca, 2004.

[4] Guardian, B., Ballester, A. "UVE de Gowin instrumento metacognitivo para un aprendizaje significativo basado en competencias", IN Revista Electrónica d'Investigació i Innovació Educativa i Socioeducativa, Islas Baleares, U. de las Islas Baleares, 2011, pp. 51-62.

[5] Cooper, M., Sandi-Urena, S. "Design and Validation of an Instrument to Assess Metacognitive Skillfulness in Chemistry Problem Solving", Journal of Chemical Education, 2009, vol. 86 (2), pp. 240-245.

Experiments on Fluorescence Thermochromism for Chemistry Class in Secondary Schools

Philipp Lanfermann[1], Ingo Mey[2], Thomas Waitz[3]
Department of Chemistry Education, Georg-August-Universität Göttingen, Germany[1,3]
Department of Biomolecular Chemistry, Georg-August-Universität Göttingen, Germany[2]

Abstract

In this contribution, we present various experiments with pyridine copper(I) iodide complexes that address aspects such as fluorescence in general as well as fluorescence thermochromism in particular. The latter describes the fascinating phenomenon of changing the fluorescence colour reversibly in dependence of temperature [1]. In the experiments, the number of pyridine ligands is successively reduced by drying and subsequent heating of the prepared complex, which at first causes a change in the emitted fluorescence radiation under UV light. The fluorescence properties of the complexes obtained can then be reversibly influenced by cooling with liquid nitrogen. This phenomenon can be explained by the different energy levels of possible excited electronic states and therefore influencing the energy gap to the energetically lower state, resulting in a change of fluorescence colour. The probability of occurrence of these states changes with temperature and is caused by different temperature-dependent distortions of the complex geometry [2, 3]. The presented experiments show an interesting play of colours and can be easily performed in experimental classes.
At the same time, they provide good didactic opportunities to connect aspects of several basic concepts in chemical education (energy as well as structure-property relationship) and to teach them in an impressive way. Accompanying material for teachers and students developed for this purpose will also be presented.

Keywords: Fluorescence, fluorescence thermochromism, school experiments, energy

1. Introduction

Some substances are able to absorb high-energy light, which leads to electrons being raised from an energetically lower state to an energetically higher excited state. This excited state is short-lived and thus strives to return to its original energetically lower state and therefore releasing the energy gained through the absorption of the light.

Broadly speaking this de-excitation can take place in two different ways. On the one hand, energy can be released without any form of radiation by molecular collision and vibrational relaxation. On the other hand, the energy can also be emitted in the form of light. In the case of a direct emission this process is called fluorescence. The energy difference between the lower energy state and the higher energy state determines which process is preferred. A high energy difference hinders the radiation less de-excitation and thus leads to the phenomenon of fluorescence.

In the case of the fluorescent thermochromic pyridine copper(I) iodide complexes which are covered in this contribution there are two possible excited states into which the electrons can be excited: The ^{3}XLCT state and the ^{3}CC state, which denote different possible charge-transfer complexes. The ^{3}XLCT state is characterized by an electronic transfer from the halide to the ligands, while in the ^{3}CC state there is a transfer from the halide to the metal. Both states can be observed when excited with UV light and their probability of occurrence depends on the temperature. The ^{3}CC state is strongly preferred at high temperature, whereas at the low temperature of 77 K the ^{3}XLCT state is increasingly occupied. The explanation for this phenomenon lies in the different temperature-dependent ligand packing, which influences the geometry of the central copper tetrahedron of the complex and thus favours the occurrence of certain excited states [2]. Due to the different energy levels in comparison to the energetically lower state, the fluorescence properties of these states also differ (see figure 1).

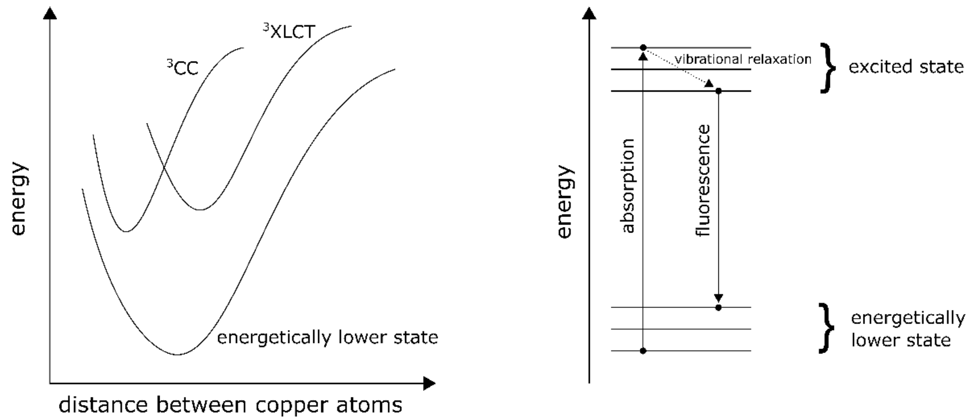


Fig. 1. *Morse potentials of the different states (left) and exemplary simplified energy diagram (right)*

While this thorough underlying explanation of the phenomenon through the use of Morse potentials is undoubtedly interesting, these interpretations are too complex for a school context and require a didactic reduction. It is therefore advisable to present the energetic considerations in a reduced form by means of simplified energy diagrams (see figure 1). This form of representation does not consider the distance between copper atoms but focuses on the resulting energy difference between the energetically lower and the excited state instead. This enables a more easily understandable teaching of fluorescence, thermochromism and other school relevant topics, without requiring a more detailed explanation using Morse potentials.

2. Experiments

2.1 Preparation of the trispyridine copper(I) iodide complex and examination of its fluorescence properties

In this first experiment, trispyridine copper(I) iodide is prepared by simply dissolving copper(I) iodide in excess pyridine. While it does not show any clearly visible fluorescence thermochromism, it exhibits other interesting fluorescence properties.

While the solution shows no fluorescence at room temperature, it emits intense orange light under UV light after cooling and freezing with liquid nitrogen. The sudden appearance of fluorescence can be explained by the effect of quenching.

Equipment: Snap-cap vial, dewar vessel, spatula, pipette, UV-Lamp (365 nm), nitrile gloves.

Chemicals: Pyridine (GHS02, GHS07), copper(I) iodide (GHS05, GHS07, GHS09), liquid nitrogen.

Procedure: To prepare the trispyridine copper(I) iodide complex, 20 mg copper(I) iodide is dissolved in 10 mL pyridine in a snap-cap vial under the fume hood and stirred for about 3 minutes. The snap-cap vial with the solution is then irradiated with UV light in a darkened environment. Afterwards the snap-cap vial is cooled by immersion in liquid nitrogen.

Observations: After dissolving of copper(I) iodide in pyridine, the solution turns an intense yellow colour. No fluorescence is observed when irradiated with UV light at room temperature. During cooling and freezing with liquid nitrogen, orange fluorescence can be observed, which reaches its maximum intensity when completely cooled (See figure 2).

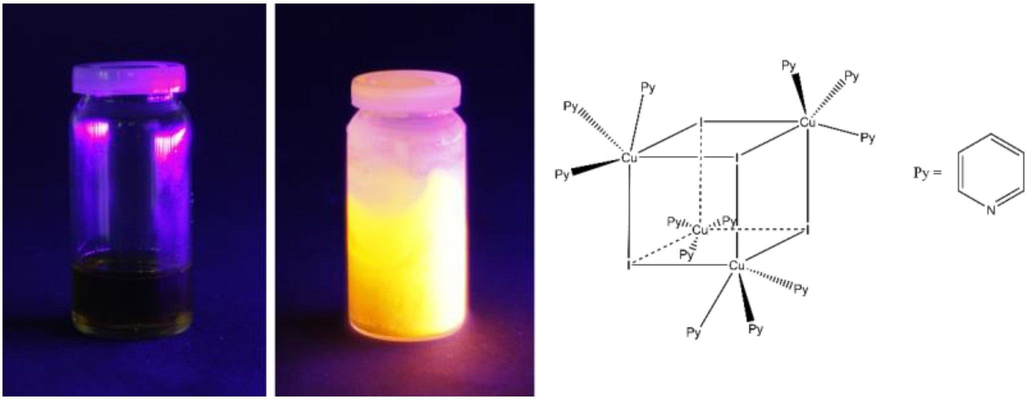


Fig. 2. *Observations at room temperature and at 77 K under UV light (left) and proposed structure for the trispyridine complex (right)*

Interpretation: Copper iodide reacts with pyridine to form the trispyridine copper(I) iodide complex [1] (see figure 2).

$$4\ CuI + 12\ C_5H_5N \rightarrow Cu_4I_4(C_5H_5N)_{12}$$

One possible explanation for the sudden appearance of fluorescence upon cooling can be the phenomenon of quenching. Collisions between the fluorescent complex in the excited state (fluorophore) and the solvent (quencher) result in a radiation-free electronic de-excitation to the energetically lower state, thus hindering fluorescence. The formation of the solid state leads to a strong reduction of molecular vibration and movement. This leads to a strong decrease of molecular collisions; thus, the probability of quenching is also decreased and fluorescence can take place to an observable level [4]. This effect increases as the temperature decreases, which could explain the increase in fluorescence intensity as the temperature continues to cool below freezing.

2.2 Preparation of the bispyridine and monopyridine copper(I) iodide complex

By drying the solution and thus removing the excess pyridine, one to two pyridine ligands can be removed from each copper atom of the complex. The resulting bispyridine and monopyridine copper(I) iodide complexes show fluorescent thermochromic properties.

Equipment: Pipette, filter paper, UV-lamp (365 nm), nitrile gloves, dewar vessel, test tube clamp.

Chemicals: Solution from experiment 2.1 [pyridine (GHS02, GHS07), copper(I) iodide (GHS05, GHS07, GHS09), trispyridine copper(I) iodide], liquid nitrogen.

Procedure: Under the fume hood, the filter paper is wetted with the solution prepared in the previous experiment and left to dry under UV light. After complete drying of the solution, which can be seen by the complete fluorescence of the previously wetted surface, the filter paper is cooled down under UV light by immersion in liquid nitrogen.

The filter paper is then left to rest for 30 minutes at room temperature or, alternatively, gently warmed using a hot air dryer until a clear change in fluorescence is visible and again cooled down with liquid nitrogen.

Observations: The dried surface of the filter paper fluoresces intensely with a bluish-green colour at room temperature. Cooling with liquid nitrogen causes a slight shift of the fluorescence wavelength into the green colour range. A slight increase in fluorescence intensity can also be observed. This phenomenon is reversible and can be shown repeatedly. After the waiting time, the bluish-green fluorescence has changed to an intense yellow, which increases its intensity with longer waiting time. Cooling again with liquid nitrogen causes a stark shift of the fluorescence wavelength into the purple colour range (see figure 3).

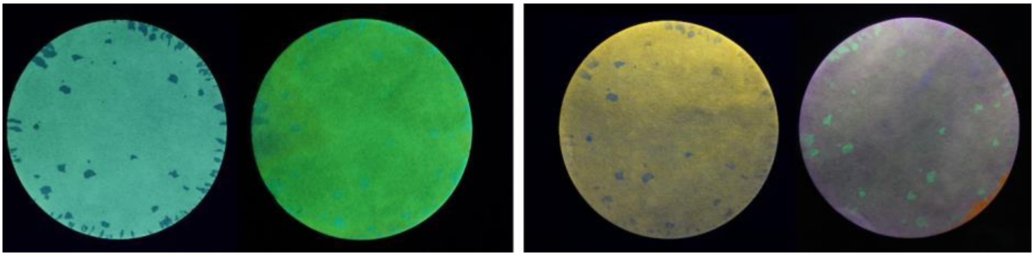


Fig. 3. *bispyridine complex (left) and monopyridine complex (right) under UV light at room temperature and 77 K, respectively*

Interpretation: Without the presence of excess pyridine, the trispyridine copper(I) iodide complex is not stable [1], pyridine ligands split off from the complex. First, the bispyridine copper(I) iodide complex is formed by splitting off one pyridine from each copper atom, the complex is characterized by its blue-green fluorescence [1]. Here, fluorescence thermochromic properties can be observed for the first time in this set of experiments: Cooling leads to a slight redshift of the fluorescence into the green range.

The distance between the energetically lower state and the excited state thus decreases.

The bispyridine copper(I) iodide complex produced is unstable as well and decays after a few minutes. Another pyridine ligand splits off and the monopyridine copper(I) iodide complex is formed, which is characterized by its intense yellow fluorescence colour.

Cooling leads to a strong blue shift of the fluorescence into the purple range, the energy distance between the states increases.

2.3 Reversible change between bispyridine and monopyridine copper(I) iodide via pyridine vapor

The reaction of the bispyridine to the monopyridine complex is reversible. The introduction of the latter into a pyridine-containing atmosphere leads to the formation of the bispyridine complex.

Equipment: Test tube clamp, UV-lamp (365 nm), storage bottle.

Chemicals: Filter paper from experiment 2.2 [bispyridine copper(I) iodide, monopyridine copper(I) iodide], pyridine (GHS02, GHS07)

Procedure: The filter paper with the monopyridine complex is placed in a storage bottle into which a few millilitres of pyridine have been previously added. The bottle is then closed and observed under UV light.

Observations: Over time (approximately 5 minutes), the fluorescence colour changes back from yellow to green (see figure 4).

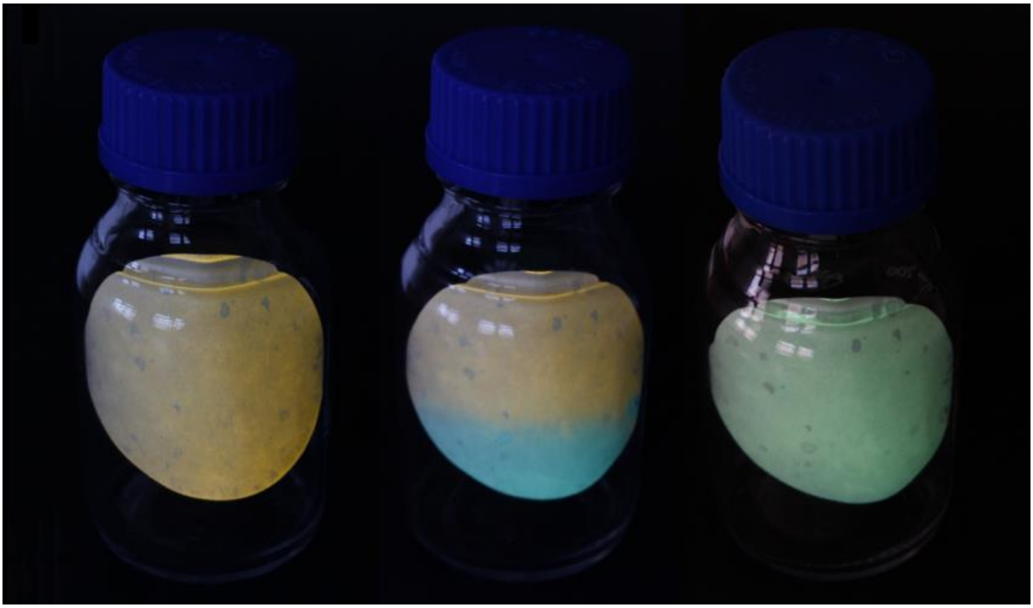


Fig. 4. *Conversion of the monopyridine to the bispyridine complex in pyridine atmosphere over time under UV light from left to right*

Interpretation: The pyridine evaporates in the bottle, its concentration in the atmosphere increases. The conversion of the monopyridine to bispyridine complex is a chemical equilibrium reaction, which can be influenced by the concentration of the available pyridine. The evaporated pyridine is sufficient to cause a reversal of the reaction according to Le Chatelier's principle.

3. Didactical Considerations

Due to several different aspects, the experiments are suitable for use in schools. First of all, the practical reasons should be mentioned:

- The experiments are easy to carry out and require few materials and chemicals.
- They practice proper handling of organic solvents. Pyridine is not toxic but has a strong malodor, which is quickly noticed when handled incorrectly.

Besides these reasons many theoretical aspects can be taught:

- The topics fluorescence and complex chemistry can be addressed.
- Experiments 2.2 and 2.3 can be used to show temperature stability of complexes and the influence of concentration on the chemical equilibrium in an easily

observable way.
- The phenomenon of fluorescence thermochromism shows an effect of temperature on energetic states, whereas classical school experiments usually only illuminate the influence on the areas of chemical kinetics and equilibria.
- The necessary transfer from the observations to the simplified energy diagrams enables the students to change between the macroscopic and the symbolic representation level [5].

Finally, the motivational factors should be mentioned:
- Despite the ease of implementation, the experiments provide stunning visuals.
- The complexes have possible applications in the field of simple temperature probes, which could possibly be reproduced in a school environment.

REFERENCES

[1] Hardt, H. D., Pierre, A. "Fluorescence Thermochromism of Pyridine Copper Iodides and Copper Iodide", Z. anorg. allg. Chem., Weinheim, Wiley-VCH, 1973, 402(1), pp. 107-112.
[2] Parmeggiani, F., Sacchetti, A. "Preparation and Luminescence Thermochromism of Tetranuclear Copper (I)-Pyridine-Iodine Clusters", J. Chem. Educ., Washington D.C., ACS, 2012, 89, pp. 946-949.
[3] Ford, P. C., Vogler, A. "Photochemical and Photophysical Properties of Tetranuclear and Hexanuclear Clusters of Metals with d^{10} and s^2 Electronic Configurations", Acc. Chem. Res., Washington D. C., ACS, 1993, 26, 220-226.
[4] Wimmer, C., Arnold, T, Großmann, K. "Untersuchungen zur Fluoreszenz von Lactat bei Raumtemperatur und tiefen Temperaturen", Chemie Ingenieur Technik, Frankfurt am Main, Dechema, 2009, 81(4), pp. 501-504.
[5] Johnstone, A. H. "Why is science difficult to learn? Things are seldom what they seem", Journal of Computer Assisted Learning, Hoboken, Wiley, 7(2), pp. 75-83.

Implementation of Strategies for Digitally Supported Learning and Experimentation in a Chemistry Lab for Primary and Secondary School Students

Andrea-Katharina C. Schmidt[1]
TU Darmstadt, Fachbereich Chemie, Merck-TU Darmstadt-Juniorlabor, Germany[1]

Abstract

The Merck-TU Darmstadt-Juniorlabor was established as a joint project of the TU Darmstadt and the science and technology company Merck KGaA in 2008 [1]. It is a teaching laboratory for primary and secondary school students and their teachers at TU Darmstadt's department of chemistry. Classes can participate in specifically developed workshops on a variety of chemistry-related topics, such as functional dyes, pharmaceuticals, anodizing processes. We aim to arouse interest and enthusiasm for the natural sciences with hands-on experiments and to provide career perspectives in STEM. Learning and experimentation take place preferably in small groups with authentic equipment and under professional guidance. Societal changes such as the growing importance of environmental awareness, sustainable development, and digitalization are integrated into our portfolio. Especially the increasing digitalization of all areas of life has an enormous impact on our daily routines. Digital media, tools and communication platforms have become ubiquitous. Not only do they change communication and work-related processes, but they also create new challenges and opportunities for chemistry education [2]. Additionally, the use of digital media was explicitly called for in a strategy paper ("Education in the Digital World") published by the Conference of Education Ministers (KMK) in 2016 [3], which was also confirmed by the German Federal Government with the Digital Pact for Schools (DigitalPakt Schule 2018) [4]. Therefore, we intend to include various types of digital media and tools in our offerings. Our lab is equipped with iPads, Vernier data-logging technology, and Wi-Fi access. We chose an action research-based approach to optimize existing and develop new workshops This includes developing and providing digital materials such as individually accessible interactive PowerPoint-presentations, e-books, video instructions that provide guidance and additional information as needed. When appropriate, data loggers are used to collect, share, and analyse data. In this contribution, a course design that incorporates several multimedia-aspects is presented.

Keywords: digitalization, iPads, hands-on experiments, data-logging, action research, chemistry education

1. Introduction

The increasing digitalization of all areas of life has an enormous impact on our daily routines. Digital media, tools, and communication platforms have become ubiquitous.

Not only do they change communication and work-related processes, but they also create new challenges and opportunities for chemistry education [2]. Additionally, the use of digital media was explicitly called for in a strategy paper ("Education in the Digital

World") published by the Conference of Education Ministers (KMK) in 2016 [3], which was also confirmed by the German Federal Government with the Digital Pact for Schools (DigitalPakt Schule 2018) [4]. The digital acquisition and analysis of data is a matter of routine in research laboratories today. Besides their usefulness as tools for research, there is a great potential for the use of digital media for teaching and learning chemistry.

Many chemistry educators and academic research groups have already recognized this potential, so the toolbox available to every practitioner is constantly growing [5, 6].

Especially the internal differentiation among learners with different cognitive conditions and different levels of knowledge appears to be a particularly promising area of application of digital media. In this context, so-called multitouch learning books, e-books with interactive content, appear to be particularly attractive and versatile [7, 8].

As part of our efforts for a meaningful and sustainable use of digital media we here present a concept for a workshop on the topic of reaction kinetics in our teaching lab for primary and secondary school students, in which different aspects of digital media are used.

2. Merck-TU Darmstadt-Juniorlabor

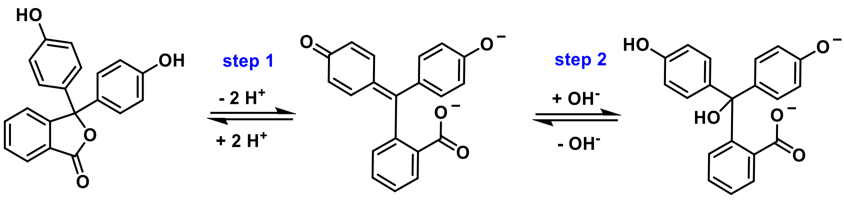
The Merck-TU Darmstadt-Juniorlabor was established as a joint project of TU Darmstadt and the science and technology company Merck KGaA in 2008 [1]. It is a teaching laboratory for primary and secondary school students and their teachers at TU Darmstadt's department of chemistry. Our lab is open to groups from all types of schools, including vocational schools. Our aim is to arouse interest and enthusiasm for the natural sciences with hands-on experiments tailored to the respective age groups and to offer career orientation in STEM fields. Learning and experimentation take place preferably in small groups with modern and authentic equipment and under professional guidance.

Classes can participate in specifically developed workshops on a variety of chemistry-related topics, such as functional dyes. Furthermore, the Juniorlab is also a place of training for future teachers. Societal changes such as the growing importance of environmental awareness, sustainable development, and digitalization are integrated into our portfolio. Our lab is equipped with iPads, Windows tablets, Vernier data-logging technology, and Wi-Fi access.

3. Reaction Kinetics Using Digital Data Logging Technology

In the following, a practical example will be described, in which digital media are integrated in different ways. Since the experiment carried out and its evaluation are known in literature [9], the following description is only meant as a summary of the procedures. The workshop in question deals with the topic of reaction kinetics and is geared towards advanced chemistry students from secondary schools. (German Gymnasium, ages 16-18).

In the introductory phase, the concepts of reaction rates, rate laws, rate constants and reaction order are introduced. Typical reaction orders (0th, 1st, and 2nd order reactions) and the corresponding plots of concentration (c) versus time, ln(c) versus time and 1/c versus time are discussed. The reaction to be studied is a simple and well-described reaction, the discoloration of phenolphthalein under strongly basic conditions (step 2 in Fig. 1) [9]. Since it is accompanied by a colour change from pink to colourless, it is perfectly suitable for examination by means of a colorimeter. The students learn the chemical background for the discoloration of the dye and then establish the general rate law according to the rules learned previously. Beer's law is introduced to clarify the relationship between absorbance (A) and concentration (c) of the dye. Finally, the special case of a pseudo 1st order reaction is discussed.



H_2In (A)	In^{2-} (B)	$In(OH)^{3-}$ (C)
pH 0-8.2	pH 8.2-12.0	> pH 12
colorless	pink	colorless

Fig. 1. *pH-dependent colour change of phenolphthalein*

After the introductory phase, students work independently in small groups (2-4 students) using material provided in digital form on iPads. They familiarize themselves with the experimental setup, then conduct the experiment and then use the iPad to analyse their data with the Vernier Graphical Analysis App. The experimental setup (Fig. 2) includes a Vernier LabQuest2 data logger equipped with a colorimeter (COL-BAT). In addition, iPads with the Vernier Graphical Analysis app are provided. While it is possible to record and analyse data with the LabQuest2 interface alone, the iPad offers a bigger screen and various other advantages such as the possibility of using the generated data and images in other apps. The communication with both devices is wireless.

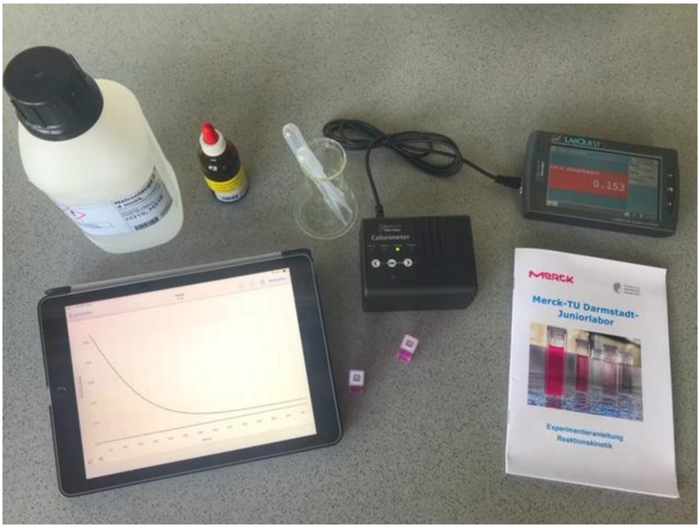


Fig. 2. *Experimental setup*

Experimental procedure: The colorimeter is set to 565 nm and calibrated according to the user's manual. A cuvette is filled with NaOH (0,4 M) solution, then a drop of phenolphthalein solution (0.5% in EtOH is added. A lid is placed on the cuvette, and it is shaken to mix the chemicals well. The cuvette is placed in the colorimeter and the measurement is started. Data points are recorded at least every 30 seconds for up to 12 minutes. The experiment is repeated with different NaOH concentrations while NaCl solution (also 0.4 M) is used to keep the ionic strength constant. Up to four different

NaOH-concentrations between 0.05 M and 0.4 M are used.

After transferring the recorded data to the iPad, the students' task is (1) to calculate the values of ln(absorbance) for all NaOH concentrations and plot them versus time, (2) to calculate the value of 1/absorbance for all NaOH concentrations and plot them versus time, (3) to determine which of these plots results in a straight line, (4) to determine the order of the reaction based on these plots, (5) to calculate the rate constants k for all NaOH concentrations used, (6) to plot ln(k) versus ln(c(OH^-)), to determine the order of the reaction with respect to the concentration of hydroxide ions, and (7) the determine the overall order of the reaction.

Our first approach to provide digital material containing the instructions for the experiment and additional information was made using Microsoft's PowerPoint software.

It allows for the presentation of relevant content in an interactive fashion. It is possible to include internal as well as external links, pictures and animations, audio and video files, which makes the resulting document similar to a multitouch learning book. For the experiment described in this contribution, the PowerPoint document includes the instructions, additional information such as pictures of the experimental setup, step-by-step instructions for data transfer to the iPad and data analysis with the Vernier Graphical Analysis App, as well as the theoretical background for the interpretation of the acquired data. There is also a step-by-step guide for evaluating the experiment. This guide provides additional assistance that may be needed by some students but can also be skipped by those who do not.

In the final phase, the individual results of the groups are compiled and discussed with all participants. The results can be printed out or sent to the students' own devices (mobile phones, tablets, etc.) as a screenshot or data set for later use.

4. Conclusion and Outlook

A workshop on reaction kinetics was presented, in which digital media are used for data acquisition and analysis on the one hand and are available as individual learning aids on the other hand. Since our project regarding digital media is only in its initial phase, this article is to be understood as one of many possibilities to use digital media in the context of a workshop designed for secondary school students. In the future, we intend to apply measures similar to those described here to other suitable topics. Furthermore, the effectiveness of these measures is to be determined to secure the quality of our workshops.

Acknowledgments

The project "Juniorlab" (https://www.juniorlabor.de/) is funded by the Educational Partnership of MERCK Darmstadt and the Faculty of Chemistry at Technische Universität Darmstadt.

REFERENCES

[1] www.juniorlabor.de (retrieved: Jan. 23, 2020).

[2] MNU (2019). Digitalisierung und Digitalität im MINT-Unterricht, Der mathematische und naturwissenschaftliche Unterricht (05), pp. 353-440.

[3] KMK (2016) Strategie der Kultusministerkonferenz "Bildung in der digitalen Welt" https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2018/Strategie_Bildung_in_der_digitalen_Welt_idF._vom_07.12.2017.pdf (retrieved: Oct. 21, 2019).

[4] BMBF (2018) “Wissenswertes zum DigitalPakt Schule” https://www.bmbf.de/de/wissenswertes-zum-digitalpakt-schule-6496.php (retrieved: Oct. 21, 2019).
[5] Maxton-Küchenmeister J., Meßinger-Koppelt J. (Eds.), (2014) Digitale Medien im Naturwissenschaftlichen Unterricht. Joachim Herz Stiftung Verlag, Hamburg.
[6] Maxton-Küchenmeister J., Meßinger-Koppelt J. (Eds.), (2018) Naturwissenschaften Digital. Toolbox für den Unterricht. Joachim Herz Stiftung Verlag, Hamburg.
[7] Huwer, Johannes & Eilks, Ingo (2017). Multitouch Learning Books für schulische und außerschulische Bildung. In Schanze, S., Groß, J., Meßinger-Koppelt, J., Maxton-Küchenmeister, J. (Eds.), Fachdidaktische Forschung zum Umgang mit digitalen Werkzeugen zur Unterstützung von Lernprozessen im naturwissenschaftlichen Unterricht Hamburg, pp. 81-94.
[8] Huwer, J., Bock, A., & Seibert, J. (2018). The School Book 4.0: The Multitouch Learning Book as a Learning Companion. American Journal of Educational Research, 6(6), pp. 763-772.
[9] Nicholson, L. (1989) Kinetics of the fading of phenolphthalein in alkaline solution, Journal of Chemical Education, 66(9), p. 725.

Internet Challenges from a Health Education Perspective

Julia Werthmüller[1]
Technische Universität Darmstadt, Germany[1]

Abstract

Risk behaviour is characteristic for adolescence phase [1]. Internet challenges in particular offer teenagers and young adults the opportunity to establish their status in their peer group and in front of an audience of millions. So far health education in German grammar schools has mainly focused on the following health risk behaviours: consumption of alcohol, tobacco, drugs, intensive sunbathing and deviant eating habits. Internet challenges such as those shown on YouTube have only recently expanded the thematic repertoire of school health education [2]. The presentation informs about popular challenges such as the cinnamon challenge, tide pod challenge, chilli challenge, ice-and-salt challenge, deodorant challenge and about their endangerment potentials [3]. In this context semi-structured interviews were conducted with six chemistry teachers in order to explore their perspective and state of knowledge on this type of juvenile risk behaviour. The cinnamon challenge was given special attention in these interviews. The evaluation of these interviews was based on a summarizing content analysis according to Mayring. Thus, a category system was created, which shows the current health education in chemistry classes of the teachers interviewed and their knowledge about current internet challenges, in particular the cinnamon challenge and its potential danger.

Keywords: internet challenges, cinnamon challenge, health education, chemistry teachers, interviews, content analysis

1. Introduction

Adolescents in particular use the internet platform YouTube to share private videos, including internet challenges, with an audience of millions. These challenges are characterized by the fact that they are often risk-related and that they encourage many users to watch and imitate them. Our research group for Chemistry Education focuses on internet challenges in which various substances come into contact with or are absorbed through mouth, nose, eyes or skin [1, 4]. Many of these substance-related internet challenges, such as the cinnamon challenge, tide pod challenge, chili challenge, ice-and-salt challenge, deodorant challenge etc., can be easily imitated and seem to be harmless. However, they sometimes involve considerable health risks, which are often not known to the predominantly young participants. With our own current research, we expand the existing spectrum of research on adolescent risk behaviours, such as alcohol and tobacco consumption, poor nutrition or delinquent behaviour, as well as the adequate explanatory models [1, 5]. These approaches are supplemented by specific perspectives, including gender aspects [6, 7]. So far, surveys have primarily focused on adolescents. A perspective on the phenomenon of internet challenges that has not yet been taken into account refers to teachers who are responsible for health education at schools and who may have to carry out preventive or interventional measures in class.

These teachers are confronted with the challenge of assessing the potential dangers of internet challenges correctly with consideration of the risk behaviour of pupils both in school (e.g., the choking game) and outside of school activity (e.g., the consumption of alcohol and drugs). This article is dedicated to this research desideratum. This article presents the cinnamon challenge and its risks as an example. It recapitulates findings on the frequency of certain types of substance-related internet challenges and offers a first insight into a recent qualitative study in which teachers were interviewed about their understanding of health education and internet challenges. Finally, it provides a perspective on the future project.

2. The Cinnamon Challenge

As an example, the cinnamon challenge and its potential danger is examined from a scientific point of view. The sequence of images in Figure 1 shows the procedure of this internet challenge.

Fig. 1. *Procedure of the cinnamon challenge (https://www.youtube.com/watch?v=aP7zc4Nvi_Q)*

The purpose of the challenge is to swallow a spoonful of cinnamon powder without taking any liquids for support. This constitutes a health hazard. The fine cinnamon powder removes all saliva from the mouth and makes swallowing impossible. Therefor mouth and throat become very irritated. Coughing and shortness of breath occur. The resulting struggle of the affected person for air causes particles of the cinnamon powder to enter the lungs [8]. Cinnamon powder is the dried, powdered bark of cinnamon trees.

Consequently, cinnamon consists cellulose fibres. Inhalation of fine cellulose fibres has a damaging effect on the lung tissue. This has been shown in an experiment with rats [8, 9]. Cellulose powder was intratracheally administered to the animals. Even a single administration can cause chronic inflammation and scarring of the lung tissue [9].

A further risk factor is coumarin, which is a component of cinnamon [10]. For small children and people with respiratory diseases, this substance can cause headaches, nausea and dizziness.

3. Findings on the Frequency of Substance-related Internet Challenges

In a survey on substance-related internet challenges in the period from 2015 to 2018 [3, 4], 2035 YouTube videos were viewed. They were categorized using an analysis grid and the percentage of types in the total number of videos viewed was determined. This investigation was discontinued at the beginning of 2019, as since then YouTube has prevented the publication of extremely dangerous internet challenges (cf. the corresponding “Harmful or dangerous content policy”). In almost half (46.2%) of the videos, substances were ingested by mouth. The oral internet challenges were further subdivided in two types: in type I, the oral intake of acidic, basic or very pungent substances causes irritation. These include the chili challenge, the cinnamon challenge and the tide pod challenge. In type II the ingested substance causes a feeling of disgust and nausea, by overstraining the sense of taste or the stomach. These includes the red-bull-and-milk challenge and milk chugging. After oral internet challenges, percutaneous internet challenges (17.7%), i.e., actions in which substances come into contact with the skin, are the second most frequent form of substance-related internet challenges. Typical examples are the deodorant challenge and the ice-and-salt challenge. In these cases, heat is extracted from the skin and the skin is damaged by so-called cold burns.

Substances in internet challenges are absorbed comparatively less frequently via the eyes and nose (5.9%). There were also internet challenges involving fire (e.g., fire challenge) (9.8%), explosions (10.6%) and weapons (3.7%). The category "other" comprises 6.1 percent.

4. Selected Findings from an Interview Study with Teachers

Six problem-centred semi-structured interviews were conducted with six chemistry teachers. They were asked about their understanding of health promotion with regard to their own chemistry lessons and their views on internet challenges in their own experience. Furthermore, the teachers' assessment of the following aspects was requested: Students' engagement with internet challenges and possibilities for integrating the topic of internet challenges into chemistry lessons. In addition, the teachers were shown a video on the cinnamon challenge during the interview, which they were asked to discuss. Using this specific example, the teachers were asked to clarify their assessment of the internet challenge phenomenon. The aim was to find out how the teachers assess the risk of the cinnamon challenge. The semi-structured interviews were transcribed and evaluated with the help of the summarizing content analysis according to Mayring [11]. Based on this analysis, seven main categories were formed that reflect the spectrum of teachers' responses. An excerpt of an interview translated into English is presented here as an example:

When asked to assess the potential danger of the cinnamon challenge, one teacher answered: "*Nah, it burns a little, they said. They laughed until the end, they're all still standing, all still breathing (laughs), so it doesn't look so dangerous, yeah.*" This text passage shows that the hazard potential of the cinnamon challenge is classified as low by the teacher in this context. She also describes the implementation of the internet challenge in the interview as "somewhat unpleasant", and she assesses the cinnamon challenge as "harmless" based on the video. To evaluate the hazard potential of the cinnamon challenge, the teacher mainly uses the reactions of the young people she can observe in the video. She does not provide scientific justifications. The concrete example shows how easy it can be to misjudge, when only one single video is used to assess the hazard potential of an internet challenge. The other chemistry teachers who were interviewed estimated the hazard potential of the cinnamon challenge to be higher.

However, they also showed ignorance and a decent uncertainty in dealing with this internet challenge and its risks. The entire analysis of the six interviews is presented in detail at a later point in time. In the context of this article, however, it can already be stated that the assessment of risks that can be associated with internet challenges is not a trivial task for teachers. Only a combination of scientific, psychological, sociological and media educational considerations will lead to an appropriate discussion of the problem. In this respect, teachers should receive support within their education and in the context of further training.

5. Outlook

In interviews, teachers showed interest in the topic of internet challenges. They were aware of the timeliness and relevance of the problem, even though they could not clearly determine to what extent their students get in touch with internet challenges in their everyday lives. The interviews revealed that teachers need help for their practice including guiding principles how to integrate the approach to internet challenges in their own lessons and an overview of internet challenges and their potential dangers. The planned expansion of the research project should address precisely this aspect. Based on the guidelines given by the teachers in the interviews, a digitally supported offer for teachers is to be created, which will provide basic information on internet challenges, i.e., descriptions of performance and physiological risk, including scientific analyses, as well as help in classifying the degree of damage. It will also provide supplementary information on interventions and didactic background information. In addition, internet challenges are to be viewed from a media perspective as a component of a modern digital culture.

Acknowledgement
The project is funded by the Faculty of Chemistry (Chemistry Education Research Group, Professor Markus Prechtl) at Technische Universität Darmstadt, Germany.

REFERENCES

[1] Raithel, J. “Jugendliches Risikoverhalten. Eine Einführung”, Wiesbaden, VS Verlag für Sozialwissenschaften, 2011.
[2] Busse, M.-H. “Mutproben aus naturwissenschaftlicher Perspektive. Befunde und Interventionsansätze zu einem aktuellen Internetphänomen”, Uelvesbüll: Der andere Verlag, 2013.
[3] Prechtl, M. (Hrsg.) “Substanzbezogene Mutproben. Befunde zum Risikoverhalten von Jugendlichen und Interpretation der Kontexte aus chemischer und biologischer Sicht”, Zweite Fassung, Weingarten, 2016.
[4] Prechtl, M. “Lehrkräfte sollten sie kennen: Internet-Challenges”, Chemie in unserer Zeit 6 (53), 2019, DOI: 10.1002/ciuz.201900877.
[5] Raithel, J. “Mutproben im Übergang vom Kindes- ins Jugendalter. Befunde zu Verbreitung, Formen und Motiven”, Weinheim: Beltz, 2003.
[6] Prechtl, M.; Spitzer, P. “Risikoverhalten und maskuline Performanz von Jungen im Chemieunterricht”, In: Juliette Wedl und Annette Bartsch (Hrsg.): Teaching Gender? Zum reflektierten Umgang mit Geschlecht im Schulunterricht und in der Lehramtsausbildung, Bielefeld transcript Verlag, 2015, pp. 137-164.
[7] Prechtl, M. “Geschlechterdifferenzen, -differenzierungen und -diffraktionen. Lesarten von Geschlecht in der Fachdidaktik Chemie am Beispiel von substanzbezogenem Risikoverhalten”, In N. Balzter, F. C. Klenk & O. Zitzelsberger (Hrsg.): Queering MINT. Impulse für eine dekonstruktive Lehrer_innenbildung, Opladen: Barbara Budrich, 2016, pp. 153-170.
[8] Bosmia, A. N. & Leon, K. J “Lung injury and the cinnamon challenge: college students should beware this Internet dare”, Journal of Injury and Violence Research 7(1), 2015, pp. 41-42.
[9] Muhle, H., Ernst, H. & Bellmann, B. “Investigation of the durability of cellulose fibres in rat lungs”, Annals of Occupational Hygiene 41(1), 1997, pp. 184-188.
[10] BfR “Gesundheitliche Bewertung 043: Verbraucher, die viel Zimt verzehren, sind

derzeit zu hoch mit Cumarin belastet”, 2006.
[11] Mayring, P. “Qualitative Inhaltsanalyse. Grundlagen und Techniken”, Weinheim: Beltz, 2015.

LabPi – A Powerful, Digital Low-Cost Measuring Station for STEM Education

Manuel Wejner[1], Timm Wilke[2]
Institute of Environmental and Sustainable Chemistry, Department of Chemistry Education, University of Braunschweig, Germany[1,2]

Abstract

Laboratory equipment is a recurring topic in the practice-oriented basic training of scientific disciplines. The acquisition costs of various digital measuring instruments, such as pH-meters, photometers or conductometers, are often in the mid-three- to four-digit range, even in the simplest equipment. Unfortunately, this circumstance often leads to the fact that only a small number of such devices can be provided and thus not all learners – quantitative determinations represent a particular challenge.
Single Board Computers (SBCs), such as the Raspberry Pi, offer a favourable approach to solving this challenge. In combination with suitable sensors and software, SBCs can be used as comprehensive digital measuring stations, offering many experimental approaches and possibilities for quantitative acquisition and evaluation. In addition to data acquisition, networking several minicomputers also offers new digital methods for comparing and evaluating measurement data – this can be done in combination with beamers, smart boards and tablets, for example, which can create new collaborative learning opportunities.
This article presents the new measuring system LabPi that can be extended with cost-effective sensors, is suitable for all STEM fields and has a modular design. It has simple operating elements to allow a quick start without programming knowledge. Measurement data can be evaluated directly at the measuring station or used for collaborative work with learning groups via the online platform. The application is also affordable for schools with a small budget, as illustrated by the example of the conductivity- and pH-electrode [1].

Keywords: Measurement Systems, LabPi, Digitalization, STEM Education 4.0.

1. Measured Value Acquisition in STEM Lessons

The acquisition of measurement data is an essential aspect of scientific-experimental investigations. However, quantitative analysis methods, which are used in research and industry on a daily routine, can hardly be represented in basic scientific education. With regard to its implementation in school chemistry education, numerous challenges are known for a long time. On the one hand, many measuring instruments are mainly designed for use in the laboratory. The high individual costs of these devices mean that measuring instruments can either not be provided at all or not in sufficient numbers for the students. The latter can sometimes lead to long waiting times, resulting in unwanted passive phases. On the other hand, the operation of the respective measuring devices must be learned by students and teachers; however, depending on the measuring device, the measured quantity and the manufacturer, this can vary greatly, which results in repetitive training phases and less time for the actual experiment.

For these reasons, teachers often resort to the use of low-cost measuring equipment to replace missing measuring devices with the simplest materials. Progressive digitization is also opening up new digital approaches to solutions by integrating programmable minicomputers, such as the Raspberry Pi or Arduino [2]. In this paper, we present a digital measuring station developed by us, which offers novel approaches to solutions based on minicomputers and precise sensors as well as teaching-learning concepts of STEM Education 4.0.

2. Development of LabPi

The "Raspberry Pi" single board computer serves as the basis of this measuring station and provides the necessary performance to display graphical applications and to function as a full computer. With the connection to a touch display, additional input devices such as mouse and keyboard are no longer required.

A large number of different sensors can be connected to the single board computer (Fig. 1) via its 40 plug-in connections and used for recording measured values by means of individual programming. To simplify the connection of sensors, we have developed an adapter board which reduces the connection of sensors to only one USB port (Fig. 2).

Thus, sensors can be connected to the Raspberry Pi simply via Plug & Play.

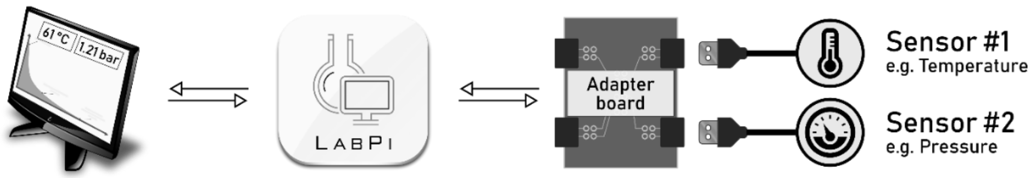


Fig. 1. *Components and schematic representation of the LabPi*

The software (also called LabPi) was designed and developed with didactic objectives in mind. It enables recurring processes, such as operation for each measured variable, to be standardized as far as possible. Thus, a renewed training in the software is reduced to a minimum. The measured values are recorded in real time and are displayed in the software both in tabular and graphical form. The evaluation can also be performed directly at the measuring station; alternatively, the data can also be exported for common spreadsheet software (e.g., Excel, Origin, ...).

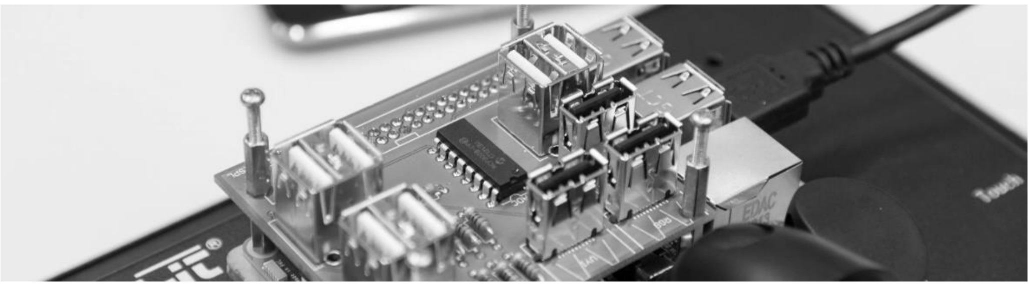


Fig. 2. *Adapter board for connecting several sensors simultaneously via USB*

By combining hardware and software, temperature, humidity, air pressure, pH-value, conductivity, gas concentration, GPS and amperage can be precisely measured and combined with each other as required [1]. For long-term measurements, the function of a data logger is also available, with which up to eight measured variables can be recorded simultaneously. Above all, the data logger offers the possibility of carrying out measurements independently of location; a common power bank can supply the measuring station and the sensors connected to it with energy for up to 28 hours.

3. Application and Experiences

The subject area of acids and bases is linked to the curriculum of chemistry lessons.

Thus, offers various opportunities to demonstrate both the precision of the sensors and practical work with the measuring station. Using a conductometric equivalence point determination with hydrochloric acid against sodium hydroxide solution, four common conductometers were compared with each other. The determined equivalence points (Fig. 3) shows that all measuring instruments lead to similarly good results and are suitable as sufficiently precise for teaching.

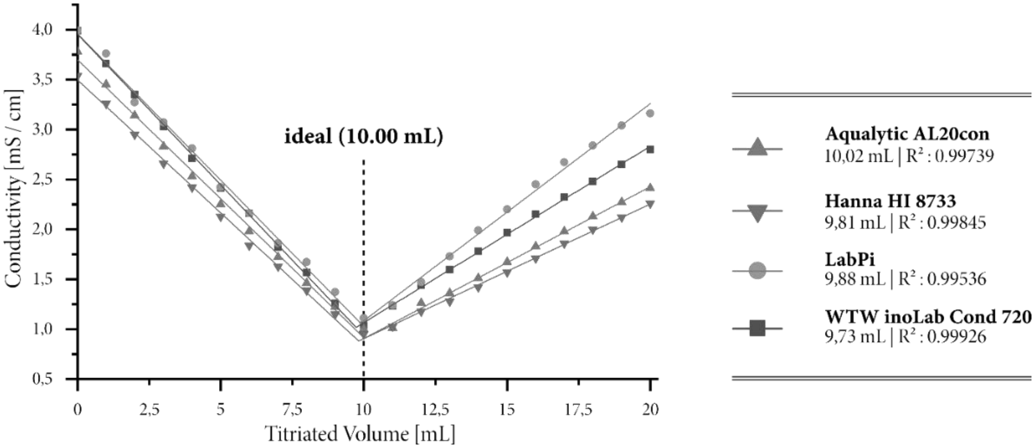


Fig. 3. *Conductivity titration of a 0.1 M hydrochloric acid solution with 0.1 M sodium hydroxide solution; comparative presentation of the values obtained from four laboratory instruments*

Teachers can unfold the full potential of LabPi by networking its technical possibilities with suitable teaching-learning concepts of STEM Education 4.0. By connecting several measuring stations with the associated cloud platform COMPare, numerous possibilities for collaborative learning formats are made possible. For example, several previously recorded measurement graphs can be merged, which ensures that results are not only secured within small groups, but in the entire learning group. The merged measurements can then be called up on various display devices (e.g., smartphones, tablets, ...), exported for evaluation and used further.

Fig. 4. *Consolidation of the results from several LabPi stations (left) via the associated cloud platform COMPare as well as graphical representation on various display devices (right)*

This evaluation possibility was pilot tested at our partner school. The learning group determined the phosphoric acid content of coke and diet coke by potentiometric methods. To enable the students to evaluate the use of LabPi, one titration curve was drawn by hand with a conventional pH-meter and the other with the measuring station.

The measurements were then uploaded to the cloud platform and compared in class; the original data can be accessed via a QR code (Fig. 5). The students could discuss the measurements together, identify deviations, describe the equivalence points and compare the amounts of phosphoric acid. In the concluding discussion round, the students found working with LabPi to be comfortable, intuitive and time-saving compared to classical recording and evaluation methods.

Fig. 5. *Measurement data of the learning group stored in the online platform COMPare*

4. Outlook

The LabPi project has been in development since 2017 and is designed as a permanent project. Since the development of the prototype, a large number of sensors for the measuring system could be opened up, enabling LabPi to measure temperature, humidity, (differential) pressure, pH-value, conductivity, magnetic field strength, various gas concentrations, GPS and amperage with the respective sensors. In addition, a digital UV/Vis photometer was developed with the aid of a 3D printed housing [3]. This variety is to serve as a basis for future projects in schools, student laboratories and universities.

Currently, the transfer into the practical phase has started; the implementation into school chemistry education and teacher trainings is accompanied by an empirical evaluation of the feedback in order to provide suggestions for the further development of LabPi. In addition, further functions such as tutorials and learning videos are under development to make the operation of the software and the connection of the sensors even easier. Developed and tested best-practice materials will be created and made available as Open Educational Resource at www.labpi.de.

REFERENCES

[1] Wejner, M., Wilke, T. (2019): Low Cost – High Tech: The Digital Measurement System LabPi, CHEMKON, 7 (26). DOI: 10.1002/ckon.201900016.
[2] Herbig, M., Böhme, U. (2018). Himbeerkuchen im Labor. Nachr. Chem. 66/5, pp. 525-527. DOI: 10.1002/nadc.20184074799.
[3] Wejner, M., Wilke, T.: J. Chem. Ed, *in preparation.*

Pro-SciencE: Strengthening STEM Proficiency in University Teacher Training

Timm Wilke*[1], Oliver Bodensiek*[2], Cornelia Borchert*[3], Annika Nimz[3]
Institute of Environmental and Sustainable Chemistry, Department of Chemistry Education, Technische Universität Braunschweig, Germany[1]
Institute for Science Education, Department of Physics Education, Technische Universität Braunschweig, Germany[2]
Institute for Science Education, Department of Chemistry Education, Technische Universität Braunschweig, Germany[3]

Abstract

Scientific subjects and expertise are of major importance in the professional practice of chemistry teachers and in the corresponding teacher training courses [1]. In order to ensure that current chemical topics are taught at a high level and to locate the acquired knowledge in professionally relevant teaching contexts, it is essential to connect chemistry and chemistry educational expertise [2]. Close cooperation between these two disciplines makes it possible to convey current topics in chemistry that are relevant to everyday life; at the same time, the relevance of these contents is made clear by systematically linking them to school contexts and requirements. In this way, the quality of university STEM teacher education can be improved [3].
The project "Pro-SciencE" at the University of Braunschweig starts right at this point and focuses on the development of professional skills of teacher students in natural sciences. In order to achieve this goal, the existing network between the STEM sciences and science education is to be expanded and supplemented by key competences in the field of digital education. The article will present how this concept is implemented at the University of Braunschweig.

Keywords: Chemistry Education, Teacher Training, Digitalization

1. Initial Situation

In Germany, there is still a severe shortage of young teachers in STEM subjects. A central problem in the courses of study in mathematics and the natural sciences (especially physics and chemistry) are the drop-out rates which are high in comparison to other subjects. For example, drop-out rates of 45% each in chemistry, physics and in geography and 54% in mathematics are reported for the 2016 cohort [4]. The most common motive for dropping out of university are performance problems (30% overall, 33% in mathematics and natural sciences [5]). For 84% of students with this motive in the subject group mathematics and natural sciences, they are even the decisive reason for dropping out [5].

To address this problem, subject structure and content as well as teaching and learning approaches need to be reformed and adapted to the specialist conditions of the degree programs. Accordingly, the German Physical Society [6] calls for a "sui generis" teacher training course geared to the requirements of the future profession. The educational goal for student teachers of natural science subjects is to make them “specialists in teaching and learning” [7] in the natural sciences. In order to achieve this, a holistic education in the subject is necessary which links teachers’ professional competences [8], especially content knowledge and pedagogical content knowledge, and promotes the development of profession-related beliefs [9]. In addition, this includes learning opportunities in which the students can develop an identification with the respective science, awareness of subject-related disciplines and the willingness to implement curricular relevant scientific progress in their teaching.

1.2 Predecessor Project: Pro-MINT

Against the above-mentioned background, the predecessor project “Pro-MINT” focused on professionalization processes of student teachers of chemistry, physics and mathematics. The subject-related individual challenges were addressed in various approaches, whose spectrum ranged from content restructuring and the increased use of real-life contexts to the use of the inverted classroom method. While initial successes have been achieved, e.g. in terms of increased motivation and interest or a stronger approach of concepts and content, the potential of digitally supported learning and teaching methods has not yet been fully exploited. On the other hand, it became clear that references to current research topics can potentially increase motivation and interest and thus indirectly improve professional performance. Against this background, both aspects – digitally-supported learning and teaching and current research topics – will be given more attention in the follow-up project Pro-SciencE.

2. Pro-SciencE: Concept

Within the framework of Pro-SciencE, students are enabled to independently deal with current research topics in a conceptual three-step process to promote constructivist appropriation processes and networked learning. In order to:

- be able to teach modern and (partly) digitally supported STEM lessons with
- a strong link to everyday life and
- to bring the latest findings of scientific progress into school,

it is also essential that future teachers can independently identify school-relevant subject content using examples of modern research and technology and prepare it for teaching purposes. This also corresponds to the recommendations of the German Science Council to “be able to apply scientific competence in a non-scientific context” [10].

Following on from the work of Frevert & Di Fuccia [11], the modular structure of ProSciencE will therefore support students in developing a STEM-related scientist practitioner habitus [12], which is a current research desideratum [13]. They acquire skills in the preparation and reconstruction of current research topics in relation to scientific methods and key concepts of STEM subjects as well as in the design of school learning arrangements for the digitally supported teaching of subject content with a research orientation and for the reflective handling of theories of digital education. Pro-SciencE thus implements the central demand to integrate digital education into pre-service teacher training from different perspectives [14].

Pro-SciencE consists of three modules (Figure 1) that students can combine according to their interests, even across disciplines. Overall, this results in a networking of subject and subject didactics. Furthermore, the boundaries between the STEM disciplines are softened through interdisciplinary cooperation and content. In addition, forward-looking digital media and new learning locations are to be integrated. An example of implementation is described below in the following chapter.

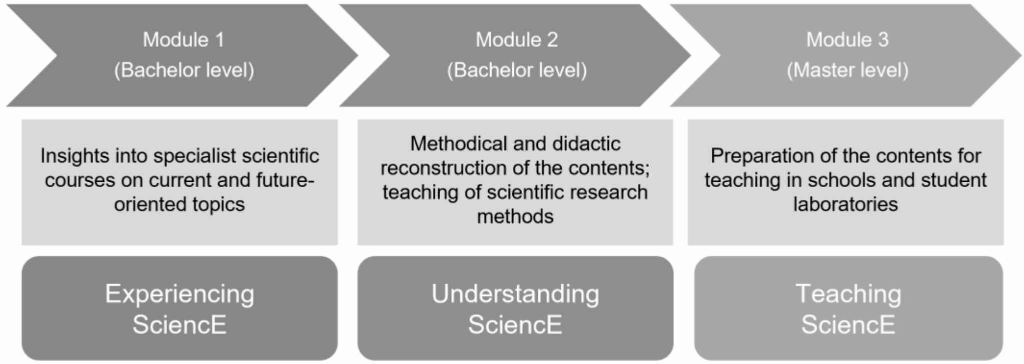


Fig. 1. *Structure of Pro-ScienceE with its modules*

2.1 Exemplary implementation of Pro-ScienceE

In the first module – **Experiencing ScienceE** – a student selects a specialist scientific course in a given subject; a number of selected courses in chemistry, physics, engineering and other interdisciplinary STEM areas are available for this purpose. In this example, the student selects the course “Fundamentals of Nanotechnology”, which is offered at the University of Braunschweig for various courses of study. During the course, the student gains insight into the scientific fundamentals as well as into the field of research. In the particular example, these insights are (among others) the high economic and scientific importance of this field of research as well as the great potential which this platform technology already offers for numerous fields of application. In addition, the essential characteristics of nanomaterials, such as the high specific surface area and quantum effects, are addressed along with their physicochemical backgrounds.

In the second module – **Understanding ScienceE** – the student expands his scientific knowledge by didactic aspects. With the aim of didactic reconstruction [15] of the acquired knowledge for application in school or student laboratories, the student learns appropriate ways of thinking as well as media and (digital) methods as tools for indexing the content. For the specific case of nanotechnology, developing models or simulations offers interesting possibilities to make the hardly accessible nano dimension more comprehensible for students. Alternatively, the student may focus on digital tools; the digital measurement station discussed here enables them to develop a suitable experiment for the synthesis and characterization of nanoparticles in school [16].

In the third module – **Teaching ScienceE** – these didactic-methodological considerations are elaborated into a practical teaching offer – ideally this can be done in the context of a master thesis. There are several possibilities for designing teaching material: the development of a teaching sequence for chemistry lessons is just as possible as the planning of a student research project or the design of a course offer for student laboratories. Finally, the practical implementation can be carried out in partner schools or in the teaching-learning laboratory of the University of Braunschweig.

Figure 2 visualizes this process and shows further possibilities how Pro-ScienceE’s modules can be completed.

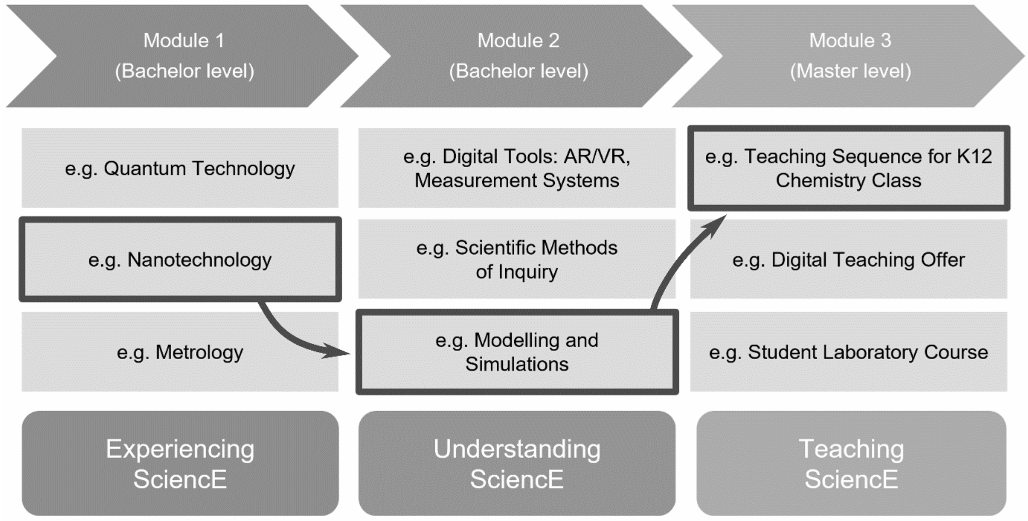


Fig. 2. *Exemplary progression path of the Pro-Science modules*

2.2 Empirical Research

Following the approach of Design-Based Research [17], the modules are evaluated and optimized over a number of successive cohorts. A mixed-method approach is used to capture the diverse constructs of interest and to answer the following research questions:

1. How do students' attitudes and values regarding subject-related parts of their studies change during the modules?
2. To what extent does the attendance of the sub-modules contribute to the competence development of the students in the selected areas compared to the areas not selected?

Competence development in the areas of scientific methods for inquiry, modelling and simulation, augmented and virtual reality and methods of teaching with digital tools as well as corresponding accompanying variables (e.g., motivation, interest, academic self-concept, self-efficacy expectations) are examined along the modules in a pre-post-test design. The options available in the modules allow for a quasi-experimental design with control groups. The attitudes and values of the students will be collected by means of guideline-based interviews and evaluated with qualitative methods.

3. Outlook

As part of the pilot phase, the first cooperation of the project with a course in electrical engineering takes place in the current winter semester 2019/20. There the students acquire basics in electrical engineering in the context of electric mobility within the framework of sub-module 1 (**Experiencing ScienceE**). In this course, which is mainly focused on practical skills, students will gain insights into propulsion engines and energy storage technologies, among other topics. The examination of simulation methods for the energetic description of such systems offers a seamless connection to the area "Modelling and Simulations" in module 2 (**Understanding ScienceE**), which will be offered for the first time in the following semester. Further points of contact can be found for a comparison of research methods experienced in an engineering discipline with those known from the natural science studies for the area "Scientific Methods of Inquiry" of the module. Based on these first experiences, more cooperation's with different disciplines of science and engineering as well as the development of further sub-modules and the re-design of the existing ones are to follow.

REFERENCES

[1] Baumert, J., Kunter, M., Ergebnisse des Forschungsprogramms Coactiv (Eds.: M. Kunter *et al*.), Waxmann, Münster 2011.
[2] Becker, H.-J., Nguyen, M. Q., Parchmann, I., Nachr. Chem. 2015, 63 (3), p. 364.
[3] Ableitinger, C., Kramer, J., Prediger, S., Zur doppelten Diskontinuität in der Gymnasiallehrerbildung, Wiesbaden, Springer 2013.
[4] Heublein, U. & Schmelzer, R. (2018): Die Entwicklung der Studienabbruchquoten a den deutschen Hochschulen. Berechnungen auf Basis des Absolventenjahrgangs 2016. Hannover: Deutsches Zentrum für Hochschul- und Wissenschaftsforschung (DZHW).
[5] Heublein, U., Ebert, J., Hutzsch, C., Isleib, S., König, R., Richter, J. & Woisch, A. (2017). Zwischen Studienerwartungen und Studienwirklichkeit. Hannover: Deutsches Zentrum für Hochschul- und Wissenschaftsforschung (DZHW).
[6] Deutsche Physikalische Gesellschaft, Thesen für ein modernes Lehramtsstudium im Fach Physik, Bad Honnef 2006, retrieved from https://www.dpg-physik.de/static/info/lehramtsstudie_2006.pdf, 20.01.2020.
[7] Deutsche Physikalische Gesellschaft, Zur fachlichen und fachdidaktischen Ausbildung für das Lehramt Physik, Bad Honnef 2014, retrieved from https://www.dpg-physik.de/veroeffentlichungen/publikationen/studien-der-dpg/pix-studien/studien/lehramtstudie-2014.pdf, 20.01.2020.
[8] Baumert, J., Kunter, M. (2006), ZfE 9(4), pp. 469-520.
[9] Eller, S., Nordmeier, V., Reform der Studieneingangsphase im Lehramt Physik. PhyDid B – Didaktik der Physik – Beiträge zur DPG-Frühjahrstagung, 2011.
[10] Wissenschaftsrat (2015): Empfehlungen zum Verhältnis von Hochschulbildung und Arbeitsmarkt. Bielefeld, retrieved from: https://www.wissenschaftsrat.de/download/archiv/4925-15.pdf, 20.01.2020.
[11] Frevert, M. & Di Fuccia, D.-S. (2017): Contemporary Science in Chemistry Education in Germany. In: IACB, ICE, & ISEC Conference Proceedings 2017, Littleton: The Clute Institute.
[12] Shapiro, D. (2002), The Psychologist. 15(5), pp. 232-234.
[13] Schreiber, W. & Zabold, S. (2015): Reform der Lehrerbildung – Zwischen Zwängen der Praxis, Erkenntnissen der Theorien und Evidenzen der Empirie. Eichstätt: Katholische Universität Eichstätt-Ingolstadt.
[14] GI-Gesellschaft für Informatik (2016): Dagstuhl-Erklärung: Bildung in der digital vernetzten Welt, retrieved from: https://www.gi.de/fileadmin/redaktion/Themen/dagstuhl-erklaerung-bildung-in-der-digitalen-welt-2016.pdf, 20.01.2020.
[15] Duit, R., Gropengießer, H., Kattmann, U., Komorek, M., Parchmann, I. (2012), Science education research and practice in Europe retrospective and prospective, Sense Publ. Rotterdam.
[16] Wejner, M., Wilke, T. (2019, CHEMKON, 7 (26), pp. 294-300.
[17] Wilhelm, T., Hopf, M. Design-Forschung. In: D. Krüger, I. Parchmann, H. Schecker (Eds.), Methoden in der naturwissenschaftsdidaktischen Forschung (pp. 31-42), Berlin/Heidelberg, Springer Spektrum 2014.

Synthesis and Application of Nanocomposites with Tailored Properties for School Chemistry Education

Björn Bartram[1], Timm Wilke[2]
Institute of Environmental and Sustainable Chemistry, Department of Chemistry Education, University of Braunschweig, Germany[1,2]

Abstract

Many objects in our everyday life are made of polymers. From drinking bottles to contact lenses, the development of materials with tailor-made properties remains an important topic of current research in chemistry and material science. While the variation of monomers, reaction parameters and additives make it possible to produce polymers with a wide range of properties, the application of nanomaterials as additives in synthesis offers outstanding potential in this context. The resulting nanocomposite materials show special properties depending on the additive. On this basis, fracture-resistant lightweight bodies [1] or antimicrobial surfaces for medical purposes are currently being developed [2].
This combination of "classical" polymer chemistry with nanotechnology offers attractive new ideas for school chemistry education. Through didactic reconstruction, this current field of research can be easily integrated into K12 chemistry curricula in a vivid way with many student experiments. The examples presented in this contribution include a simple synthesis strategy using conventional laboratory equipment, tea light shells and unsaturated polyester resin from a hardware store. Magnetite nanoparticles are an example of research-relevant nanomaterials. As an additive they modify the magnetic properties of the polymer and visualize the effect of the modification of nanomaterials. The properties can then be investigated (e.g., based on industrial materials testing) in descriptive model experiments [3]. Overall, it should be shown that the synergistic networking of polymer chemistry and nanotechnology results in a variety of learning opportunities and questions with curricular relevance for the upper secondary school.

Keywords: Nanoscience's, polymer, model experiments, smart materials, chemistry education

1. Introduction

Polymers are among the most important materials of our time and are constantly being developed. By varying the educts, the reaction parameters and by adding so-called additives, the polymers are to be tailored for their later application. A current trend here is the use of nanomaterials as additives, which reduce material costs and significantly modify the properties. The variety of nanocomposites – a technical term for composite materials with nanomaterials as additives – is greatly increased by the range of nanomaterials alone. But nanomaterials can also be further processed. Even though the properties of nanomaterials are largely determined by morphology and surface-to-volume ratio, they can be adapted by specific surface modification.

One example is the modification of aluminium oxide nanoparticles with carboxylic acids. Depending on the objective, the carboxylic acids can be selected to influence the nanoparticles and thus the nanocomposite. In unsaturated polyester resins, an unsaturated carboxylic acid enables a covalent bond between additives and resin, which leads to a change in the fracture strength. These types of nanocomposites are therefore attractive for use in lightweight car bodies [1]. In the following, it will be shown how this important principle can be combined with current experiments on nanocomposites and thus be taught in schools and student laboratories.

2. Objectives

For upper secondary level (students aged 16-19), alumina and silver nanocomposites (Al_2O_3-NC and Ag-NC) have already been synthesized and analysed on the basis of simple polyester resins available in hardware stores. By stirring the particles into the resin, then curing them in tea light bowls and using equipment similar to industrial testing tools, the increased breaking strength of Al_2O_3-NC relative to corresponding polymers without nano additives was determined. For Ag-NC an antimicrobial activity with depot effect could be demonstrated analogously [3]. For the synthesis of these nanocomposites, a modification is not necessary. It is now conceivable to modify these already approved nanomaterials, but

- many of the methods that are commonly used in research for their modification are not suitable for school use, as they require unsuitable conditions (expensive/hazardous chemicals, protective gas, long synthesis times, …),
- a success of the modification cannot be directly determined by simple means, so that the products usually have to be tested with TEM, SEM or other methods.

For a successful implementation of nanocomposites with modified nanomaterials in schools, it must therefore be possible to meet these two challenges: to modify the nanomaterials and to verify the modification with suitable means.

3. Didactic Reconstruction

Magnetite nanoparticles (short: Fe_2O_3-NP) represent a promising solution to these challenges. These are easy to produce with school resources. Furthermore, there is a simple and convincing method to analyse the size and functionalization. Under certain conditions magnetite nanoparticles in aqueous solution behave like a magnetic fluid (“ferrofluid”), that shows a characteristic feature called Rosenzweig effect. In the proximity of a magnet “spikes” form along the magnetic field, which is not only easy to examine but also has a vivid effect.

A prerequisite for the successful synthesis of a ferrofluid are superparamagnetic nanoparticles, and the nanoparticles must be shielded from other nanoparticles. Many different approaches have been documented for this purpose. The synthesis principle for Fe_2O_3-NP is a basic precipitation reaction of iron(II) and iron(III) ions. For the functionalization e.g., oleic acid, tetramethylammonium hydroxide (short TMAH) and tetrabutylammonium hydroxide (short TBAH) are documented, the use of TBAH has been proven. Since the hydroxide anions of the molecule orient themselves towards the surface, the cation protrudes outwards and can thus shield the particles from each other by electrostatic repulsion and stabilize them in the medium (Fig. 1). The Fe_2O_3-NP in the liquid can thus continue to align themselves with the magnetic field [4].

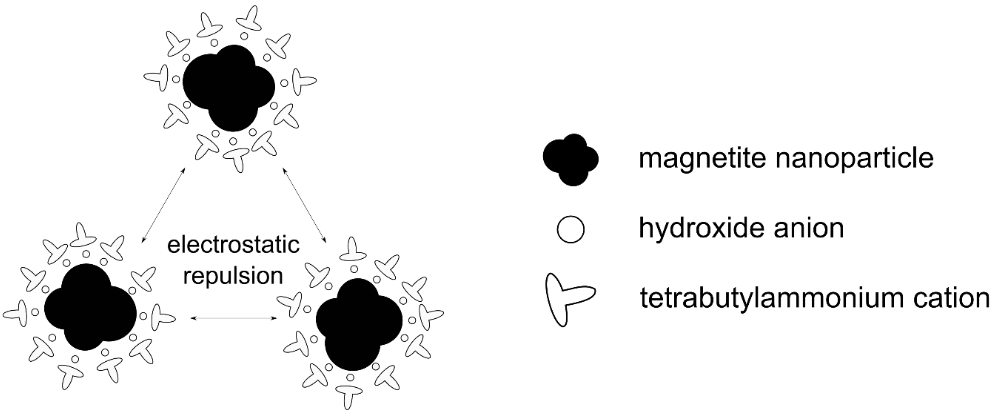


Fig. 1. *Principle of electrostatic repulsion between modified Fe_2O_3-NP (based on [4])*

3.1 Synthesis of the ferrofluid

The concept for the synthesis of the ferrofluid used here goes back to Berger *et al*., [4]. The procedure presented in the following has proven to be successful for the synthesis of nanocomposites. The starting materials used were iron (III) chloride pentahydrate, iron (II) sulphate heptahydrate, ammonia (15 mL 25% diluted to 100 mL), TBAH (40% in water), water.

In a common synthesis 3.5 g $FeCl_3$ and 2.0 g $FeSO_4$ were diluted in 25 mL demin water. With stirring, 100 mL of the diluted ammonia solution is added over the course of five minutes. The following reaction occurs:

$$2\ FeCl_3\ (aq) + FeSO_4\ (aq) + 8\ NH_3\ (aq) + 4\ H_2O \rightarrow Fe_3O_4\ (s\downarrow) + 6\ NH_4Cl\ (aq) + (NH_4)_2SO_4\ (aq)$$

By attaching a neodymium magnet to the glass, the excess liquid can be decanted (also called magnetic separation). The Fe_2O_3-NP are washed by adding water again and decanting analogously until no more ammonia odour can be perceived. Then 0.3 g TBAH solution is added to the solid and stirred with a glass rod until the black liquid shows the Rosenzweig effect.

After the addition of ammonia, the solution turns black immediately. The subsequent addition of the TBAH does not lead to any optical change at first. As the working process progresses, the liquid reacts increasingly to the magnet. If the magnet is held at a distance of about 2 cm from the ferrofluid, characteristic spikes can be seen, aligning themselves with the magnetic field.

3.2 Synthesis of the magnetic nanocomposite

The ferrofluid that has now been synthesized can be worked into the resin A usual preparation contains 4 m% hardener, 2 m% additive and 94 m% resin. For a 10 g composite, 9.4 g resin, 0.2 g additive and 0.4 g hardener were used. To vary the mass fraction of the additive, the resin quantity is adjusted accordingly and the hardener is kept at 4 m%. During synthesis, the resin is first placed in a beaker and the additive is added. With a glass rod, the mixture is thoroughly mixed so that the ferrofluid is distributed as homogeneously as possible. Finally, the hardener is stirred in and the hardening mixture is quickly poured into tea light bowls. Approximately 10 g of composite was added per bowl (Fig. 2 [3]).

Fig. 2. *Left to right: magnetic separation of Fe_2O_3-NP, checking the Rosenzweig effect, dispersing in the resin, weighing the reacting polymer mixture into tea light bowls*

3.3 Characterization of the nanocomposite

After curing, it can be clearly seen that the resulting nanocomposite with the ferrofluid appears completely black without major colour differences. If only Fe_2O_3-NP are incorporated, a clear difference becomes apparent in the comparison: the upper side of the product appears light brown (the polymer without additives is yellow/orange) and the lower side is deep black. From this it can be concluded that the Fe_2O_3-NP cannot be stabilised well in the polymer without TBAH and will sink during the curing process. For the ferrofluid the Fe_2O_3-NP are stabilized in the polymer by the TBAH, so that the particles do not sink and are distributed more homogeneous (Fig. 3).

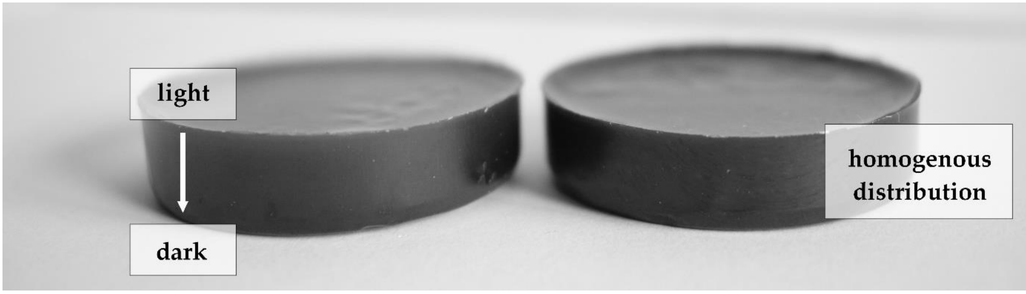


Fig. 3. *Comparison of nanocomposites.*
Left: Without functionalization; right: with functionalization

This effect can also be investigated quantitatively. Since the magnetizability by a magnetic field is proportional to the amount and distribution of Fe_2O_3-NP in the polymer, the force required to remove the magnet from the sample can be measured using a force meter. To do this, a magnet is attached to the sample and pulled against the force meter until the magnet is released from the sample. If the magnetic additive is homogeneously distributed, the force required to release it should be approximately the same for the top and bottom sides. In case of an inhomogeneous distribution, the magnet should adhere more strongly to the bottom side than to the top side: Due to the sinking of the Fe_2O_3-NP, more magnetizable substance reaches the bottom side and the magnetic attraction force is thus greater.

For analysis, a suspension is attached to a tea light with string and hot glue. Thus, the bowl can be attached to the spring force meter. On the underside of the holder, a form is attached that fits the magnet, so that the magnet can always be attached as identically as possible (Fig. 4).

Fig. 4. *Low Cost analysis for school chemistry education: Bowl to hang up the sample with attachment for the magnet (left); deflected force meter, during measurement (right)*

For the actual measurement, the nanocomposite to be examined is now placed in the bowl, the magnet is attached at the bottom and carefully pulled down. The exact value is noted down before the magnet separates from the sample. This is repeated five times per side of the sample. Then the difference between the forces for the top and bottom sides is calculated and these values are averaged. From these average values, an average value can be calculated for all samples. These mean values are given in the following diagram.

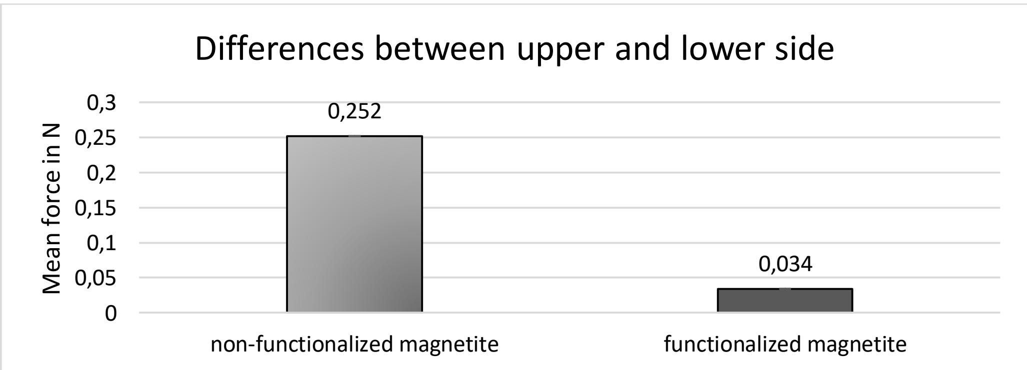


Fig. 5. *Mean values of the averaged differences for two samples each*

4. Practical Experience

Using ferrofluids produced with non-hazardous and easily obtainable chemicals, it is possible to produce homogeneous magnetic nanocomposites, which additionally illustrate the influence of surface modification by using TBAH. This can be determined either optically or via the magnetic behaviour. For STEM lessons K12 school chemistry education, this offers an experimental approach to research topics. Polymer chemistry, which is an integral part of the upper secondary level curriculum, provides a starting point here. However, the series of experiments presented here enables a deeper understanding of polymer chemistry through the use of nano additives.

An initial course design for school laboratories with pupils and students was successfully piloted (Fig. 6). An in-depth evaluation of this first positive impression is currently being prepared.

Fig. 6. *Students during the synthesis of Fe_2O_3 nanoparticles*

REFERENCES

[1] Kockmann, A., Porsiel, J. C., Saadat, R., Garnweitner, G. Impact of nanoparticle surface modification on the mechanical properties of polystyrene-based nanocomposites, RSC Adv. 8 (20), 2018, pp. 11109-11118.

[2] Abbas, M., Naeem, N., Iftikhar, H., Latif, U., Silver nanoparticles. Fabrication, characterization and applications, 2018, Intech Open, pp. 71-91.

[3] Saadat, R., Bartram, B., Wilke, T. Made to measure: Easy Synthesis and Characterization of Nanocomposites with Tailored Functionalities for Chemistry Education, W. J. Chem. Ed., 7 (2), 2019, pp. 65-71.

[4] Berger, P., Adelman, N. B., Beckman, K. J., Campbell, D. J., Ellis, A. B., Lisensky, G. C., Preparation and Properties of an Aqueous Ferrofluid, W. J. Chem. Ed., 7 (76), 1999, pp. 943-948.

What Do Legionella, EHEC and Botox Have in Common? An Interdisciplinary Science Camp on Bio-membrane Research and the Nature of Science

Hilko Aljets[1], Lea Leibold[2], Ingo Mey[3], Thomas Waitz[4]
Institute of Inorganic Chemistry, Department of Chemistry Education, Georg-August University Göttingen, Germany[1,2,4]
Institute of Organic and Biomolecular Chemistry, Georg-August University Göttingen, Germany[3]

Abstract

Nine students aged 16 to 19 took part in a XLAB science camp in Göttingen (Germany) in October 2019 entitled 'What do Legionella, EHEC and Botox have in common?'. In order to answer this question, the underlying scientific concepts such as the transport mechanism across biomembranes and as the basis of that the self-assembly of lipids to bilayers were developed during the five days of the camp based on the heterogeneous prior knowledge of the participants. Using specific developed experiments and information materials, the students acquired both the scientific principles and the important research method of fluorescence microscopy independently. Therefore, the phenomena of colour and fluorescence were systematically investigated from a chemical and physical point of view. On the last day, the learned contents were applied to the pathogens Legionella pneumophila, EHEC (enterohemorrhagic Escherichia coli) and Botulinum toxin (Botox) by comparing adapted primary literature on current research on SNARE-mediated exocytosis at the presynapse with a newspaper article on medical research on Botox. By analysis of scientific communication, an authentic insight into the work of a scientist is given in addition to the experiments. An accompanying questionnaire study examined the changes in the participants' understanding of the nature of science.

Keywords: adapted primary literature, nature of science, science camp, biomembrane

1. Introduction

When do students come into contact with science? According to PISA 2015, only a minority of students are involved in science outside school activities [1]. As a result, science education is of particular importance for the teaching of scientific literacy and at the same time stuck in a dilemma: In a short time and with few resources, students should be trained to become "reflective citizens" being able to "engage with science-related issues, and with the ideas of science" [1, p. 50]. In addition to the teaching of scientific knowledge, knowledge about the nature of science is necessary in order to be able to discuss current scientific results [2]. In education and in the media, however, current results from fundamental scientific research are rarely discussed [3]. In fact, scientific knowledge is generally presented rather in an explanatory, narrative, absolute and simplified way. In addition, it's difficult for teachers to integrate current research into the classroom for several reasons, as we outlined previously [3].

With this background, the science outreach project of the Collaborative Research Center 803 (CRC 803) at the University of Göttingen aims to prepare current complex basic research in the interdisciplinary field of biomembranes and to transport it to the general public [4]. The cooperation of the scientists and science educators led to the development of numerous experiments and teaching units (e.g., 'From Surfactants to Biomembranes' [5]), whose contents are related to the research done in CRC 803. In addition to the dissemination of scientific knowledge and the state-of-the-art methods at CRC 803, an authentic insight into the work of a scientist is given. In this article the concept of a science camp entitled 'What do Legionella, EHEC and Botox have in common?' is described, which attempts both to impart scientific knowledge and how scientific knowledge is gained.

2. Educational Framework of the Science Camp

Science Camps offer the possibility to teach knowledge, free of normative restrictions to interested students over several days and provide more time and resources compared to classroom teaching. Therefore, it is possible to discuss current research in such a format. The course took place in the XLAB, an experimental laboratory for students located in Göttingen, Germany [6], which is also characterized by its proximity to the University of Göttingen and its research.

With the heterogeneous prior knowledge of the participants in mind, the camp focuses on the independent processing of the contents. The participants have to achieve different learning goals and can choose from a total of 40 experiments, various information materials and tasks from the developed script as well as the possibility of searching for more information on the internet or in textbooks. Figure 1 illustrates the contents of the camp by days. At the end of each day there is a joint backup of the results. The arrangement of the topics is comparable to the canonical structure of a scientific article (introduction – material and methods – results – discussion) [7]. The first three days are used to convey the basics of biomembrane research and its methods, so that a basis for the observation of transport processes on the fourth day is given. This general knowledge can then be applied to the pathogens and toxins Legionella, EHEC and Botox on the last day to answer the title question of the camp. Besides pathogens, the analysis of scientific communication is also a topic of the last day.

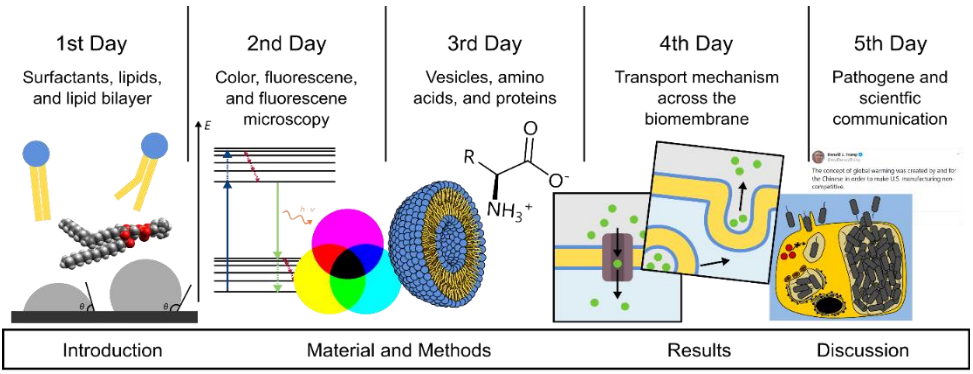


Fig. 1. *Illustration of the content of the science camp. The arrangement of the topics is similar to the structure of a scientific article*

3. Analysis of Scientific Communication

For non-scientists, scientific communication is the only way to get in touch with science. Due to different preconditions of the addressees and goals of the communication, different communication channels can be distinguished (see Figure 2).

Transfer of knowledge from the scientific community to the general public is not only simplified in terms of content, but also structurally different from communication within the scientific community. Science described by primary scientific literature (e.g., articles in peer-reviewed journals) is characterized by arguments justifying methods, results, hypotheses and explanations, and comparisons of results. In secondary literature (e.g., popular scientific newspaper articles, textbooks) this argumentative structure of research is often neglected [8]. The comparison of a scientific newspaper article and a journal article offers a promising opportunity for students to learn how different science is communicated and thereby how scientific knowledge is gained and discussed in the scientific community. This can lead to an improvement of the student's views of nature of science [9, 10].

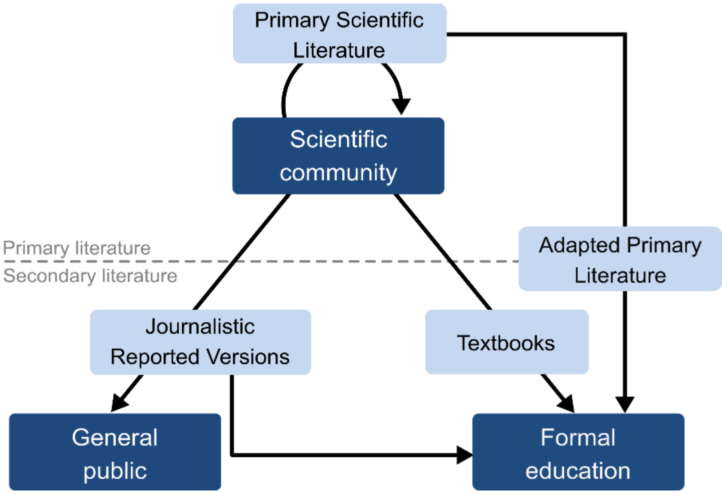


Fig. 2. *Overview of the genres of scientific texts according to Goldman und Bisanz [8]. The three different communities use different types of texts to communicate about science. Adapted primary literature, a new text genre developed by Yarden et al., [10], acts as a missing link between textbooks and primary literature. Figure cited from von Hoff et al., [9].*

Facing the fact that original primary scientific literature is for novice difficult to read, the format of adapted primary literature (APL) represents a didactically reduced variant of primary scientific literature without losing important features such as the argumentative style, the canonical structure or the uncertainty of scientific knowledge.

The reduction is necessary because the students have a different prior knowledge than the scientific community. Unlike textbooks, APL confronts students with the representation of knowledge in the scientific community [10]. For the camp, an APL based on current research by CRC 803 on SNARE-mediated exocytosis at the presynapse [11] was prepared and categorically compared with a freely available newspaper article on medical research on Botox. The considered categories were the target groups, structure, language, illustrations and reference sources of the texts.

4. First Experiences and Evaluation

The science camp took place for the first time in October 2019 with nine students aged 16 to 19. In order to investigate the success of the camp, a questionnaire was developed to test the participants' understanding of the nature of science. The questionnaire was based on the three dimensions of the nature of science according to Osborne *et al*., [12] ("Nature of Scientific Knowledge", "Methods of Science" and "Institutions and Social Practices in Science", see Figure 3), for which various statements were developed, which the participants could agree or disagree with on a four-level scale. In addition, the students' opinions about the camp were asked for in further informal talks.

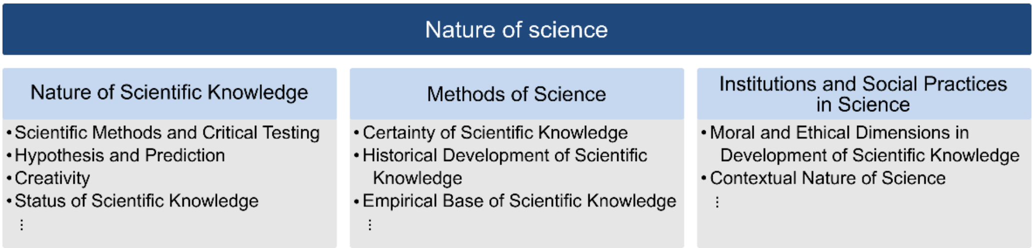


Fig. 3. *Three Dimensions of nature of science with exemplary themes based on the Delphi-study form Osborne et al., [12]*

The discussions with the participants drew an overall positive picture of the Science Camp. The possibility of working autonomously was positively emphasized, but also the analysis of science communication was evaluated as exciting and informative. However, some experiments of the first four days were described as worthy of revision, especially because the experimental instructions were still difficult to understand. The results of the survey give reason to hope for an improvement in the understanding of the nature of science in the first two dimensions. This includes the student's views of the status and the empirical base of scientific knowledge as well as the need of creativity for research.

In the third dimension "Institutions to Social Practices in Science", however, no change could be observed. Since the number of participants is still very small, no absolute statements can yet be made about the effect of the camp. However, the first results are motivating for the further pursuit of the project, so that an improved edition of the camp can already be offered in April. Further dates are planned, so that after several performances a significant statement about the effect of the camp can be made.

REFERENCES

[1] OECD. *PISA 2015 Results (Volume I): Excellence and Equity in Education*, Paris, OECD Publishing, 2016.
[2] Osborne, J. Science Without Literacy: A ship without a sail? *Cambridge Journal of Education*, 32 (2), 2002, pp. 203-218.
[3] Von Hoff, E., Waitz, T., Mey, I. Science Outreach Activities on Biomembrane Research in Formal and Non-Formal Settings, Pixel (ed.), *Conference Proceedings. New Perspectives in Science Education. 7th Conference Edition*, 2018, pp. 301-306.
[4] Von Hoff, E., Milsch, N., Ehlers, M., Waitz, T., Mey, I. Membranforschung für die Öffentlichkeit: Ein Kooperationsprojekt zwischen Fachdidaktik und

Fachwissenschaft. *CHEMKON*, 24 (4), 2017, pp. 165-169.
[5] Dege, J., Irmer, E., Steinkuhle, A., Steinem, C., Waitz, T. Vom Tensid zur Biomembran. *Praxis der Naturwissenschaften – Chemie in der Schule*, 65 (2), 2016, pp. 5-10.
[6] Goodman, C. From students to scientists at XLAB. *Nat Chem Biol,* 5 (4), 2009, p. 194.
[7] Suppe, F. The Structure of a Scientific Paper. *Philosophy of Science*, 65 (3), 1998, pp. 381-405.
[8] Goldman, S. R., Bisanz, G. L. Toward a Functional Analysis of Scientific Genres. Implications for Understanding and Learning Processes. In: J. Otero, J. A. León und A. C. Graesser (eds.), *The psychology of science text comprehension*. Mahwah, NJ, Erlbaum, 2002, pp. 19-50.
[9] Von Hoff, E., Aljets, H., Milsch, N., Waitz, T., Mey, I. Arbeiten mit Adaptierter Primärliteratur im Chemieunterricht. *CHEMKON*, 26 (5), 2019, pp. 190-193.
[10] Yarden, A., Norris, S. P. & Phillips, L. M. Adapted Primary Literature. The use of authentic scientific texts in secondary schools. Dordrecht, Springer, 2015.
[11] Kuhlmann, J. W., Junius, M., Diederichsen, U., Steinem, C. SNARE-Mediated Single-Vesicle Fusion Events with Supported and Freestanding Lipid Membranes. Biophysical Journal, 2017, 112 (11), pp. 2348-2356.
[12] Osborne, J., Collins, S., Ratcliffe, M., Millar, R., Duschl, R. What 'ideas-about-science' should be taught in school science? A Delphi study of the expert community. *J Res Sci Teach.*, 40 (7), 2003, pp. 692-720.

Curriculum Development

Designing Augmented Reality Experiences for Science Education

Jordan Ellsworth[1], David Pixton[2]
Brigham Young University, Unites States of America[1,2]

Abstract

In science education, there are often highly three-dimensional concepts, processes, and objects which are difficult to understand in a two-dimensional context, yet, this is how we usually attempt to teach them. For example, when teaching chemistry, we may attempt to describe an atom by drawing it on a whiteboard and describing it. Although this method can be beneficial, it leaves much up to the imagination and can often leave many students confused. However, augmented reality (AR) can be leveraged to help students not only visualize three-dimensional objects and ideas but interact with them in a meaningful way. It provides many affordances, such as recreating existing aspects of the physical world in a controlled environment or allowing visibility of things normally invisible to the naked eye. Using sound design principles and relevant earth science education content, we created an AR experience using the tether-free Magic Leap AR headset to enhance a 6-ft globe exhibit in a university library. It teaches about the Earth's magnetic field and how it protects the Earth from harmful solar particles. In designing and testing the experience, we have learned many valuable lessons about AR in science education and important considerations when designing and developing a virtual learning experience that we hope to share with the world.

Keywords: Augmented Reality, Instructional Design, Earth Science

1. Background

The graduating class of 1966 left Brigham Young University (BYU) with a rare and memorable gift. Perhaps referring to the campus motto, "the world is our campus," this group of departing students gifted the University a 6-foot (1.8-meter) diameter geophysical relief globe.

In 2018, the Library began looking at ways of refreshing this exhibit, with a desire to increase the educational experience provided by this rare asset. Two engineering students proposed using augmented reality (AR) to add content to the globe. This emerging technology offers a means to provide the exhibit with nearly unlimited educational content and creates a lab for active learning. For example, students and instructors in geology, political science, anthropology, geographic information systems, etc. could use this platform to create and display data or other information in an engaging manner that connects events with their geographical context.

The following sections discuss lessons learned as we have progressed through the design phase of an AR application for this globe exhibit. We expect that our findings may provide value to those considering use of AR technology in their teaching efforts by illuminating aspects of the design process and by providing a basis for informed decision-making.

2. Literature Review

A study was recently published that provides profound insight into the affordances generated by AR technology [1]. These affordances include: diminishing negative aspects of the physical world, enhancing positive aspects of the physical world, recreating existing aspects of the physical world, creating aspects that do not exist in the physical world, and overcoming space-time linearity.

Researchers in educational fields have previously applied AR to help students learn abstract concepts in the Earth Sciences. Some report findings that using AR to learn difficult concepts decreases the cognitive load of university students and aids learning and retention [2]. Others utilize AR to create new opportunities for learning by facilitating student experimentation relating to what happens when the Moon is too close or too far away from the Earth [3].

3. Method

3.1 Project Definition

***Design goals & objectives*.** The application design, development, and implementation are meant to: 1) assist students in comprehending highly abstract concepts relating to the Earth; and 2) provide an example to students and teachers at BYU of a meaningful educational experience leveraging AR technology. To achieve these goals, the experience should incorporate active learning to increase engagement, and the quality of the augmentations should be realistic and immersive enough to increase comprehension, not distract from the learning experience, and truly represent the technology.

Target audience. To better understand our users, personas were developed for three types of individuals in our target audience [4]. The “curious freshman” persona captures the demographic of younger students that just want to experience AR in some form out of curiosity. The “struggling with physics” persona represents students who are struggling with understanding a certain concept and are interested in the AR platform as a study help. Finally, the “interested professor” persona represents the faculty and staff that have heard about AR and are looking for an example of its use in education.

These personas were informed by our literature review, some initial testing feedback, and frequent interaction with our user population as our classmates and colleagues. For example, one study found that 48% of BYU students reported being “not familiar at all” with AR technology and only 2% reported being “extremely familiar” with the technology [1]. We expect even lower rates of familiarity with AR being reported by faculty and staff.

3.2 Selection of appropriate content

The novelty of the technology is not a sufficient reason for employing it. However, in the context of the globe exhibit, compelling value is seen in AR’s ability to take abstract, difficult-to-visualize concepts and make them concrete and understandable. One such abstract concept is the Earth’s magnetosphere – the invisible yet powerful magnetic field that protects the Earth’s atmosphere. Since many have little concept of its presence or importance, we decided that this would be a good test of AR’s educational promise.

In designing this AR experience, learning outcomes were chosen that could exploit specific affordances of the technology. These include: 1) knowing that the Earth’s magnetic field is generated by its iron core, 2) explaining how the Earth is protected from solar wind, and 3) understanding that the northern lights are visible evidence of the magnetosphere.

Examples of how we leveraged these affordances to meet learning objectives include:

- Most representations in instructional materials utilize field lines to depict the Earth's invisible magnetic field because of their simplicity and the 2-dimensional media typically used to depict the field. With AR, we are able to depict the true 3-dimensional nature of the field, utilizing AR's affordance to *enhance the physical world*.
- AR can not only show a representation of the core of the Earth but can also facilitate *adding additional information* that does not exist in the physical world, such as the centerline axis of the Earth to assist in comprehension.
- AR allows visualizing an alternate reality that would be, were the magnetosphere absent. This exploits AR's ability to *ignore space-time linearity*. Furthermore, spatial distances are not constrained to be to scale, and so the observer can play the role of another body in outer space interacting with the magnetosphere without being concerned with scale.
- Though it is possible to see visible evidence of the magnetosphere, an observer would need to travel far north to see this. The authors used AR to help users experience Aurora Borealis regardless of their location, capitalizing on AR's ability to *recreate aspects of the physical world* in a location convenient to the user.

3.3 Structuring the Content

We used a cognitive task analysis (Fig. 1) when organizing the content for this learning experience [5]. This meant researching how experts think about the content and organizing it in the manner that they would. Task analyses seem especially appropriate for AR experiences as they provide additional direction and flow to the experience.

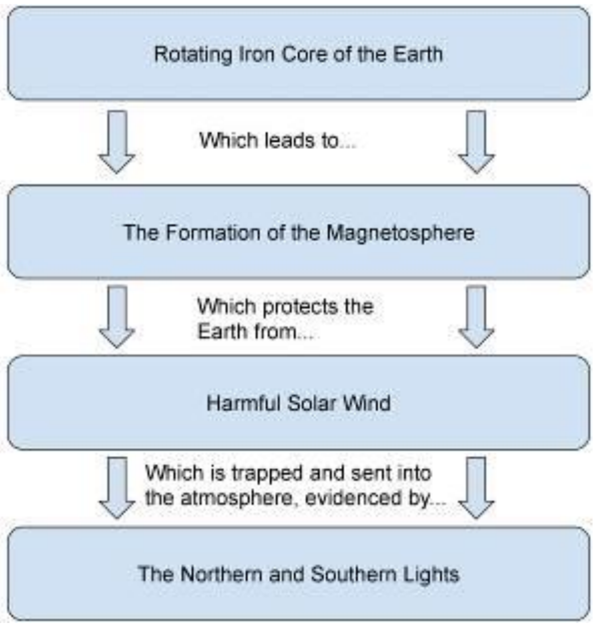


Fig. 4. *Cognitive Task Analysis*

In seeking to implement the principles of embodied cognition in our design, we found that it is valuable to involve the most interaction from the learner on the main learning objective [6]. In our AR app, this meant focusing the learner's interaction on the protection the magnetosphere provides by making an activity where the learner can use a controller to fire solar particles at the Earth and observe as its magnetic field deflects them (Figs 2, 3).

4. Results and Discussion

In designing our AR experience, we found rapid prototyping to be a useful method of instructional design. Per Nixon and Lee, this does not eliminate the need for sound learning theories on which instruction is based but, rather, it guides the designers as they create and revise a learning solution [7]. This was very helpful as it allowed weaknesses to be identified early in the design process.

Fig. 5. *Controller becomes Sun in interactive activity*

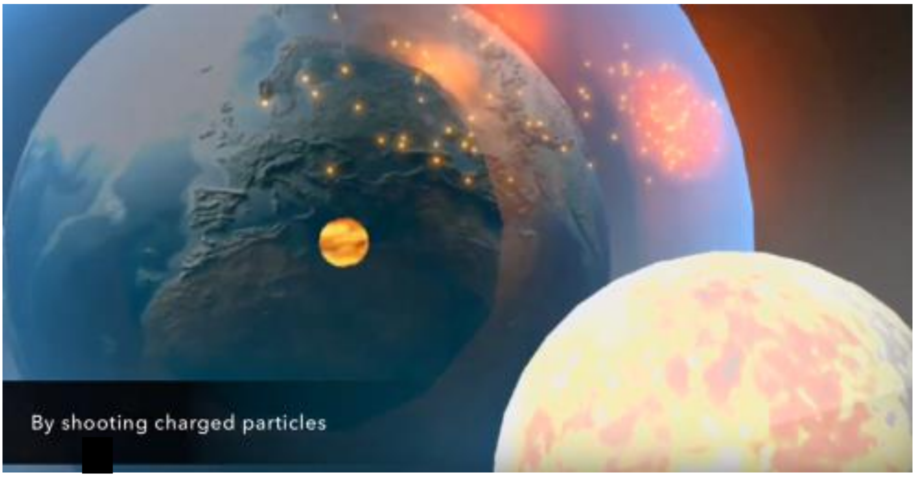


Fig. 6. *User firing solar particles at magnetosphere*

We asked some students to test a medium-fidelity version of our prototype and provide feedback. They suggested that we be clearer about the controls, create a more engaging introduction, and that we include more interactivity. Their feedback reinforced that interactivity usually increases engagement and should be implemented as often as feasible, especially on the parts of the lesson that are at the core of the learning objective.

User comments also underscored that the communication of interactive controls should be clear and intuitive so that they do not detract from the learning objectives.

Finally, we observed that what students see in the first few seconds influences their attitude toward the experience in large measure. By prototyping and testing often, designers and teachers can avoid ineffective or impractical designs for educational AR experiences.

One challenge noted in developing the prototype was the lack of documentation on and functionality of the head-mounted display AR software. All such devices on the market are immature consumer devices, so many 3D assets either do not show in the headset or require alterations in the code to get them to appear. Also, only one user can use the headset at a time, so class interaction is difficult unless more headsets are purchased. However, at $2300 USD each, multiple headsets are far from affordable for many.

5. Conclusion

In summary, AR development can be time-consuming and require a high amount of effort and planning, but AR provides affordances not offered by other media. In designing such experiences, great care should be taken in considering the audience, constraints, content, instructional design, and practical implementation. The content, especially, should be analysed to determine whether an AR experience will provide perception, insight, and engagement unattainable through other methods. By employing these design practices, an engaging experience can result that fortifies understanding and forms mental connections not easily forgotten.

6. Future Work

An assessment phase will follow this design phase where feedback from those experiencing the magnetosphere exhibit will be sought. A survey will be administered to willing participants to gather quantitative and qualitative data regarding the experience – its instructional value, user-friendliness, and their assessment of the value of AR in education. Based on feedback, improvements to the initial application will be made, and future development efforts can be informed.

REFERENCES

[1] Steffen, J.H., Gaskin, J.E., Meservy, T.O., Jenkins, J.L., & Wolman, I. "Framework of affordances for virtual reality and augmented reality", *Journal of Management Information Systems, 36*(3), 2019, pp. 683-729, doi: 10.1080/07421222.2019.16288774.

[2] Turan, Z., Meral, E., & Sahin, I. F. "The impact of mobile augmented reality in geography education: achievements, cognitive loads and views of university students", *Journal of Geography in Higher Education, 42*(3), 2018, pp. 427-441, doi:10.1080/03098265.2018.14551745.

[3] Lindner, C., Rienow, A., & Jürgens, C. "Augmented reality applications as digital

experiments for education – An example in the Earth-Moon System", *Acta Astronautica, 161*, 2019, pp. 66-74, doi: 10.1016/j.actaastro.2019.05.0256.
[4] Zaugg, H., "Using Persona Descriptions to Inform Library Space Design", *The Future of Library Space (Advances in Library Administration and Organization, Vol. 36)*, Emerald Group Publishing Limited, 2016, pp. 335-358. https://doi.org/10.1108/S0732-067120160000036015 11.
[5] Clark, R. E., Feldon, D., vanMerrienboer, J., Yates, K., & Early, S. "Cognitive Task Analysis". Spector, JM, Merrill, MD, van Merriënboer, JJ G., & Driscoll, MP (Eds.) *Handbook of research on educational communications and technology*, *3rd ed.,* 2008, pp. 577-593.
[6] Skulmowski, A., Rey, G.D. "Embodied learning: introducing a taxonomy based on bodily engagement and task integration". *Cognitive Research 3*, 2018, p. 6. doi:10.1186/s41235-018-0092-9.
[7] Nixon, E. & Lee, D. "Rapid Prototyping in the Instructional Design Process". *Performance Improvement Quarterly, 14,* 2008. 95 -116. 10.1111/j.1937-8327. 2001.tb00220. x.9.

Scientometry of Domestic non-English Didactic Journals

Petr Novotný[1], Vanda Janštová[2], Karolína Kotvaltová Sezemská[3], Romana Schubertová[4]

Charles University, Faculty of Science, Department of Teaching and Didactics of Biology Czech Republic[1,2,3]

Matej Bel University, Faculty of Natural Sciences, Department of Biology and Ecology, Slovakia[4]

Abstract

The aim of the study is to propose metrics that are based on publicly available data and do not require citation analysis (in this case unavailable) that are usable for evaluating local didactic journals. Based on a literature review and our suggestions, we compiled a set of indicators divided into four groups as follows – editorial board, website, indexing, and author guidelines. Preliminary testing on journals of didactics of biology and pedagogy from the Czech and Slovak Republics advise that the set of proposed indicators is capable of distinguishing the quality of journals, although its limits compared to citation metrics are obvious.

Keywords: journal assessment, editorial board, national context, metrics

1. Introduction

Social sciences are bound to the local cultural and historical context [1], local context embedding is symptomatic also for subject didactics. Domestic journals are often the main vehicle for disseminating relevant results of indigenous research dealing with issues of predominantly or solely local relevance [2].

However, domestic journals, that often have a long publication history and a clear professional and societal role, do not only fulfil the need to disseminate scientific information at multiple levels but also contribute significantly to building the professional discourse on the national context. Given that, especially in non-Anglophone countries, they are rarely indexed in international or local databases [3], domestic research is thus somewhat separated from international ones, even in terms of the availability of scientometric indicators [4]. Then the Social Science Citation Index or similar does not allow for in-depth analysis of the local dimensions of the discipline.

In the case of didactics of biology, an example of the local context is the specificity of the organisms' spectrum that are common and thus taught in a given country, the approach to the organization of the curriculum and history of the concept of teaching biology. Many of the problems addressed by didactics are of local significance, and it is highly desirable to discuss them in the national language, so that the broader professional public can easily participate in this discussion without barriers.

In Central Europe, local educational journals have a long tradition, which is also reflected in their number – there are currently 24 scientific journals in the Czech and Slovak Republics dealing with biology didactics or general educational issues. In countries mentioned, there is no local citation database as can be found among a few other European countries (Poland, Serbia [3]), therefore, the current perception and evaluation of journals purely habitually. Due to the absence of citation databases, it is not possible to work with citation metrics and we asked ourselves whether indicators can be found that will be detectable from publicly available sources and will characterize the level of the journals.

2. Methods

The first step in our work was a cursory survey of all current journals in the Czech and Slovak Republics. To identify them, we used national ISSN registries, whose catalogues we manually browsed, and selected scientific journals that relate to specific fields, i.e., didactics of biology, pedagogy, and psychology (in the sense of school psychology). Unlike [5], we excluded 2 journals registered on the Web of Science and 2 in Scopus because their metrics are known. We got an overview of 20 (15 Czech and 5 Slovak) domestic non-English journals that were the subject of our further interest.

Based on the screening of information that is detectable about the journals and literature search, we have formulated proposed indicators. By means of a repetitive process, we verified whether it is possible to clearly identify them in all journals, whether they can be formulated unambiguously to cover untypical situations and to estimate their relevance in relation to the quality of journals. The resulting overview of the set of verified indicators is presented in the following section.

3. Results

The result of this work is ta set of indicators divided into four groups – editorial board, website, indexing, and author guidelines. The name of each indicator, description of the method of data collecting and argumentation about its relevance are presented below.

We do not include gender distribution analysis of editorial board according to non-significant correlation founded by [6].

3.1 Editorial board

Geographic distribution – does the editorial board includes at least 10% of members from foreign countries? Membership of scholars from foreign countries helps to follow contemporary trends and standards.

Bibliometric analysis – average H-index of editorial board members in a similar sense as used in [7], but we propose to divide domestic and foreign members for better informative value of the characteristic. The scholarly production of members is proof of their ability to work as ‘gatekeepers’ for local science.

Publisher – is a profit or non-profit organization, which kind of organization – university, scientific institution or other? Editorial affiliations’ correlation with journal impact was proved by [6].

Periodicity – does the journal comply with its periodicity, it means has it published the corresponding number of issues in the past year? The ability to keep the periodicity is a sign of a functional editorial board and also an indicator of the authors’ interest to publish in the journal.

3.2 Website

Archiving – does the journal use some service to provide alternative access to the content published? More than half of journals in our sample are published only online; destroy of their website could lead to complete loss of published papers.

Specialized software – does the journal use specialized software deter for online journal administration like an Open Journal System? Using a proprietary software reduces user-friendliness and the ability to use advanced features such as citation manager.

3.3 Indexing

English metadata – does the journal provide title, keywords and abstract in English?

These are the minimum necessary for making the paper ‘visible’ to the readers out of the journal domestic scope.

Digital Object Identifier (DOI) – does the journal use DOI for unambiguous reference of published papers? The indicator that helps to describe the editorial board’s efforts to make papers ‘visible’, again.

Google Scholar – is it possible to find papers from the journal on Google Scholar?

License – does the journal publish under some of the open-access licenses like Creative Commons ore is the license reserved? Many published papers are teacher-oriented, containing classroom materials or worksheets; really usability of these materials depends on the license used for their publishing.

Content syndication – does the journal provides a way how to inform readers about newly published papers? Domestic journals, mostly not indexed in search engines have to take care of how to inform readers about new issue published – in a way of the Facebook message, email subscription or other.

3.4 Author guidelines

Citation style – does the journal use widely accepted citation style (for humanities and didactics of biology is it the American Psychological Association Style – APA) or other (especially obscure local) style? Insisting on the local citation style indicates a lack of international outlook.

Wide range of accepted languages – some analysed local journals accept manuscripts in languages that are not common for the domestic community; does the journal accept another language than the national and English?

Mono-thematic issues – does the journal published a mono-thematic issue last year or is there any active call for it? The amount of work with the organization of mono-thematic issues is pretty large, we propose them as a sign of active editorial board.

4. Conclusions

Local journals not indexed in international databases have a specific meaning in relation to the local community – international journals are perceived as having a scientific role; national journal, on the other hand, is perceived as having a ‘professional’ role [8] and it is desirable to preserve and support their development. Incomparability with international journals should not become a pretext for resignation on their quality and do not serve only as a ‘vehicle of poor science’ [8]. The solution is finding usable criteria for their evaluation.

Although the assessment is most often projected in terms of career and finances, we must not forget that its main task is to orient the authors and readers in a wide range of journals. Based on a model set of journals of two Central European countries, we designed a set of indicators and argued their relevance to the ability to characterize a given journal and in many cases to evaluate its quality. Based on the preliminary results, the set of indicators from the editorial board area seems to have the largest predicative value as the editorial board plays a key role in the research integrity [9].

The next step in describing local non-indexed journals will be to apply them to journals from another state that has a local citation database to verify their value.

REFERENCES

[1] I. López-Navarro, A. I. Moreno, M. Á. Quintanilla, and J. Rey-Rocha, 'Why do I publish research articles in English instead of my own language? Differences in Spanish researchers' motivations across scientific domains', Scientometrics, vol. 103, no. 3, pp. 939-976, 2015.
[2] R. J. W. Tijssen, J. Mouton, T. N. van Leeuwen, and N. Boshoff, 'How relevant are local scholarly journals in global science? A case study of South Africa', Res. Eval., vol. 15, no. 3, pp. 163-174, Dec. 2006, doi: 10.3152/147154406781775904.
[3] D. Pajić, T. Jevremov, and M. Škorić, 'Publication and Citation Patterns in the Social Sciences and Humanities: A National Perspective', Can. J. Sociol., vol. 44, no. 1, pp. 67-94, 2019.
[4] C. López Piñeiro and D. Hicks, 'Reception of Spanish sociology by domestic and foreign audiences differs and has consequences for evaluation', Res. Eval., vol. 24, no. 1, pp. 78-89, Jan. 2015, doi: 10.1093/reseval/rvu030.
[5] I. H. Grgić, 'Scholarly journals at the periphery: the case of Croatia', Learn. Publ., vol. 27, no. 1, pp. 15-20, 2014.
[6] J. Petersen, F. Hattke, and R. Vogel, 'Editorial governance and journal impact: a study of management and business journals', Scientometrics, vol. 112, no. 3, pp. 1593-1614, 2017.
[7] Y. Xie, Q. Wu, and X. Li, 'Editorial team scholarly index (ETSI): an alternative indicator for evaluating academic journal reputation', Scientometrics, vol. 120, no. 3, pp. 1333-1349, 2019.
[8] D. Sambunjak, M. Huić, D. Hren, M. Katić, A. Marušić, and M. Marušić, 'National vs. international journals: views of medical professionals in Croatia', Learn. Publ., vol. 22, no. 1, pp. 57-70, 2009, doi: 10.1087/095315108X378785.
[9] N. A. Mazov and V. N. Gureev, 'The editorial boards of scientific journals as a subject of scientometric research: A literature Review', Sci. Tech. Inf. Process., vol. 43, no. 3, pp. 144-153, Jul. 2016, doi: 10.3103/S0147688216030035.

The Capabilities of Interdisciplinary Instructional Design Held by the Elementary Pre-Service Teachers

Ying-Feng Wang[1]
Department of Science Education and Application, National Taichung University of Education, Taiwan, Republic of China[1]

Abstract

The purposes of the study were to investigate the capabilities held by the pre-service teachers in interdisciplinary instructional design for elementary science teaching and learning. In order to inspire student active thinking and construct their schema by organizing the concrete concepts instead of the discrete concepts, interdisciplinary instructional design was emphasized in the new Taiwanese National Curriculum Guideline. Seventy-three pre-service teachers taking the elementary science methods course at the National Wise University participated in the study. The participants completed a sequence of inquiry-based science activities across the different disciplines, including: science, technology, engineering, art, mathematics, social studies, and literature. They tried to develop the instructional design for elementary science by integrating science, art, literature, and so on. Both quantitative and qualitative methods were applied in this study. This instrument was consulted and validated by six science researchers. At the end of the course, the participants did their efforts to exhibit their pedagogical content knowledge in their lesson plans, mind-maps, micro-teaching and filled out the questionnaires. The questionnaires were created by the researcher to measure their interests and self-efficacy concerning about interdisciplinary teaching and learning held by the pre-service teachers. Then, pre-service teachers' self-efficacy of interdisciplinary instructional design were examined and analysed with statistical methods. Data were collected from the lesson plans, micro-teaching, mind maps, and feedback from the pre-service teachers. The results indicated that the performance and self-efficacy of over seventy-five percent pre-service teachers exhibited high interests about interdisciplinary learning and teaching. They enjoyed doing inquiry-based activities through integrating botany, art, and literature. They also designed the hands-on activities integrating science, engineering, and different disciplines. They presented their science work in an artistic way, describe it with elegant words, and explain science phenomenon in depth. Most pre-service teachers presented their creative thinking and well-organized science concepts across the disciplines and made science learning more fun. In order to enhance the pre-service teachers' science teaching and instructional design skills, it is worth to put more emphasis on multidisciplinary learning for elementary science teacher preparation.

Keywords: Interdisciplinary instructional design, pre-service teachers, self-efficacy, inquiry-based, creative thinking

1. Rationales

According to 2019 Taiwanese National Curriculum Guidelines, the key concepts are addressed in science teaching and learning, including: scientific literacy, scientific inquiry, hands-on, minds-on, and develop integrated curriculum in science teaching and learning. In Taiwan, curriculum design and instruction are with an emphasis on interdisciplinary, project-based, and issue inquiry according to the new National Curriculum Guidelines. Science course content and instruction put much emphasis on scientific inquiry are applied in elementary science teaching and learning. The main purposes of the study were to investigate the capabilities held by the pre-service teachers in the interdisciplinary instructional design for elementary science teaching and learning. In order to inspire student active thinking and construct their schema by organizing the concrete concepts instead of the discrete concepts, interdisciplinary instructional design was emphasized in the new Taiwanese National Curriculum Guideline. Seventy-three pre-service teachers taking the elementary science methods course at the National Wise University participated in the study. Two research questions were designed to guide the study.

1) How did self-efficacy exhibit by the elementary pre-service teachers concerning interdisciplinary instructional design?
2) How did the elementary pre-service teachers perform in interdisciplinary instructional design?

2. Theoretical Underpinning

Nowadays teaching and learning target new domains of expertise: evaluating and applying seemingly disparate information, including the accelerated emergence of new knowledge and sophisticated technologies, preparing for transdisciplinary fields, and merging traditional disciplines to better meet the needs of citizens in the 21st century (Nadelson & Seifertb, 2017). Morrison (2010) indicated that science, technology, engineering and mathematics (STEM) is recognized and widely used as a meta-discipline bridging the discrete disciplines such as science, technology, engineering and mathematics using applications or processes from each to create knowledge. Robelen (2011) also suggested that combining the arts to ‘move STEM to STEAM’ which can produce more authentic learning opportunities. STEAM, where the ‘A’ represents arts and humanities, is conceptualized as a transdisciplinary learning process.

Interdisciplinary learning which is like STEM and STEAM education are implemented around the world.

Interdisciplinary teaching and learning are also addressed in the new Taiwanese National Curriculum Guidelines. Integration knowledge is built on the relationships which exist among all things. This approach inspires the student’s ability to transfer their learning to other settings. Fogarty (1991, 1993) stated ten models for designing curricula that help students make valuable connections while learning. Beginning with exploration with the fragmented, connected, or nested models within the single discipline, and integrating across several disciplines. The approaches of nested models stated by Fogarty (1991) was also applied to implement in the science methods course. The science teacher preparation courses that the pre-service teachers take will directly impact their ability, attitude, and efficacy to teach science. The learning experience of science teacher preparation courses can be the main factors for influencing elementary teachers’ personal science teaching efficacy (Hechter, 2011). Bandura (1994) defined that self-efficacy is a belief in one’s abilities to accomplish a task, not a measure of those abilities. Meanwhile, self-efficacy affects every area of human endeavour. Gibbs (2002) indicated that teachers’ self-efficacy beliefs are suggested as impacting on how teachers think, feel, and teach in the classroom. In Taiwan, elementary pre-service teachers are needed to finish pre-service training before they pass the national teacher examination to become formal teachers. More productive and solid trading would be much helpful for science teacher preparation. Hence, the capabilities of self-efficacy and performance exhibited by the pre-service teachers concerning the interdisciplinary instructional design would be investigated in the study.

3. Methods

Both quantitative and qualitative methods were applied in this study. The participants were seventy-three pre-service teachers from university junior and sophomore with science major and non-science major who took a two-semester hour methods course for elementary science teacher preparation. Science literacy, scientific inquiry, hands-on, minds-on, interdisciplinary integration and argumentation are emphasized in the science methods course to implement the key concepts of 2019 National Curriculum Guidelines.

In the elementary science methods course, seventy-three pre-service teachers completed a sequence of inquiry-based science activities across the different disciplines, including: science, technology, engineering, art, mathematics, social studies, and literature. This instrument was consulted and validated by six science researchers. The questionnaires were created by the researcher to measure their interests and self-efficacy concerning about interdisciplinary teaching and learning held by the pre-service teachers. Then, pre-service teachers' self-efficacy of interdisciplinary instructional design were examined and analysed with statistical methods. At the end of the course, the participants did their efforts to exhibit their pedagogical content knowledge in their lesson plans, mind-maps, micro-teaching and filled out the questionnaires. In the study, the effective statistical data were analysed from fifty-nine participants. Qualitative data were also collected from the lesson plans, micro-teaching, mind maps, and feedback of the seventy-three pre-service teachers.

4. Results

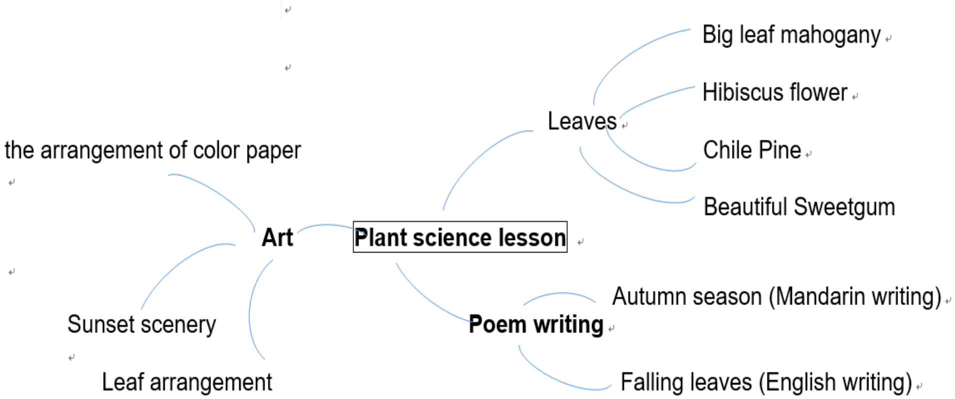
In the study, most of the pre-service teachers stated that interdisciplinary learning made learning more fun, organize the discrete concepts across several disciplines and transferred rigorous science concepts to easy understand. During the science methods course, pre-service teachers complete a sequence of inquiry-based science activities to discover the natural phenomena and science concepts, such as sunset, day and night, lunar phases, and so on.

They tried to develop instructional design for elementary science by integrating science, art, literature, and so on. For instance, creative plant work presented by the elementary pre-service teachers was integrated with science, art, and writing. The results indicated that the performance and self-efficacy of over seventy-five percent pre-service teachers (N=59) exhibited high interests about interdisciplinary learning and teaching. They enjoyed doing inquiry-based activities through integrating botany, art, and literature. They also designed the hands-on activities through integrating science, engineering, and different disciplines. They presented their science work in an artistic way, describe it with elegant words, and explain science phenomenon in depth. Most pre-service teachers presented their creative thinking and well-organized science concepts across the disciplines and made science learning more fun. Their work was presented a story with literature in an artistic way, such as castle, cartoon hero, and three-dimension product.

Pre-service teachers learned to find out the shapes and characteristics of plant leaves, flowers, and the interaction with the environment, including Jungle Flame, Norfolk Island Pine, Shaddocks, Pummelo, Koelreuteria elegans and many kinds of plants. Some of the pre-service teachers designed the plant lesson unit, including: plant science, Mandarin writing, plant art work and to count the plant price in mathematics.

The approaches of addition, subtraction and multiplication of mathematics were arranged in the interdisciplinary lesson design. Some pre-service teachers developed the lesson unit with an emphasis on art, science, and creative poem writing in different languages. They also tried to introduce the colour change of leaves and to explain the reasons of season change. A pre-service teacher's mind map of interdisciplinary instructional design was shown as the following Figure 1. A pre-service teacher described the above mind map. In the learning unit, the pre-service teacher introduced the different kinds of plant leaves in a science lesson, made an art work by using plant leaf, flower, seeds, and colour paper. Then, the pre-service teacher guided students to read and write poems describing the sunset scenery, falling leaves, leaf colour change in autumn (Figure 1).

Figure 1: A pre-service teacher's mind map of interdisciplinary instructional design



The results indicated that over seventy-five percent (N=59) pre-service teachers exhibited their high interests about interdisciplinary learning and teaching. Data from the questionnaires were presented that elementary pre-service teachers exhibited their self-confidence in developing interdisciplinary lesson plans and teaching activities. Many pre-service teachers thought that they had more confidence in interdisciplinary instructional design and teaching. Data from the questionnaire was stated that many of them were interested in designing science inquiry-based interdisciplinary curriculum and instruction (mean=3.74, N=59). Many of them thought that they were confident for themselves to implement interdisciplinary teaching (mean= 3.58, N=59). More creative and divergent thinking was presented by the pre-service teachers in their interdisciplinary lesson plans.

It was needed to enhance the elementary pre-service teachers' capabilities and self-confidence in instructional design and teaching skills across the different disciplines.

5. Conclusion

Most of elementary pre-service teachers exhibited their interests and abilities in interdisciplinary instructional design for elementary science lesson; however, their self-efficacies and capabilities are needed to be enhanced by integrating the discrete concepts and construct a whole picture of the main concepts across the different disciplines. In order to raise their confidence and self-efficacy of elementary pre-service teachers, some suggestions for science teacher preparation are to develop the interdisciplinary inquiry-based learning activities according to pre-service teachers' academic background and to nurture the pre-service teachers' pedagogical content knowledge and self-efficacy across the disciplines. For enhancing the pre-service teachers' instructional design and science teaching skills, it is worth to put more emphasis on multidisciplinary learning for elementary science teacher preparation.

REFERENCES

[1] Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), Encyclopaedia of human behaviour (Vol. 4, pp. 71-81). New York: Academic Press. (Reprinted in H. Friedman [Ed.], Encyclopaedia of mental health. San Diego: Academic Press, 1998).
[2] Fogarty, R. (1991). The mindful school: How to integrate the curricula. Palatine, IL: Skylight.
[3] Fogarty, R. (1991). Ten Ways to Integrate Curriculum. *Educational Leadership, 49* (2) pp. 61-65.
[4] Fogarty, R. (1993). Bringing integrated curriculum into the elementary classroom. Palatine, IL: Skylight.
[5] Gibbs (2002). Effective teaching: Exercising self-efficacy and thought control of action. Paper presented at the Conference of the British Educational Research Association, Exeter, United Kingdom.
[6] Hechter, R. P. (2011). Changes in preservice elementary teachers' personal science teaching efficacy and science teaching outcome expectancies: The influence of context. *Journal of Science Teacher Education, 22*, pp. 187-202.
[7] Morrison, J., 2010. The STEM education monograph series, attributes of STEM education, the student, the school, the classroom. Baltimore, MD: Teaching Institute for Excellence in STEM.
[8] Nadelson & Seifertb (2017). Integrated STEM defined: Contexts, challenges, and the future, *The Journal of Educational Research, 110*(3), pp. 221-223.
[9] Robelen, E.W., 2011. STEAM: experts make case for adding arts to STEM. *Education week, 31* (13), p. 8.

Educational Strategies

A Project-Based Internship Approach to Bioinformatics Education Geared towards Undergraduates and Early-Career Scientists

Dominic Albao[1], Kenneth Kim[2], Rosjel Jolly Lambungan[3], Shebna Rose Fabilloren[4], Francis Tablizo[5], El King Morado[6], Joshua Gregor Dizon[7], Carlo Lapid[8], Jan Michael Yap[9]

Philippine Genome Center, University of the Philippines System, Philippines[1,2,3,4,5,6,7,8,9]

Abstract

Advances in high-throughput technologies are driving the need for computational skills among biologists. In response, we developed a 6-week internship program called IMBUE introducing bioinformatics to life and computational scientists. We implemented IMBUE within 6-week durations of 17 June to 26 July 2019 and 02 September to 11 October 2019 at the Philippine Genome Center. Each cohort had 25 individuals with varying life and computational science backgrounds. Six lecture modules designed to introduce concepts in biology and computation were implemented in the first two weeks. The remainder consisted of project-based learning through hands-on bioinformatics research projects. We report increased knowledge gain and retention among both biology and computation cohorts. Biologists reported no increase in programming confidence, as opposed to increased confidence of computational scientists in biological knowledge. This highlights the need for rigorous interventions to teach programming among biologists. Meanwhile, the use of project-based learning improved interest in bioinformatics. The mix of computational and life scientists enabled cross-disciplinary collaboration in their respective research projects.

Keywords: bioinformatics, genomics, computational biology, project-based learning

1. Introduction

Bioinformatics is an interdisciplinary field involving the development and utilization of computational models, methods, and tools towards solving biological problems [1].

Advances in DNA sequencing and other high-throughput technologies have resulted in a flood of “big data” in the life sciences [2]. This so-called “bioinformatics revolution” [3] is transforming biology research, with computational models undergirding our current understanding of life. To say that all modern biology is computational biology would not be an understatement [4].

The skills necessary in bioinformatics are considerable, requiring training in multiple disciplines [5]. Biologists need data analysis skills, such as statistics and programming; while computational scientists must know molecular biology [6]. Cross-disciplinary education in these fields, particularly in the Philippines, is limited and has failed to meet the necessary challenges, incentivizing many Filipinos to seek bioinformatics training and careers overseas. Consequently, there is a strong demand for bioinformaticians among the country’s scientific institutions [7]. In the Labor Market Information Report published by the Department of Labor and Employment, “Bioinformatics Analyst” is listed among the “Hard-to-Fill Occupations” for 2013 to 2020 [8].

Answering the need for bioinformaticians, the Philippine Genome Center has delivered capacity-building projects such as bioinformatics workshops, and trainings.

Here we describe the bioinformatics training and internship program called IMBUE.

Within the six-week periods of 17 June to 26 July 2019 and 02 September to 11 October 2019, we trained 50 individuals with varied backgrounds in molecular biology, medicine, marine science, and chemistry to computer science, physics, and statistics.

The program was designed to provide theoretical knowledge and practical experience in bioinformatics. The first two weeks were devoted to lecture modules to familiarize the interns on the prerequisite knowledge and concepts necessary to understand and appreciate research topics in bioinformatics. The remaining four weeks were devoted to the independent execution of a research project in bioinformatics.

2. Design and Assessment of Training Modules

Six topics in biology, mathematics and computation were deemed crucial in understanding concepts in bioinformatics. Lecture modules were designed for these six topics such that these could be implemented in one-day “crash-course” lectures during the first two weeks. These modules where:

1. Biochemistry and Molecular Biology (Biology Module 1; BM1)
2. Evolution and Population Genetics (BM2)
3. High-Throughput and Next-Generation Sequencing Technologies (BM3)
4. Statistics and Probability Theory (Computation Module 1; CM1)
5. Programming and the Linux Environment (CM2)
6. Introduction to Bioinformatics Pipelines (CM3)

The reliability of these modules was measured through knowledge gain and retention.

Knowledge gain was assessed using objective multiple-choice exams. Pre-assessments were given before each module and were re-administered as post-assessments immediately afterwards. Knowledge retention was measured using a different objective multiple-choice exam testing concepts from the six modules. This was administered as an entrance exam on the first day and re-administered as an exit exam at the end.

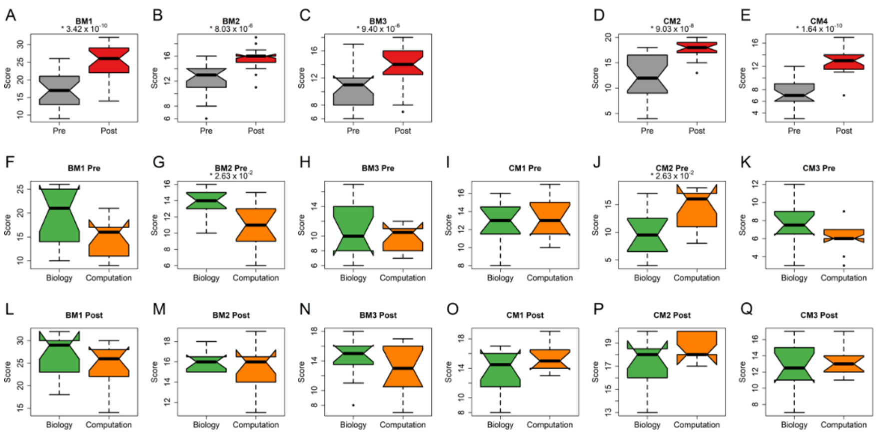


Fig. 7. *Pre- and post-module assessment statistics. (A-E) Comparison of pre- and post-module assessments. Comparison of biology and computation cohorts in (F-K) pre- and (L-Q) post-module assessments*

Although we were not able to measure knowledge gain from CM1, we find significant knowledge gain from the other five modules (Fig. ***7***A-E). Knowledge was retained towards the end of the internship (Fig. ***8***; $p=7.50x10^{-9}$). Examining differences between cohorts, there were no differences in pre-existing knowledge between undergraduates and professionals, nor did implementation differentiate the two (data not shown), suggesting undergraduates and professionals can be treated equally.

Comparing biology and computation cohorts, we find differences in pre-existing knowledge in two topics: biology majors are more knowledgeable in genetics and evolution (Fig. ***7***G; BM2; $p=2.63x10^{-2}$) while computation majors are more knowledgeable in programming (Fig. ***7***J; CM2; $p=2.63x10^{-2}$). Otherwise, biology and computation cohorts fared equally (Fig. ***7***F, H, I, K). The knowledge asymmetry was abrogated after implementation of BM2 and CM2, while implementation of the other modules did not introduce differences in knowledge gain (Fig. ***7***L-Q).

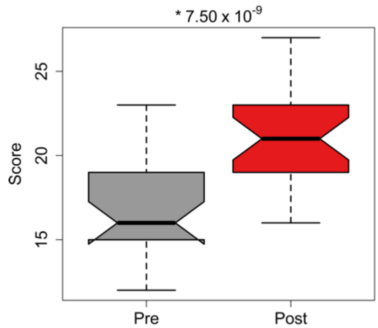


Fig. 8. *Comparison of entrance (pre) and exit (post) exam scores*

While pre-existing knowledge asymmetry between biology and computation cohorts was expected, it was surprising to observe no difference in biochemistry and molecular biology (Fig. ***7***F; BM1), and probability and statistics knowledge (Fig. ***7***I; CM1). The lack of pre-existing knowledge in biochemistry and molecular biology suggests a lack of emphasis in these topics among biology courses in the Philippines. The apparent lack of asymmetry in probability and statistics is probably explained by the lack of rigorous design and testing of CM1. We expect no pre-existing knowledge asymmetry in next-generation sequencing technologies (BM3) and bioinformatics pipelines (CM3) as these topics are advanced genomics-specific topics that are not covered in traditional biology or computation curricula [9].

3. Project-Based Learning

The hallmark of our internship program is the independent research project undertaken during the last four weeks. This is a form of project-based learning wherein interns learn from the execution of an open-ended project in bioinformatics with minimal supervision [10], [11]. This model of training has been used by multiple institutions to train biologists in bioinformatics [11]-[14]. While previous project-based bioinformatics trainings were either (1) short one- to two-week intensive training courses or (2) semesterly university courses, ours is a six-week long, full-time internship with a month dedicated to independent research work. In addition, our cohort is heterogeneous with undergraduates and professionals trained in biology and computation, rather than the homogenous composition of biology graduate students in traditional bioinformatics trainings [11]-[14]. The research topics we assign are active and open bioinformatics research problems that are pursued by research staff of the Philippine Genome Center, or its institutional partners.

Table 1. *Examples of research projects assigned to the interns*

Project Title	**Field**
A tool for MHC I Epitope Prediction	immunology
Molecular Dynamics of Integrin Heterodimers	molecular dynamics
Reconstructing Prehistoric Human Mobility in Southeast Asia using Chicken DNA	archaeology
Identification of Hydrocarbon Stress-Specific Biomarkers of Coral Bleaching	environmental science
A Directed Minimum Connected Dominating Set in Breast Cancer Protein-Protein Interaction Network	complex systems
Workflow Management System for De Novo Genome Assembly	software design
Analysis of GC-Biased Gene Conversion	evolutionary genomics
A Simulation Tool for RAD-sequencing	software design
A Prototype Variant Prediction Program for Precision Medicine	clinical genomics

All projects were conducted to the satisfaction of the program facilitators and our partner institutions. The choice of research projects represented a diverse set of specializations in bioinformatics; from genomics, complex systems, to archaeology (Table 1). Some projects evolved to become much different than envisioned. These shifts in implementation were brought about by the collaboration of interns from diverse fields of specialization. In one instance, a group working on the prediction of T cell epitopes consisted of a (1) computer science undergraduate, (2) a dual-degree holder in computer science and biochemistry, and (3) a physics graduate student. Expertise contributions from the three members resulted in an ultimately different implementation of an existing algorithm from our partner institution.

We assessed the internship through the shift of attitudes towards bioinformatics. We administered a modified Colorado Learning Attitudes about Science Survey (CLASS) previously developed by Madlung (2018) to assess the effectivity of a bioinformatics course [13]. The intern's attitudes shifted favourably towards bioinformatics at the end of the internship, with biologists viewing bioinformatics as a nuanced discipline rather than a "black box" as most often do [15]. We find that computational scientists increased their confidence in biology topics, but biologists did not increase confidence in programming, showing the need for rigorous interventions to teach coding to biologists.

4. Conclusions

We described the successful implementations of the IMBUE training program.

Administration of lecture modules in biology and computation levelled the knowledge disparity among biology and computation cohorts, though this did not translate to perceived confidence increase in the said topics. While the computation cohort reported increased confidence in knowledge in biology and genetics, the biology cohort did not report increased confidence in programming skills. Interventional steps are needed in future iterations to help resolve confidence in programming among biology cohorts, though the confidence disparity did not affect the project outputs which the facilitators deemed to be of excellent quality.

Acknowledgements

This work is funded by the Department of Science and Technology-Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD Funding No. 2019-101).

REFERENCES

[1] M. Huerta, F. Haseltine, Y. Liu, G. Downing, and B. Seto, "NIH Working Definition of Bioinformatics and Computational Biology," 2000.

[2] R. M. Ward, R. Schmieder, G. Highnam, and D. Mittelman, "Big data challenges and opportunities in high-throughput sequencing," *Syst. Biomed.*, vol. 1, no. 1, pp. 29-34, Jan. 2013, doi: 10.4161/sysb.24470.

[3] M. Bloom, "Biology in silico: The Bioinformatics Revolution," *Am. Biol. Teach.*, vol. 63, no. 6, pp. 397-403, Aug. 2001, doi: 10.2307/4451145.

[4] F. Markowetz, "All biology is computational biology," *PLOS Biol.*, vol. 15, no. 3, p. e2002050, Mar. 2017, doi: 10.1371/journal.pbio.2002050.

[5] C. Hack and G. Kendall, "Bioinformatics: Current practice and future challenges for life science education," *Biochem. Mol. Biol. Educ.*, vol. 33, no. 2, pp. 82-85, Nov. 2006, doi: 10.1002/bmb.2005.494033022424.

[6] NatureJobs Editor, "Spotlight on Bioinformatics," *Nature*, Apr. 2016, doi: 10.1038/nj0478.

[7] R. R. Reyes, "Bioinformatics Offers a Lot of Career Opportunities," *BusinessMirror*, 2015. [Online]. Available: https://businessmirror.com.ph/bioinformatics-offers-a-lot-of-career-opportunities

[8] Department of Labor and Employment, "JobsFit Labor Market Information Report 2013-2020," 2013.

[9] N. Loman and M. Watson, "So you want to be a computational biologist?" *Nat. Biotechnol.*, vol. 31, no. 11, pp. 996-998, Nov. 2013, doi: 10.1038/nbt.2740.

[10] L. Helle, P. Tynjälä, and E. Olkinuora, "Project-Based Learning in Post-Secondary Education – Theory, Practice and Rubber Sling Shots," *High. Educ.*, vol. 51, no. 2, pp. 287-314, Mar. 2006, doi: 10.1007/s10734-004-6386-5.

[11] L. R. Emery and S. L. Morgan, "The application of project-based learning in bioinformatics training," *PLOS Comput. Biol.*, vol. 13, no. 8, p. e1005620, Aug. 2017, doi: 10.1371/journal.pcbi.1005620.

[12] M. V. Schneider and R. C. Jimenez, "Teaching the Fundamentals of Biological Data Integration Using Classroom Games," *PLoS Comput. Biol.*, vol. 8, no. 12, p. e1002789, Dec. 2012, doi: 10.1371/journal.pcbi.1002789.

[13] A. Madlung, "Assessing an effective undergraduate module teaching applied bioinformatics to biology students," *PLOS Comput. Biol.*, vol. 14, no. 1, p. e1005872, Jan. 2018, doi: 10.1371/journal.pcbi.1005872.

[14] T. Korcsmaros, Z. A. Dunai, T. Vellai, and P. Csermely, "Teaching the bioinformatics of signalling networks: an integrated approach to facilitate multi-disciplinary learning," *Brief. Bioinform.*, vol. 14, no. 5, pp. 618-632, Sep. 2013, doi: 10.1093/bib/bbt024.

[15] R. M. May, "Uses and Abuses of Mathematics in Biology," *Science (80).*, vol. 303, no. 5659, pp. 790-793, Feb. 2004, doi: 10.1126/science.1094442.

Active Learning in Higher Education: Students and Multiple Skills in the Spotlight

Inês Braga[1]
Instituto Superior de Contabilidade e Administração do Porto – Politécnico do Porto; Centro de Estudos Organizacionais e Sociais – Politécnico do Porto; Centro de Investigação Transdisciplinar Cultura Espaço e Memória – Universidade do Porto, Portugal[1]

Abstract

The active learning which presupposes an active and deep student learning rather than a passive and shallow student stance aligns with the Bologna process assumptions that place higher education students at the center of learning in order to develop skills of different natures. In opposition to the traditional teaching model, the protagonists of this new and necessary learning process are no longer the teachers who debit material that students memorize to reproduce mechanically and without critical judgment at the moment of assessment. Nowadays, students are in the spotlight, they should be the focus of all attention, always bearing in mind that they learn better the more opportunities they are given to be the protagonists of building their knowledge, according to their interests and needs. We intend to review the literature on some motivating and enhancing pedagogical strategies for the development of skills for the 21st century, as they are proven to be useful for the success of individuals not only in the academic context but also in the professional environment. We will highlight role-play, as it's a strategy that we consider to be less pedagogically explored but very suitable for teaching in which we want students to learn better, with more pleasure, recognizing usefulness in their learning and obtaining better results. We will complete the investigation with the report of a pedagogical experience implemented with Portuguese polytechnic higher education students that fit the theme under study and which we consider beneficial.

Keywords: Active learning; role-play; students; 21st century skills; pedagogical changes

Active Learning (AL) is an instructional method aligned with Bologna philosophy, which is student-centred, engaging students in the learning process, and that fits in with the constructivist philosophy.

According to constructivism definition, knowledge is not absolute because it's continually changing, since the individual interprets the world around him from a certain historical, social and cultural perspective, which implies different views of the world.

Regarding Piaget and Vygotsky's constructivism, in learning there are intra and interpsychological aspects, the referred learning being a process carried out by the individual who learns, interacting with the context [1] and for these two authors the answer to the question "What is learning?" is equal, rejecting any passivity: "Active discovery and construction of knowledge" [2].

In contrast to the passive and traditional teaching, teacher-centred, constructivism presupposes an active posture of the student, being themselves the fundamental piece in the construction of his knowledge, adding and synthesizing new information with the existing one.

In a reference article from the 1990s, according to a literature review about AL, Bonwell and Eison highlight that students cannot simply listen to teachers but should do other activities – reading, writing, debate and being involved in problem solving. AL strategies should engage students "in doing things and thinking about what they are doing" [3] and the authors underline AL advantages over traditional lectures – student preference for AL and greater development of thinking and writing skills. Some features consensually related to strategies promoting AL – student engagement beyond just listening, students' skills development that overlaps passive information transmission, guidance for students to develop higher order thinking (analysis, synthesis, evaluation), involvement in different activities such as reading, debate and writing and a greater exploration of students' attitudes and values are also mentioned.

Many reflections on this "new" pedagogical approach although published almost thirty years ago remain quite current. Because change creates resistance in the people and institutions where they occur, it's convenient to know some obstacles to overcome them.

Thus, AL requires more pre-class preparation, appropriate materials/equipment and a different teacher's behaviour because they feel uncomfortable and anxious about the "new" and not encouraged to change as rewards are scarce [3]. More recently, suitability, resource and risk are also mentioned by [4].

Among several activities promoting AL, [3] refer, among others, writing in class, problem solving, cooperative learning, case studies, cooperative learning, debates, drama, role-playing, simulations, and games. We agree with that and, like other authors, we defend the adoption of several strategies.

In this paper, our focus is on role-playing which, in our opinion, promotes the development of several 21st century skills, such students' communicative skills, problem solving, critical thinking in order to provide solutions to problems and cooperative learning that enhances skills such as decision making and conflict management.

Additionally, AL creates motivation and pleasure in students who use autonomy and creativity, drawing on previous knowledge and experience gained in in/formal teaching contexts.

The boundary between role-playing, simulations and games is sometimes not clear and there may be some overlap between them. According to [3], an objective difference is that role-play duration is less than one hour, while simulations and games are longer.

Simulations are better defined than role-plays which can be spontaneous and don't need special equipment/materials. This pedagogical strategy leads to a students' reflection about their attitudes in the interrelationship they establish with others. Even if role-plays are usually spontaneous and short, they can be long and require in-depth preparation by students before the presentation. The teacher acts as an advisor, framing the situation, giving information about the roles to play and serving as a mediator in the presentation and its evaluation.

Defining role-play and simulation, [5] present a third pedagogical strategy – role-play simulations – and they state that while role-play is transitory and intends to solve different issues or problems, role-play simulations presents a permanent characteristic (during a semester) and has an elaborated goal.

In 2012, from different experiments, a prospective typology of role-play emerges, including three categories – Role-Switch (student learn from an interiorization, embodying the role of other people to understand them), Acting (the development of students' practical skills through "acting" in a scenario with few players) and Almost Real Life (as close as possible to reality) [6].

The effectiveness of role-playing is mentioned in several studies and we cite a case of Psychology students. In this case, having applied a pre-test and post-test to compare the differences in the results of the evaluation, the investigator found an effective improvement after the role-playing activity [7]. Another example is with Jordanian students attending the tenth grade English as a foreign language. Significant statistical differences in the results of oral assessment between a control and an experimental group prove that students submitted to the role-playing experience were more successful than the others who learned through the Teacher's book instructions. [8]

AL is used in multiple areas, at different levels of education and has several proven advantages. As reported by [9] the use of this methodology is beneficial in classroom teaching but also in distance learning, obtaining better students' results and promoting students' emotions and self-efficacy beliefs.

In our career in higher education, we have adopted the role-playing practice in several courses, the most relevant experience being carried out during six academic years (from 2011 to 2017) in a course of Organizational Communication of Human Resources. The main objective was to evaluate communication skills, with these specific objectives: i) Enhance the application of communication techniques; ii) adequately produce texts of different typologies, according to organizational needs.

The program contents are related to communication techniques, argumentation and persuasion, preparation and conduct of meetings, the call and the minutes. Since the beginning of the semester, students were informed that the final group work would have a written and oral component (role-play). Thus, learners would represent roles of characters invented by them in an organizational context that could be created or adapted of their professional experiences (some classes have student workers).

The role-play situation was a professional meeting where internal and/or external organizational communication should take place. Students should invent and describe a real organizational "situation/problem" related to their professional field, expose and solve it. At that meeting, the meeting's chair, his secretary and other participants should act in accordance with the good practices of a meeting. The students knew that they were being evaluated in terms of their verbal and nonverbal communication performance, that simulations revealing creativity and as close possible to professional reality (use of props) would be valued. Initially, role-plays were presented in person, later on, the presentation scheme has changed and the students were exempted from doing the live presentation if they had recorded a video to be seen in class. Students wouldn't be evaluated about technical questions concerning the video and the only requirements were good sound and image to allow viewing and listening in good conditions. At the end of each oral presentation, there was hetero-evaluation, self-assessment and, as a synthesis, the qualitative assessment, by the teacher, in a pedagogical way, encouraging to improve.

Earlier, during classes, feedback about communicative exercises and oral guidance were given by the teacher. In addition, students could ask him for support and a specific class to follow up the work in progress was scheduled.

The evaluation of this role-play activity was very positive, although students have never had a similar experience before. They understood the objectives, joined the initiative, carried out it with enthusiasm and motivation, learning better because they put theory into practice and thought about the way they should do it and actually did it. The video was another stimulus once the students liked to do this task that required more work before the presentation but simultaneously allowed them to be more relaxed in the final presentation.

Several groups invested in greater realism in the meeting, with a welcoming atmosphere, introducing typical objects, such as computers, sheets, pens, water bottles and, in some cases, even sweets. Many presented themselves dressed differently than usual, as executives, and there were some few groups that made the video in their own workplaces. Self and hetero-assessment, after the presentations, made according to some previously announced criteria, was adequate and useful, giving immediate qualitative feedback to students on their performance. As for the final results of the written component and role-play, they were positive, mostly with good and very good results.

In this process, in addition to the syllabus contents, successfully learned, we highlight the way how to do it, through the development of crucial skills such as communication skills, autonomy, critical thinking, problem solving, teamwork, conflict management, leadership and creativity.

Concluding, with this activity, students were protagonists of their own learning, they were on a stage, in the spotlight, performing in the most appropriate way for the challenges of professional reality. This is an example of how 21st century skills that are increasingly valued by the job market and can be developed in academia to prepare better students, more critical, autonomous and responsible workers and citizens.

REFERENCES

[1] Vasconcelos, Y, Manzi, S. "Processo ensino-aprendizagem e o paradigma construtivista" Interfaces Científicas – Educação, 2017, pp. 66-74.

[2] Kivunja, C., "Do You Want Your Students to Be Job-Ready with 21st Century Skills? Change Pedagogies: A Pedagogical Paradigm Shift from Vygotskyian Social Constructivism to Critical Thinking, Problem Solving and Siemens' Digital Connectivism", International Journal of Higher Education, 2014, pp. 81-91.

[3] Bonwell, C., Eison, J. "Active Learning: Creating Excitement in the Classroom". ASHE-ERIC Higher Education Reports, Washington, 1991.

[4] Moizer, J., Lean J., Towler M., Abbey C. "Simulations and games: overcoming the barriers to their use in higher Education", Sage, 2009, pp. 207-224.

[5] DeNeve, K., Heppner, M. "Role Play Simulations: The Assessment of an Active Learning Technique and Comparisons with Traditional Lectures", Innovative Higher Education, 1997, pp. 231-245.

[6] Raoa D., Stupansb, I. "Exploring the potential of role play in higher education: development of a typology and teacher guidelines". Innovations in Education and Teaching International, 2012, pp. 427-436.

[7] Vinay, A. "Action Research in Education: Encouraging higher order thinking skills among students using Active learning strategy of Role Play", Eric, 2018.

[8] Alzboun, B., Smadi, O., Baniabde lrahman, A. "The Effect of Role Play Strategy on Jordanian EFL Tenth Grade Students' Speaking Skill". Arab World English Journal, 2017, pp. 121-136.

[9] Jeong, J., González-Gómez, D., Cañada-Cañada F., Gallego-Picó, A., Carlos Bravo, J. "Effects of active learning methodologies on the students' emotions, self-efficacy beliefs and learning outcomes in a science distance learning course". Journal of Technology and Science Education, 2019, pp. 217-227.

An Examination of Misconception in Earth Sciences and Research into Effective Teaching Methods

Tetsuhide Shigeno[1]
Ryukoku University, Japan[1]

Abstract

In Japan, misconception research is conducted relatively frequently in the field of physics and chemistry, but it is not very actively pursued in the field of earth sciences. The reasons for this are thought to be related to the fact that many elementary- and middle-school science teachers in Japan major in fields other than earth sciences at university, and in turn, many university teachers who train science teachers specialize in fields other than earth sciences. Upon surveying undergraduate students on the basis of this hypothesis, we discovered that there are many misconceptions in the field of earth sciences. Misconceptions that the author is currently aware of have been revealed to arise in various units, including weather maps and wind direction, clouds, and other parts of the field of meteorology, and the distance between the sun and the planets, and light emission by meteor in the field of celestial bodies. Misconception research in the field of earth sciences leads to extremely important research for protecting citizens from meteorological disasters, such as heavy rain, typhoons, heavy snow and thunder, that occur in Japan each year and from earthquake and volcanic disasters. This study gathers information on the actual situation of students with cooperation from middle- and high-school teachers, based on case examples of misconceptions in the field of earth sciences that the author investigated of in his university classes.

Keywords: Misconception, meteorological disasters, earthquake disasters, improvement of teaching

1. Introduction

Misconception, when translated directly into Japanese, is "misunderstanding, misunderstanding". Regarding misconceptions in science, Taga (2019) [7] stated, it will not be easily modified and will remain intact when you grow up. In addition, "School-Made Misconception" which is newly occurring in science classes has been pointed out.

Among them, Barke *et al*., (2009) [2] clarified that there are some that arise from textbook figures and materials.

There are many studies in the field of physics and chemistry regarding such misconceptions. For example, if a college student gives one dry cell, one miniature bulb, and one conductor and performs the operation of "turning on the light bulb", many students cannot turn on the light well. It uses a miniature light bulb in a socket when learning electricity in elementary and junior high school science, so it has not learned the structure of the light bulb and cannot contact the conductor with the brass side of the miniature light bulb Because. Most students do the following (Figure 1). These cases are typical of the School-Made Misconception.

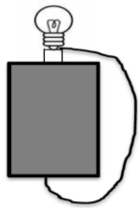


Fig. 1. *Connection example of wrong conductor*

2. Examples of Misconceptions in the Meteorological Field

2.1 What is a cloud?

In both elementary and junior high school textbooks, there is a statement that “clouds have water droplets and ice crystals floating”, and they are also shown in the textbook diagrams. However, when asking college students, quite a few say clouds are gas. When asked why he answered, he answered, “I did an experiment to make clouds at elementary and junior high schools”.

In the experimental apparatus shown in FIG. 2, a liquid crystal thermometer is contained in a plastic bottle, and a change in heat insulation can be visualized. When the air in the PET bottle is compressed, the temperature rises by 2 to 4 °C. When the experiment is performed again with incense smoke, clouds can be reproduced in all groups. The water drop disappears when the stopper is closed and compressed immediately. Thus, it can be understood that the evaporation and condensation of the water droplets are caused by the temperature change in the PET bottle container.

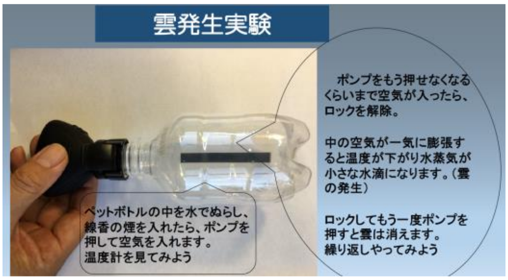


Fig. 2. *Cloud formation experiment. Liquid crystal thermometer in PET bottle*

2.2 Cumulonimbus and thunder

If you look at Japanese textbooks, there is little to teach thunder. Although it is described that thunderstorms occur due to cumulonimbus clouds in the meteorological field, lightning disasters are rarely treated. Shigeno (2019) [6]. “Let’s make cumulonimbus clouds with milk” Aichi Prefectural General Education Center (2002 By performing the experiment [1], we can visualize the appearance of cumulonimbus from its occurrence to its disappearance.

As for lightning, the author created 10 questionnaire items from the Japan Society of Atmospheric Electrical Engineers (2001) [4], “How to Protect Yourself from Lightning-Safety Measures Q & A-Revised Version”, and surveyed junior high and high school students. The following results were obtained.

The number of responses to the questionnaire is as follows. Junior high school students 280, high school students 760, college students 67

The answer was two-choice. Here are some of them.

(1) Ten seconds after the flash, a rattling sound was heard. Still, occasionally the sun is bright and not raining. The correct answer is (B)

(A) The lightning strike is far away, so it's OK for a while. (Wrong answer: 43.5%)
(B) A dangerous situation where it is not known when a lightning strike will occur.

(2) The sky became dark and rumbling and thunder began to be heard. The correct answer is (B)

(A) It is safer to remove the metal attached to the body and keep it away from the body. It is. (Wrong answer 67.6%)
(B) Since the human body is easy to conduct current in the first place, when metal is attached and detached, almost all No change.

The level of understanding about lightning found in the questionnaire was almost the same for junior high school students, high school students, and university students.

Considering the above results, the phenomenon associated with cumulonimbus is that lightning starts before precipitation, and lightning strike (negative lightning) is the fastest stepping leader (precursor discharge) coming down from cumulonimbus and reaches the surface of the earth first. There is no indication that a lightning strike will occur in the area where the lightning strikes. The misconception that removing the metal is safer than attaching the metal is considered to be caused by the inability to understand that the human body is a good conductor.

It is hypothesized that such misconceptions are taught by adults to children, and that children become adults and then teach children. It is thought that misconceptions are also held by teachers, and When I asked the incumbent faculty for comment, it was inferred. Regarding the fact that the human body is not sufficiently recognized as a good conductor, a misconception concept that "current flows or does not flow" has arisen in electric classes in elementary and secondary education depending on whether the miniature bulb is lit or not. It is presumed that it will be lost. It is not dealt much in compulsory education that current flows in water and human body when conditions such as voltage are changed. As an experiment to eliminate this misconception, I would like to introduce a lightning experiment using a piezoelectric device and an anti-vibration bulb. (Fig. 3)

Adhere the lead from the piezoelectric device to either the bottom or brass part of the anti-vibration bulb with vinyl tape. The interior of the room is darkened, and a finger is put on the glass of the bulb, and the piezoelectric device is moved to discharge.

Fig. 3. *Lightning test device using vibration-resistant bulb and piezoelectric device*

Then, electric discharge occurs from the filament of the bulb to the finger touching the glass. This experiment has an impact, and you can experience “the human body induces electricity”. In other words, it is possible to realize that lightning is easy to strike even if a person does not wear metal because his body is a good conductor. The piezoelectric device can be easily removed from the used lighter by pulling it out with a pair of pliers. When conducting this experiment, it is better to let the students start by connecting the bulb and the piezoelectric device separately and connecting them with vinyl tape instead of connecting them. This is important for understanding the structure of the light bulb.

2.3. Weather map and wind

When the students were asked to write the wind direction on the weather chart as shown in Fig. 4, all of them entered the following wind directions.

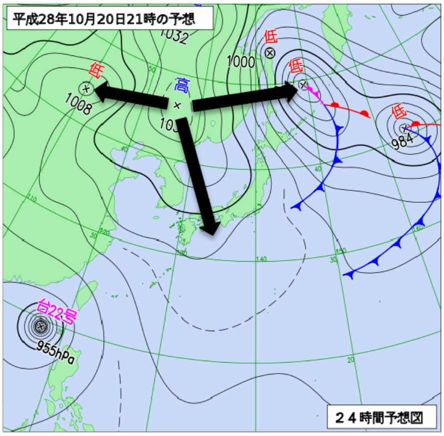


Fig. 4. *Wind direction written by the student on the weather map*

A junior high school textbook (Keirin-kan 2011) [3] states that “where there is a difference in atmospheric pressure, the power to move the atmosphere from higher to lower pressure works”. Actually, the Coriolis force due to the rotation of the earth works.

“The wind blows parallel to the isobar while looking at the higher air pressure to the right (above 1 to 1.5 km or above where there is no friction with the ground surface)”. Is easier to understand.

If the wind blows from the south, the advection of the warm air, if it blows from the north, the temperature changes such as advection of the cold, and if the north-south wind hits, there will be a front line there, such as reading the wind from the weather map, knowledge will be systematic Should be. I think these points are important for improving weather classes at the junior high school stage. Figure 5 shows what I have developed and implemented for that purpose. The weather map is sandwiched between A3 size transparent clear holders and used as a group work material. Use a blue marker pen for north winds and a red marker pen for south winds with a marker pen from above the clear holder. This material can be used as a whiteboard, and can be rewritten many times by wiping it with tissue paper.

Fig. 5. *Clear holder with weather map in between Teaching material for writing wind direction with marker pen*

3. Examples of Misconceptions in Other Earth Science Fields

An example of a celestial unit is related to the distance between celestial bodies. I understand the names of planets very well. However, about 70% of students answered, "Which is farther from Earth to the sun or from Earth to Jupiter?" The reason for this is that the whole page of the planet is shown on the facing page of the textbook, suggesting that the image is related to misconception. Meteor showers were also reported during the activity of the meteor shower, but I was shocked to see that some students thought that the stars that make up the constellation were moving.

4. Misconception Research Perspective

Misconception research cases in science are biased to fields other than earth science, where there are many researchers. In Japan, few faculties have majored in earth sciences at universities, and faculty from other majors are often teaching earth sciences. Classes are considered to be conducted according to textbooks, but systematic guidance may not have been achieved.

Under these circumstances, it is very meaningful to understand the misconceptions of university students and develop effective teaching methods while sharing information with those in charge of compulsory education and high school education. The misconceptions introduced this time are only part of what I have learned, and learning about whether such as lightning, heavy rain, and tornadoes is related to disaster prevention and mitigation, so eliminating misconceptions is a national issue.

REFERENCES

[1] Aichi Prefectural Education Center “Let’s Make Cumulonimbus with Milk” (2002) Acquired March 14, 2019 2019 http://www.aichi-c.ed.jp/contents/rika/syotou/syo9/sekiranun/sekiranun.htm

[2] Barke. H.D. Hzari. A. & Yitbarek. S (2009) Misconception in Chemistry Addressing Perceptions in Chemical Education. Springer, p. 294.

[3] Keirinkan “Science 2 to spread to the future” (2011) p. 74.

[4] Japan Atmospheric Electrical Society, “How to Protect Yourself from Lightning-Q & A for Safety Measures-Revised Edition” (2001) p. 7. p. 23.

[5] Shigeno Tetsuhide, “Misconception on Lightning-Questionnaire Survey of Junior High School, High School, and University Students” Proceedings of the 11th Meeting of the Japan Meteorological Forecast Society (2019) pp. 40-41.

[6] Shigeno Tetsuhide, “Reproduction experiment teaching material that does not cause misconception in the field of meteorology” Kyoto Geogaku No. 36 (2019) pp. 2-6.

[7] Taga Yutaka, “The Origin of School-Made Misconception and Changes after Acquisition”, Ryukoku Kyosyoku Journal No. 6 (2019) pp. 114-115.

An Online Causal Mapping Tool for Environmental Systems Education

Conor McCrossan[1], Owen Molloy[2]
National University of Ireland, Galway, Ireland[1,2]

Abstract

Systems thinking is the development of an understanding of how the individual elements of a system interact with each other, thereby influencing each other, and determining the behaviour of the system as whole. Causal mapping is used in systems thinking to visualize and educate people on how the different components of the system interact with each other. In this research, we present an online causal mapping tool which can be used for ocean/environmental systems education. The paper contains a review of the existing approaches to the use of system thinking in education and how those approaches compare with our approach. The results of the comparison show that our tool compares favourably with existing approaches which use system thinking as a basis for education. The tool also has the advantages of being based on an ontology and can be used to link the causal map elements with the contents of an online knowledge base. We also provide an analysis, from an education perspective, regarding the use of the online causal mapping tool to create causal maps of ocean related topics. This analysis reveals how the tool was used to create the causal maps and provides insights into how the causal maps can be improved to make them more educationally beneficial.

Keywords: Systems thinking, Education, Causal Mapping, Environment, Ocean

1. Introduction

The importance of the Ocean to the wellbeing and perhaps even survival of human life on Earth is becoming more and more obvious. As we learn more about the impact we have had on the oceans in a relatively short period of industrialisation, we are faced with a number of challenges such as plastics pollution, acidification, coral bleaching, and of course polar ice melt, to mention but a few. Of course, to fix a problem, you must address the causes of that problem, rather than merely focusing on the symptoms. And to do this, we must understand causes, which can sometimes be a rather complex web of interaction between human and natural activities. This web of interactions must be understood in order to identify those points at which we must intervene for maximum effect. There may be many such points, with different human actors involved at each one. Take for example, the micro-plastics problem. Some plastics enter the oceans through spillage accidents during shipping. Therefore, shipping companies are obvious actors to engage in ensuring their practices minimise such risks. Further up the supply chain, we can look to consumers to choose products which do not contain micro-plastics, thereby reducing the amount that is flushed into the waste water systems, and ultimately ends up in the marine environment. Other actors, such as manufacturers and product developers, can work together to find biodegradable alternatives to plastics for use in everyday products.

The commonly used definition of Ocean Literacy [6], which is to understand "… the influence the ocean has on you and your influence on the ocean" is useful, but ultimately we need to be clear about the meaning of the word "understand" in this context, and push for not just improved understanding, but the modifications in the attitudes and behaviour needed for change. While the Ocean Literacy Framework [7] is useful in categorising the topics and providing a framework for teaching ocean topics, it does not focus to any great extent on the joint human-ocean systems which reveal the real detail behind our interactions with the oceans. To truly influence peoples understanding of their impacts on the oceans, they must have some knowledge of their own and others place and role in the web of interactions. Armed with such knowledge of the systems involved and the cause-and-effect relationships between human activities and natural systems, people are more truly ocean-literate and capable of making informed decisions regarding not just their own behaviour, but also how they communicate on ocean issues with others. The causal maps created by users using the online causal mapping tool are based on the DAPSIWR framework, as shown figure 1.

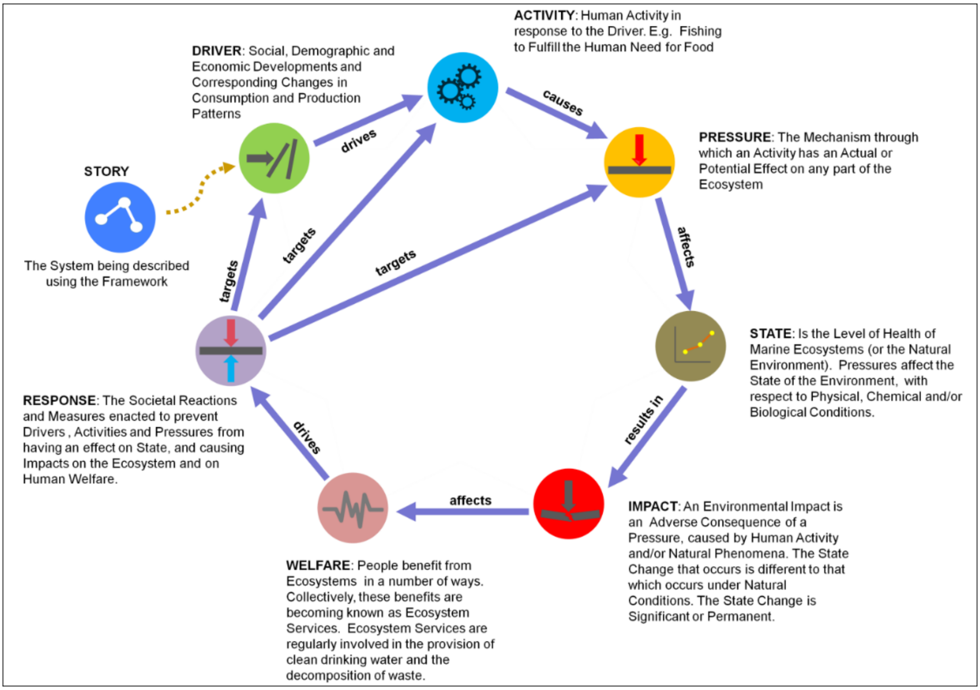


Fig. 1. *The DAPSIWR Framework [2]*

2. Systems Thinking in Education

The study performed by Brandstädter [1] examined whether particular features of concept mapping practices affected the valid assessment of students' system thinking.

The study applied 3 variations of concept mapping practices: (i) highly directed computer mapping, (ii) highly directed paper-pencil mapping, and (iii) non-directed paper-pencil mapping. The concept maps were created using the software package MaNET® and the results showed that the computer-based approach positively influenced student performance in concept mapping when compared with the paper-pencil approach. The purpose of the study performed by Evagorou [3] was to investigate the impact of a simulation-based learning environment on 11-12 years old students' development of system thinking skills. The Stagecast Creator visual programming language was used to simulate the ecosystem of a marsh. Sheehy [8] developed two computer simulations to investigate system thinking and environmental problem solving in children aged between 8 and 11 years. The simulations were computer based and consisted of a generic storyboard into which different problems could be coded. The findings showed that through efficient use of resources and recycling strategies the older children in the study outperformed the younger children.

In research performed by Jeong [5], students constructed causal maps to graphically explain their understanding of how selected factors influence learning in collaborative environments. The students' causal understanding was measured by comparing the causal maps they constructed with the causal map created by the instructor.

Urwannachotima [9] used a group model building approach to engage stakeholders in the creation of a causal map of the dynamic interrelationships between a sugar-sweetened beverage tax, sugar consumption, and dental caries. A group of seven dentistry and health professionals developed a causal loop diagram which was then presented and discussed.

A number of online tools exist for creating causal loop diagrams and causal maps.

Visual Paradigm Online Diagramming provides an online diagramming tool which allows users to create a causal loop diagram. The left section of the tool allows users to choose from a selection of causal loop diagram elements e.g., Data process, Loop, start state, Stop state, and Data store. Vensim provides a desktop application for the creation of causal loop diagrams. The Microsoft Visio drawing programme was used by Fairweather [4] to reproduce a digital format version of causal maps drawn by individual farmers. The causal maps drawn by the farmers were based on how they thought their farm ecosystem worked. The causal connection map data for each farmer was stored in an Excel spread sheet. Kumu is an online tool which allows users to organise complex data into relationship maps which can then be viewed interactively by others. The online causal mapping tool described in this paper is based on an ontology and links the causal map elements with the contents of an online knowledge base.

3. Results and Discussion

The purpose of the causal maps created by the users of the online tool was to provide a graphical representation of the elements of an ocean literacy topic, to show the interconnections between the elements, and to input relevant information for the elements of the causal maps. The causal maps are based on the DAPSIWR framework.

In this research, we analyse the causal maps to (i) gain an insight into what elements are used to create the causal maps of the topics, (ii) check what information is associated with each of the elements, and (iii) propose ways of improving the causal maps to make them more educationally beneficial.

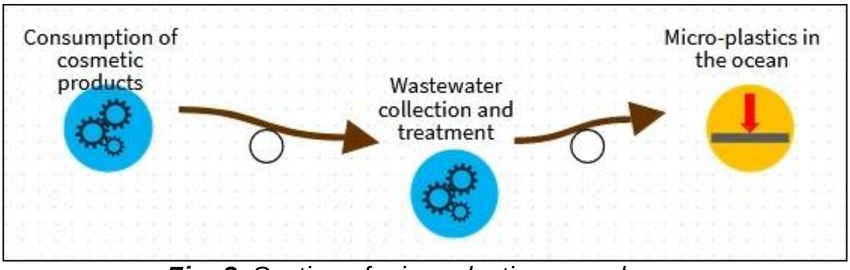


Fig. 2. *Section of micro-plastics causal map*

An example of an educationally beneficial section of the Micro-plastics causal map created using the online causal mapping tool is shown in figure 2. It shows that the Activity: "Consumption of cosmetic products" has an effect on the Activity: "Wastewater collection and treatment" which in turn can lead to the Pressure: "Micro-plastics in the ocean". In the Coastal Tourism causal map, the Drivers identified by the user are Globalisation, Economic structure, and Economic growth which constitutes a more general view of the drivers of coastal tourism. It would improve the educational value of this causal map to be more specific regarding the causal map elements. Examples of more specific drivers of Coastal tourism are "Interest in sun, sea, and sand holidays" and "Economic benefits of tourism".

The information entered by the users into the property's sections of the causal map elements has good educational value. In the properties section of the Driver: "Population variability" in the "Sustainable fisheries and aquaculture" causal map, the user has entered referenced information related to the projected increase in the global population and the extent to which the world's population depends on seafood for protein intake. An example of where the causal maps could be improved with regard to the information entered into the properties sections is in the case where similar information has been entered for the properties of the Impacts: "Physical and chemical features" and "Habitat – Seabed structure" in the "Sustainable fisheries and aquaculture" causal map. It would be more beneficial to enter information which relates more specifically to the individual impacts.

The causal map created for the topic "Ballast water and invasive alien species" contains a sizeable map of the Actors associated with the topic. Part of the causal map is shown in figure 3. This causal map could be improved by grouping the actors into groups based on how they are involved. An example of a group of actors which could be created is "Shipping Actors" and the Actors which would be attached to the group are "Ship officers", "Marine equipment manufacturers", "Industrial manufacturers", and "Financial & insurance institutions". Having the actors grouped would help in the situation where the causal map is being viewed by a user who is interested in learning about the different information that is specific to the different types of actors.

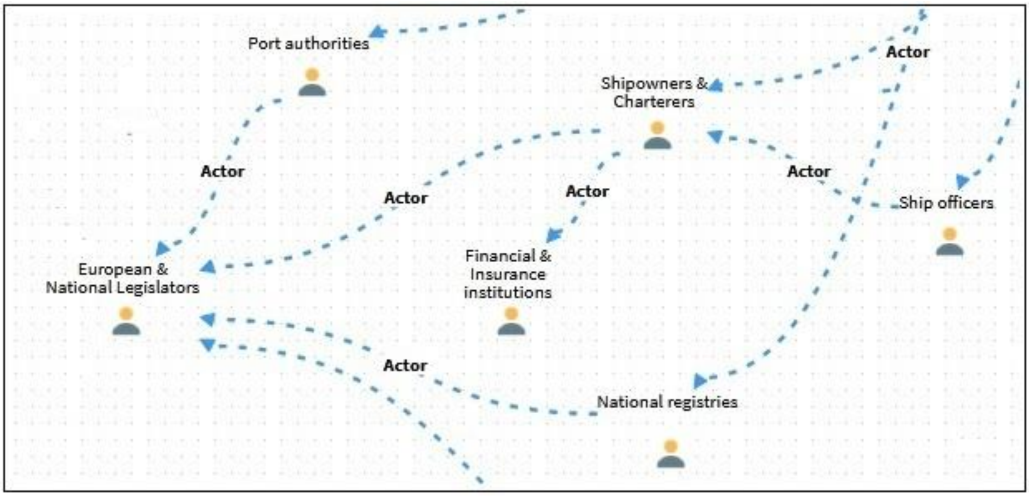


Fig. 3. *Section of causal map for "Ballast water and invasive alien species" topic*

4. Conclusion

The comparison of the online causal mapping tool with existing approaches and tools shows that it is a useful tool which is based on an ontology and allows the causal map elements to be linked with relevant knowledge stored in an online knowledge base. The users of the tool successfully created educationally beneficial causal maps which can be viewed online by people interested in learning about the ocean related topics. In the future, the approach to the creation of the causal maps can be improved by implementing the improvement techniques described in this paper. The techniques can also be applied to the creation of causal maps on other topics related to the ocean and the environment.

REFERENCES

[1] Brandstädter, K., Harms, U. and Grosschedl, J. "Assessing system thinking through different concept-mapping practices". International Journal of Science Education 34(14), 2012, pp. 2147-2170.
[2] DPSIR. Driver, Pressure, State, Impact, Response Framework. Web. 4 Apr. 2018. http://www.ejolt.org/2013/02/dpsir/ 2013.
[3] Evagorou, M., Korfiatis, K., Nicolaou, C. and Constantinou, C. "An investigation of the potential of interactive simulations for developing system thinking skills in elementary school: A case study with fifth-graders and sixth-graders". International Journal of Science Education, 31(5), 2009, pp. 655-674.
[4] Fairweather, J. "Farmer models of socio-ecologic systems: Application of causal mapping across multiple locations". Ecological Modelling, 221(3), 2010, pp. 555-562.
[5] Jeong, A. and Lee, W.J. "Developing causal understanding with causal maps: The impact of total links, temporal flow, and lateral position of outcome nodes". Educational Technology Research and Development, 60(2), 2012, pp. 325-340.
[6] OL. Ocean Literacy. Web. 8 Jun. 2018. http://oceanliteracy.wp2.coexploration.org/ 2015.
[7] OLF. Ocean Literacy Framework. Web. 4 Apr. 2018. http://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework 2015.
[8] Sheehy, N.P., Wylie, J.W., McGuinness, C. and Orchard, G. "How children solve environmental problems: Using computer simulations to investigate systems thinking". Environmental Education Research, 6(2), 2000, pp. 109-126.
[9] Urwannachotima, N., Hanvoravongchai, P. and Ansah, J.P. "Sugar-sweetened Beverage Tax and Potential Impact on Dental Caries in Thai Adults: An Evaluation Using the Group Model Building Approach". Systems Research and Behavioural Science, 36(1), 2019, pp. 87-99.

Analysis of Students' Attitude towards Online Education

Victoria Torop[1], Lyudmila Egorova[2]
National Research University Higher School of Economics, Russian Federation[1,2]

Abstract

Recently appeared online courses rapidly gained their popularity due to the great opportunities. Absolutely different people can study any discipline for various purposes. Online courses can be useful both to children in preparing for lessons, and to adults in advanced training. Gradually, courses are becoming not only part of the additional curriculum at the university, but part of the mandatory program, too. However, not everyone supports the new way of education. Therefore, the goal of this work was to identify students' attitudes towards online education, the reasons for their preferences on online format of education and the willingness to replace traditional lectures into an online format. The study was carried out on the basis of a survey of more than 6,000 students as part of the Student Life Survey conducted every year at the HSE. The analysis was made by using various clustering methods, such as hierarchical clustering, clustering using the K-means method and analysis of latent classes, as well as analysis of variance. The students were divided into 6 clusters based on the different attitude towards the replacement of all lectures to the online format: devotees of HSE, amateurs of online courses, disciplined, social, learners for the grades, a mixed cluster.

Keywords: online education, hierarchical clustering, K-means, latent classes, analysis of variance

1. Introduction

Online-platforms with massive open online courses (MOOC for short) like Coursera, edX and Udacity appeared in the Internet in the beginning of 2000s and rapidly gained their popularity. Many of online courses are available to anyone freely and every year the number of applicants grows faster and faster. According to the report in 2019 of MOOC aggregator Class Central [1], the number of people registered for at least one course is more than 110 million and the number of courses increased to 13500.

Some experts forecast the replacement of all traditional lectures by the MOOCs. Such an intention was expressed by the Rector of the Higher School of Economics (HSE) Yaroslav Kuzminov in his interview in 2018 [2]: "We will cancel the lecture classes in a classical form. I think that in five years we will definitely replace absolutely all lectures with online courses."

Today the online courses already became a part of education in HSE. All HSE educational programs have courses that have to be completed in an online format in whole or partly. But a complete transition to online education is a serious and fundamental reform of the education system, and before its implementation it is necessary to analyse the willingness of students to switch to online format. One of the most important problems of MOOCs is the lack of contact and direct interaction between the teacher and the student. Also, it is impossible to completely control how the student solves the assessment tasks. So, the certificates might not accurately reflect the knowledge of the student who received it and might not be appreciated by employers.

Such possible disadvantages can be very frightening and cause a negative attitude to online learning both for students and teachers, as well as for future employers.

The goal of this work is to analyse the opinion of HSE students regarding the online learning format using the results of student surveys and several clustering methods to identify the factors that influence their attitude to the online format.

2. Literature Review

Ku and Lohr [3] were among the first who draw attention to this and conducted a study in 2003. They interviewed students from America and China and revealed that students positively evaluated the main advantages of online learning, such as the lack of the need to spend time traveling to the university and the absence of parking problems.

However, foreign students were faced with the lack of contact with new foreign people and the opportunity to improve their language skills.

Mostly, authors consider the activity of students during the course. Four types of activity during the study of the course: the number of videos watched, the number of attempts to pass the tests, the number of written posts on the forum and the number of clicks were considered in [4]. The data on navigation of students on the course, completion of tests, watching videos, and participation in discussions were analysed in [5, 6].

In [4, 5] a general tendency to drop out of the course at the very beginning of its study was revealed, in addition, there is a very low activity during the course [6]. In the case when the course is compulsory, the number of people who drop out of the course decreases sharply, but the percentage of students who complete the course in tricky ways (that is, they pass tests for a high score without listening to video lectures) increases [4]. Even if students on average praised the quality of online courses, still the number of students who include these courses in their program is about a third of the total number of students [7].

It seems that students are not very interested in studying online courses or they are not satisfied with the quality of the courses. Therefore, it is important to identify factors that influence students' attitudes to online courses, and to increase the motivation of students to study courses of this format.

3. Data and Methods

We used the data of the 2018 Student Life Survey. This survey is an annual survey at the HSE conducted by the Centre for Institutional Research in order to reveal the attitude of students to the quality of education at the university, to the conditions of study and living conditions, to involvement in student life, etc. The data contains answers of 6631 students. For our study we need only a part of the questions from this questionnaire, namely, the year of study, place of residence, citizenship, working status, financial situation, etc. Also, the general information about students, i.e., gender, average grade, state-funded or fee-paying place, and language were taken from the accounting and analytical system for managing the educational process of the HSE.

The main questions are questions about online courses and preferences regarding the online learning format described in Table 1.

Table 1. *Questions about online education on Student Life Survey*

Question	Responses
Did you include the following types of courses in your curriculum in the past or current academic year?	1. Online courses (all classes and exams were held in an online format) 2. Mixed courses, where you had to listen to online lectures and attend offline seminars 3. Mixed courses with offline exam only 4. None of them
Which course format is preferable for you: an online course or a course that involves offline sessions with a teacher?	1. I definitely prefer online courses 2. I mostly prefer online courses 3. I have the same attitude to both formats 4. I prefer courses that combine online lectures with offline seminars with a teacher 5. I mostly prefer courses that involve classroom sessions with a teacher 6. I definitely prefer courses that involve classroom sessions with a teacher 99. I find it difficult to answer
Rate the degree of agreement with the following statements	1. The list of online courses offered to students is short (there are not enough options) and of low-quality (there are no courses of interest to me) 2. There are problems with translating grades into the HSE rating system 3. I had to pay for online course included in my curriculum 4. It is easy to cheat at the exam 5. The office manager makes mistakes in working with online courses. 6. The program of online lectures did not correspond to the program of offline seminars
How do you assess the idea of converting all HSE lectures to an online format?	1. I definitely support it 2. I mostly support it 3. I mostly do not support it 4. I definitely do not support it 5. I find it difficult to answer
For what reasons do you not support this idea?	1. Personal communication with the teacher is important for me 2. Personal communication with other students is important for me 3. It is important for me to have a strict schedule 4. I perceive information better in the audience 5. Other

The attitude of students is rather heterogeneous, so we applied different clustering methods to identify groups of people with similar preferences. We used the hierarchical clustering method, K-means and latent class analysis, and the latter method gave us the clearest results that is described below.

4. Results

Using the hierarchical clustering method, we found that the best number of clusters is 6, that was confirmed with the Bayesian information criterion (BIC) test. The main difference between obtained clusters is described in Table 2.

Table 2. *The average responses of students from different clusters*

Cluster	Inclusion of online courses	Preference for online, offline or mixed format	Attitude to the disadvantages	Attitude for conversion into online format
1	Nobody included	No response	No response	Definitely support
2	All included (online and mixed)	Mixed, offline	Mostly do not agree	Definitely support
3	Nobody included	No response	No response	Definitely do not support
4	All included (online and mixed)	Mixed	Mostly do not agree	Definitely do not support
5	Nobody included	No response	No response	Definitely support
6	Mostly included (online)	Mixed, offline	Equal support	Mostly do not support

To analyse the difference between clusters and factors affecting attitude we used the ANOVA analysis of variance on all set of questions from the survey and identified several significant parameters that can describe the type of students in each cluster.

Students in cluster 1 most likely are very loyal to HSE and highly appreciate any university innovations, as well as transfer of lectures to the online format. Students in cluster 2 are fond of online courses and also support the idea of translation. Students from the cluster 3 might be very disciplined, who like everything to be on schedule and listen carefully to the teacher in class, so the online format of education does not fit their usual way of life. Cluster 4 includes social people who like to communicate and interact with people, and this group of people is also against changes. People from the 5th cluster can be called students, studying only for the grades, and they also favour the online format. Cluster 6 can be described as mixed and diverse.

5. Conclusion

We found six clearly separated clusters that differ in their attitude to the translation of traditional lectures into an online format, and the reasons for this relationship. Briefly, clusters can be characterized as HSE devotees, online courses devotees, disciplined, social, students for grades, and mixed cluster.

REFERENCES

[1] Shah, D. "By The Numbers: MOOCs in 2019", MOOC Report, https://www.classcentral.com/report/mooc-stats-2019/
[2] "Lectures will be transferred to an online auditorium", Newspaper Kommersant No. 179 of October 2, 2018, p. 5, https://www.kommersant.ru/doc/3758336
[3] Ku, H.-Y., Lohr, L. L. "A case study of Chinese student's attitudes toward their first online learning experience", Educational Technology Research and Development, 51(3), pp. 95-102, 2003.
[4] Khalil, M., Ebner, M. "Clustering patterns of engagement in Massive Open Online Courses (MOOCs): the use of learning analytics to reveal student categories", Journal of Computing in Higher Education, 29(1), pp. 1-19, 2016.
[5] Ferguson, R., Clow, D. "Examining engagement: analysing learner subpopulations in massive open online courses (MOOCs)", 5th International Learning Analytics and Knowledge Conference (LAK15), Poughkeepsie, NY, USA, ACM, 2015.
[6] Kovanovic, V., Joksimovic, S., Poquet, O., Hennis, T., Hatala, M., Vries, P.,

Dawson, S., Siemens, G., Gasevic, D. “Examining communities of inquiry in Massive Open Online Courses: The role of study strategies,” The Internet and Higher Education, 40, pp. 20-43, 2019.

[7] Maiorescu I., Razvan D., Sabou G. C., Dobrea M., “The value of MOOC based learning as perceived by higher education students,” The 12th International Scientific Conference eLearning and Software for Education Bucharest, 2016. 10.12753/2066-026X-16-184.

Children's Creative Writing Using Lexical Diversity Indices

Ioanna Tyrou[1]
Department of Italian Language and Literature, National and Kapodistrian University of Athens, Greece[1]

Abstract

In the field of education, especially in primary school, we can favour the development of creative thinking and written expression of the first grades pupils, using teaching (didactic) practices of selected fairy tales, with creative dynamics. Through fairy tales we encouraged children to produce original ideas, free their imagination and express themselves through creative writing. The selected texts written by the pupils as well as the criteria for creativity evaluation digitized were submitted to judges-educators and subjected linguistic processing. In this paper we present a methodology, correlating judges-teachers' evaluation with the linguistic processing statistics, comparing fairy tales as for their creative potential and, finally, comparing creativity of different aged pupils based on the same fairy tales. The creativity criteria used are seven: the four of the [18], [11] rubric plus the three classic ones [5], [16], [12]. Results of our statistics comprise a k-means clustering of tales, using all seven creativity indices (rubric), designating their relevant didactic practices. An important result is that a very similar clustering of tales is produced based on either the seven creativity criteria mentioned or the percentage of the part of speech (POS) used by the pupils. The above results confirm our initial hypothesis that some aspects of creative writing can be fairly successfully evaluated using linguistic features, [10]. Moreover, our research results can be further exploited in the development of automatic assessment systems and automated content analysis of fairy tales, written by primary school pupils.

Keywords: Creative writing assessment, fairy tales, linguistic features

1. Creative Writing and Expression in the Classroom

When children come to school, they "carry" with them an inner need to express themselves orally, which combined with children's love of fairy tales and stories, a strong foundation for emotional engagement and spiritual stimulation could be established.

The child in Primary School has to work creatively, to early cultivate a personal relationship with the words and the way to combine them to form a homogeneous whole, without missing the joy from other actions such as storytelling, theatrical or drawing representation of the fairy tale. Of course, children enjoy benefit in many ways when they get actively involved with children's literature: sharing experiences from a book in small or large groups may lead to essential conversations and writing applications.

As a main procedural approach in primary school, it offers liberation of thought and flexibility of personal experimentations on writing ways, it frees self-expression and presents pupil's personal ideas, emotions and feelings [16], [17]. Creative writing as an educational activity should be "guided by the instructor" [15], who has to be flexible and to provide a trigger for the "liberation" of the imagination, to encourage pupils, to suggest and also motivate them in creative written expression [9].

2. Learning Through Fairy Tales

The full of exaggerations and contradictions fairy tale is to entertain, to charm, to teach in an indirect way, above all to reach the Aristotelian catharsis by escalating tensions: to relieve and to purify. It has a simple style, stereotype expressions of beginning and end, deliberate repetitions, it provides its interior for explosive ventures and turnovers.

We can say that fairy tale school reading develops creativity, extends thought, train memory and exploits children potentiality, nourishing dialogue, language expression and semantic abundance of words, fostering pluralism of opinions, cultivating a co-operation and teamwork climate. In other words, it contributes to the child's overall psychokinesis, cognitive, perceptual and emotional development [4], [14], [6].

3. Assessment of Creative Writing by Judges and Language Tools

3.1 Creative Tales

In order to confirm and support some theoretical approaches, we conducted a field research in the classroom. Through specific **creative tales**, using established **teaching practices**, we encouraged children to express themselves through creative writing. Fairy tales written by B and E grade pupils were selected, from different teaching practices.

We compared full of fantasy children's stories such as "the dog that did not know how to bark". The aim was to find out whether pupils would contribute to the story creating images, sounds, characterization of the hero, how well formed and aesthetic their narrative could be, whether quantity and types of ideas would be important, enriching their text, and how original their story could be, written at the beginning of the school year. Under the same aim we presented a fairy tale "the clean wolf and the dirty pigs", reverting the well-known story, aiming at bringing about new elements to it.

Furthermore, children of the B and E grade working as a group on an invented narrative of the Rodari "the planet of truth", presented ideas on how to give life to an invented "small-human" [17], made up of material other than that of a human (such as glass, plastic, wood, ice cream, paper, iron, etc.) and guide the humanoid to act, to develop relationships and hit by accidents appropriate to the material chosen.

Finally, responses of the B and E grade pupils relevant to the Rodari fairy tale "Rinaldo adventure" were organized at the end of the school year. Without an end for this story pupils were asked to change parts of the story, using their imagination, trying to act as writers and giving their own end version of the story.

3.2 Judges and Creativity Criteria

The use of judges for the evaluation of creative writing, writing in general, is considered as an established methodological approach [1], [2], [20], [7], [8], [3].

Following this practice, six experienced school teachers were selected to act as **judges**. Creative criteria with sample assessing examples were presented to them and explained in detail.

Some of the pupils written story versions were digitized and given to judges for an **assessment**, based on the following **creativity criteria**: Quantity of Ideas (Cognitive Ability), Types of Ideas (Cognitive Flexibility), Rarity of Ideas (Originality of Thought), Picture/Verbal Iconification, Sound/Verbal Audio Description, Character Description/Characterization, Narration/Story Telling. The former three are referred to by various works [5], [16], [12], [13], [19]. The four latter criteria [18], [11], despite their relative difficulty in utilization, provided interesting data.

Each judge separately processing the material, recorded his evaluation giving one of the four grades for each fairy tale and for each student: *Excellent (4), Good (3), Reasonable (2), Poor (1)*.

To integrating judges' assessment for statistical processing, we tested inter-rater agreement by taking into account assessments which are in agreement more than or equal to 70%. For each student, every fairy tale and each creative criterion separately, the median value of the resulting evaluation of these judges was calculated. Following the same inter-rater agreement process, for the "collective creation" of pupils of the same grade (age group), we calculated the median of the assessments of judges who agree 70% or more for all pupils of that grade, per creativity criterion and per tale. The resulting numbers were normalized from 0 to 1.

3.3 Linguistic Processing

The digitized texts were also tested by **linguistic processing** to record for each pupil and every fairy tale under consideration the following language characteristics [18], [11]:

- Absolute **number** and **percentage** of **lemmata** per part of speech (names, verbs, adjectives, adverbs, conjunctions, pronouns, prepositions, articles, etc.), where all lemma types are taken into account.
- **Percentage of lemma types** per part of speech (names, verbs, adjectives, adverbs, etc), i.e. each lemma is recorded once, irrespective of its number of occurrences.
- **Percentage of apax lemmata** (the words that appear only once), per part of speech (names, verbs, adjectives, adverbs, etc.).

In this paper we present results based on both content words (names, verbs, adjectives and adverbs) and functional words (prepositions, conjunctions, articles, etc.), but the apax lemmata.

For calculating the percentage of the word types in the text of each pupil for each fairy tale, the lemma of each word was found (using the ILSP lemmatizer) and the unique types were identified, where each lemma is recorded once irrespective of the number of its occurrences. Then, the percentage of the types and the unique types was calculated for all the words in their relevant grammatical category (ILSP-http://nlp.ilsp.gr/soaplab2-axis/).

The values of all parameters, in tables, were normalized to the number of students in each age group and, if applicable, to the number of words or sentences per age group, for comparison.

3.4 The Research Questions

Central questions that initiated and led this research, for which an initial answer is attempted in this paper, is the correlation of Fare Tales and Age Groups by means of creativity criteria and linguistic parameters. More specifically:

- Similarities between **Fairy Tales/Teaching Practices**. Namely, whether there is a difference in pupils' creativity depending on the kind (subject, teaching practice) of the fairy tale. *(Figure 1, Figure 2)*
- Correlating **Age Groups**. Namely to compare creativity of different age pupils, using creativity criteria and linguistic parameters. *(Figure 3)*
- Clustering of Fairy Tales, using creativity criteria and linguistic parameters. *(Figure 4)*

4. Conclusions

Observing Figure 1 we conclude that characteristic is the “Small Human” fairy tale written by the pupils of the Grade B (BTA12), whose evaluation is just as excellent in character description and story (narration) as that of the Grade E pupils (ETA17), while it is assessed as average only in the image and voice criteria. Almost identical pattern is found for the “Rinaldo” fairy tale (BTR13, ETR19)! The evaluation of the fairy tale “Wolf” (BAL10) is found below average except in story (narration) in which is assessed as 0,7.

The “Dog” (BAS11) in image and story (narration) is assessed over 0,7 and average in voice and character description.

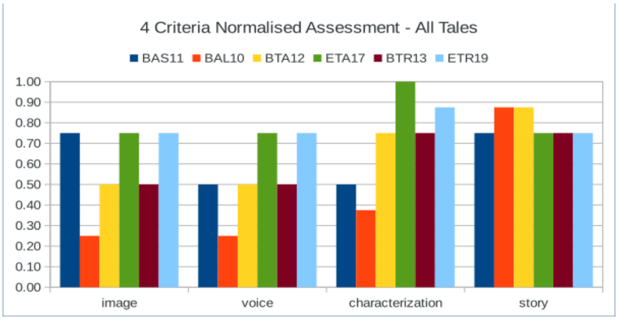


Fig. 1. *A noticeable difference is presented in assessing tales of all age groups (B and E) using image (picture) and voice (audio) criteria. Similar figures are related to the criteria story (narration) and mostly to characterization (character description)*

Based on Figure 2 we observe that the fairy tale “Dog” (BAS11) is assessed as almost nil, whereas the “Wolf” (BAL10) is assessed as average as for the Rarity of Ideas. The assessment of the fairy tale “Small Human” for both age groups (BTA12, ETA17) and that of the “Dog” (BAS11) are assessed above 0,7, reaching the maximum value in all the criteria, as is found for the “Rinaldo” of B grade (BTR13)!

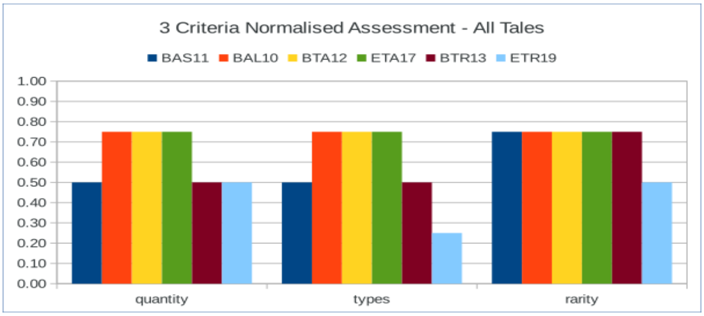


Fig. 2. *A comparative assessment of almost all tales is presented using these 3 criteria*

Comparing the assessment of the same tale (“small human”), using all 7 creative criteria along with percentage of lemmata, we observe (Figure 3) a high similarity between age groups. A comparative result emerged comparing all relevant tales using all creativity criteria and the linguistic parameters lemmata types.

Correlations	B-average ETA	E-average ETA
B-average ETA	1	
E-average ETA	0.97	1

Fig. 3. *High similarity in the assessment of tale "small human" of the two age groups, using all creativity criteria and lemmata types*

Considering clustering of all fairy tales based on all 7 creativity criteria in combination with linguistic parameters (lemmata types) we find (Figure 4) that Fairy tale "Wolf" forms a distinct cluster (cluster 3), while fairy tale "Dog" belongs to the same cluster as "Rinaldo" and "Small Human" (LITTLE_HUMAN) fairy tales of the E Grade (cluster 2).

"Rinaldo' and "Small Human" of Grade B form their own group (cluster 1).

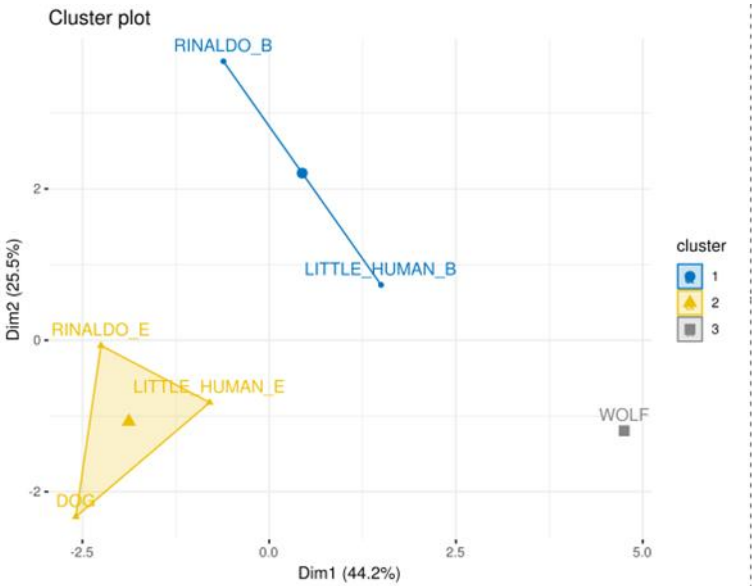


Fig. 4. *3 distinct clusters emerged, differentiating tales, using all 7 creativity criteria and either percentage of lemmata or lemmata types.*

As we can see differentiation between fairy tales and ages is depended on the creative criteria and/or the linguistic parameters applied. The above results confirm our initial hypothesis that some aspects of creative writing can be fairly successfully evaluated including some linguistic features.

REFERENCES

[1] Amabile, T. M. "Social psychology of creativity: A consensual assessment technique", Journal of Personality and Social Psychology, 43, 1982, pp. 997-1013.

[2] Amabile, T. M. "Creativity in context", Boulder, CO, Westview Press,1996.

[3] Baer, J. & S. S. McKool. "Assessing creativity using the consensual assessment

technique", S. Schreiner (ed.), Handbook of research on assessment technologies, methods and applications in higher education, Hershey, PA: Information Science Reference, 2009, pp. 65-77. 10.4018/978-1-60566-667-9.ch004
[4] Budihastuti, Dra. Exti. "Short Story Text in Project-Based Learning Model on 7th Graders", American Journal of Educational Research 3.2, 2015, pp. 109-115. http://pubs.sciepub.com/education/3/2/1/index.html
[5] Crossley, S.A., Muldner, K., McNamara, D.S. "Idea Generation in Student Writing: Computational Assessments and Links to Successful Writing", Written Communication, Vol. 33 (3), SAGE Publications, 2016, pp. 328-354, https://doi.org/10.1177/0741088316650178
[6] Hung, C.M., Hwang, G.J., & Huang, I. "A Project-based Digital Storytelling Approach for Improving Students' Learning Motivation, Problem-Solving Competence and Learning Achievement", Educational Technology & Society, Volume 15 (4), 2012, pp. 368-379. https://pdfs.semanticscholar.org/ce24/85df8c9f48a964b36f7f9fe36030192cad3d.pdf?_ga=2.2498805.430862470.1577960894-1975653073.1577960894
[7] Kaufman, J. C., & Baer, J. "Beyond new and appropriate: Who decides what is creative?", Creativity Research Journal, 24(1), 2012, pp. 83-91. https://doi.org/10.1080/10400419.2012.649237
[8] Kaufman, J. C., Gentile, C. A., & Baer, J. "Do gifted student writers and creative writing experts rate creativity the same way?" Gifted Child Quarterly, 49, 2005, pp. 260-265. http://www-usr.rider.edu/~baer/KaufmanGentileBaer.pdf
[9] McNamara S. Danielle, Scott A. Crossley b, Rod D. Roscoe, Laura K. Allen, Jianmin Dai. "A hierarchical classification approach to automated essay scoring", Assessing Writing 23, 2015, pp. 35-59. https://doi.org/10.1016/j.asw.2014.09.002.
[10] Mozaffari, H. "An Analytical Rubric for Assessing Creativity in Creative Writing." Theory and Practice in Language Studies 3 (12), 2013, pp. 2214-2219. https://pdfs.semanticscholar.org/fd69/adb2f145b923e94596cc0f734e6e653191d1.pdf.
[11] Runco, M.A., Acar, S. "Divergent Thinking as an Indicator of Creative Potential", Creativity research journal, 24 (1), 2012, pp. 1-10. http://www.researchgate.net/publication/8902778_Creativity
[12] Slabon, A.W., Richards, L. R., Denneny, P.V. "Learning by restoring", Instructional Science, Volume 42, Issue 4, 2014, pp. 505-521.
[13] Souliotis, M. "Creative writing", Athens: Ministry of Education and Culture, Δημιουργική Γραφή. Οδηγίες Πλεύσεως, 2012. (In Greek).
[14] Tyrou, I. "Creative Writing with Fairy Tales – Evaluating Creativity in Primary School", 4th Panhellenic Conference "Neos Paigagogos", Eugenides Foundation, Athens, 2017. (In Greek). http://users.sch.gr/synedrio/Praktika_Synedriou_04_Synedrio_Neos_Paidagogos_2017.pdf
[15] Tyrou, I., Karakitsou, V., Koutli, M., Larios, N. "Creative Writing and Activities Based On Multiple Intelligences Upon Gianni Rodari Fairy Tales" 4th International Conference of Education, Research and Innovation (ICERI2011), 2011, Madrid, Spain.
[16] Vaezi, M & Rezaei, S. "Development of a rubric for evaluating creative writing: a multi-phase research", New Writing, 16:3, 2019, pp. 303-317, https://doi.org/10.1080/14790726.2018.1520894

https://www.academia.edu/37495741/Development_of_a_rubric_for_evaluating_creative_writing_A_multi-phase_research
[17] Zedelius, C.M., Mills, C. & Schooler, J.W. "Beyond subjective judgments: Predicting evaluations of creative writing from computational linguistic features", Behavior Research Methods, 2018. https://link.springer.com/content/pdf/10.3758%2Fs13428-018-1137-1.pdf
[18] Kotopoulos, T. "Teaching Creative Writing. The case of writing literary works for adolescents", Θέματα παιδικής λογοτεχνίας, Εκδ. Πανεπιστημίου Μακεδονίας, 2012, pp. 93-162. (In Greek).
[19] Xanthakou, G. "Creativity in School", Athens, Ελληνικά Γράμματα,1998. (In Greek).
[20] Sioutas, N., Zimianitis, K., Koutaleli, K. & Panagopoulou, E. "Creative Thinking – Producing Innovative and Original Ideas, Ministry of National Education and Religious Affairs, General Secretariat for Adult Education, 2008. (In Greek).

Correlations between Syllabus Schedule and Academic Achievement, a Case Study

Rodolfo Bojorque[1], Fernando Moscoso-Merchán[2], Fernando Pesantez-Avilés[3]
Universidad Politécnica Salesiana, Ecuador[1,2,3]

Abstract

There is a lot of literature about syllabi importance but does not exist studies than measure the impact of the syllabi, some studies asses the degree to which a syllabus achieves a learning-centered orientation other studies analyse its design. A syllabus can be useful in engaging students, yet discussions of their effective use rarely appear. The function of syllabi has seven purposes: It sets the tone for a course, motivates students to set lofty but achievable goals, serves as a planning tool for faculty, structure students' work over the course of the semester, helps faculty plan and meet course goals in a timely manner, serves as a contract between faculty and students about what students can expect from faculty and vice versa, and is a portfolio artefact for tenure, promotion or jobs applications. Nowadays, the information technology allows collect data from the educative process, this work analyses the correlations between syllabi schedule and grades obtained by students in an Ecuadorian technical university. We analyse data of four semesters over an information system for register and follow syllabus progress. Our results show that good scheduling of the activities, at least one per class, has a direct correlation with grades, in conclusion, while more activities were scheduled, the student's grades increase.

Keywords: Academic Achievement, Syllabus, Learning Analytics

1. Introduction

A syllabus is generally defined as a plan that states exactly what students at a school or college should learn in a particular subject [1]. However, there is a lot of literature about syllabi importance in other scopes [2-3], especially about higher education; but does not exist studies than measure the impact of the syllabi, some studies asses the degree to which a syllabus achieves a learning-centered orientation other studies analyse its design [4-5]. A syllabus can be useful in engaging students, yet discussions of their effective use rarely appear. While the scholarship of teaching and learning literature has made great advances in our understanding of how learning might best occur, the syllabus as a teaching and learning tool appears to have been almost completely left out of the developmental conversation [6]. Our study gathering information about syllabi at Salesian Technical University. We collect data from 4700-course groups in four semesters. Approximately 450 courses of different kinds of subjects, grades of 185000 students and syllabi scheduling of 760 lecturers. Nowadays, the information technology allows collect data from the educative process, this work analyses the correlations between syllabi schedule and grades obtained by students. To understand how our information system gathering information, the educative process at the university is as follows: a) When a lecturer has been assigned to a course, it is necessary to plan the syllabus activities in the information system, each lecturer can plan his/her activities as he/she considers pertinent, for instance, hour by hour, or to bunch topics in many hours. b) The activities include grade activities or assessments with their respective values. c) Along the semester the lecturer has to register finished activities in the information system. Lecturers and students can verify the syllabi progress at any time.

Our Information System allows us to perform the learning analytics process, as we sill se besides, so we can execute more sophisticated artificial intelligence techniques [7], all of them are part of our Academic Quality Management System.

The remainder of this work is divided as follows: Section two is a review of essentials concepts, section three shows and explains the methodology used, in section four we outline the results and finally in section five we present the work conclusions.

2. Review

In this section, we focus on the syllabus utility and fundamentals of learning analytics.

2.1 Syllabus

The function of syllabi has seven purposes: It sets the tone for a course, motivates students to set lofty but achievable goals, serves as a planning tool for faculty, structure students' work over the course of the semester, helps faculty plan and meet course goals in a timely manner, serves as a contract between faculty and students about what students can expect from faculty and vice versa, and is a portfolio artefact for tenure, promotion or jobs applications [2].

The syllabus should delineate the responsibilities of students and of the instructors for various tasks, including attendance, assignments, examinations and other requirements [4]. It is important to highlight that a syllabus is a learning tool. Students usually receive the course syllabus at the first-class meeting, the syllabus is often the first contact a student has with a faculty member, one way to assess learner-centeredness is through the syllabus [8]. A good course and syllabus need not be rigid in providing this structure but should be flexibly responsive to student concerns and external events [9]. Our Information System allows any change at any time.

In our case, the Information System for each syllabus activity saves activity detail, kind of activity, duration, resources, and grade if exists. Each lecturer has to plan his/her syllabus and record in the Information System before course beginnings.

2.2 Learning Analytics

Learning analytics is an emerging field in which educators and researchers are using data to improve their students' educational experiences [10]. According to [11], the most dramatic factor shaping the future of higher education is data. Learning analytics is the evolution of social networks (Web 2.0) and previously of learning management systems.

The learning analytics process includes data collection, analysis, model selection, and intervention treatment [12]. There are lots of techniques to analysis data, in our case, we only use a correlation coefficient among different syllabi features. In addition, we apply similarity measures to the lecturers' features, our aim is trying to find out hidden patterns in the data like lecturer's clusters. Fig. 1 shows the interaction among stages of the learning analytics process, double arrow lines indicate that the process can go back to the previous stage, and single arrow lines indicate that the process has to pass the next stage. The "Choose model" stage is a generic representation since we choose among different techniques. The main and most useful are:

- Data visualization: it is the graphical representation of information and data, the main idea is provided an accessible way to see and understand trends, outliers, and patterns in data.
- Prediction: It is a data analysis to try to predict future data trends, there are two kinds of prediction. The first one is a regression when the goal is to predict a real number. The second one is classification when the goal is to predict class membership.
- Clustering: It is a technique to group similar objects in sets named clusters. When the groups are formed, we can explain details about the data like hidden patterns or relationships.

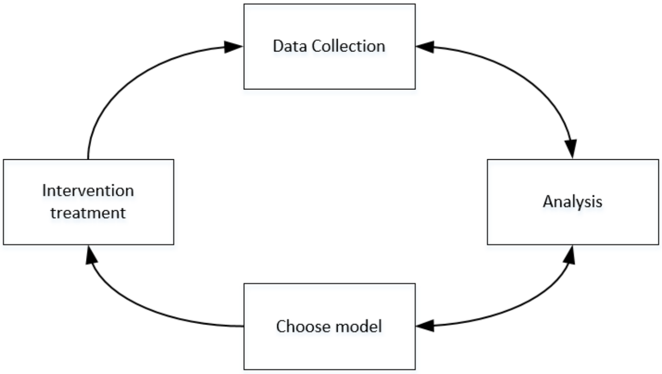


Fig. 1. *Learning analytics process*

3. Methodology

The data collection stage is performed by the information system. The syllabi data is ranked by campus, career, subject, and lecturer. For each rank, we summarize the data features like the number of students, number of groups, academic achievement and several more. Our aim is to make a multidimensional vector, that represents the features of this rank level. The set of multidimensional vectors by rank is a matrix. Fig. 2 shows a matrix example; with this structure we can probe different learning analytics models.

	#students	#promoted students	average hours	Average Activities
Career 1	13086	5550	3.30	13129
Career 2	645	172	3.70	843
Career 3	644	388	2.24	516
Career 4	220	0	2.75	116
Career 5	11426	4001	3.60	7676
Career 6	15103	7127	4.03	12380
Career 7	18846	7423	3.48	13749
Career 8	653	0	3.19	482
Career 9	9195	2906	8.12	8196

Matrix representation

Multidimensional vector

Fig. 2. *Matrix representation example for data analysis*

Once we had matrixes, we apply two techniques: a) Correlation coefficient, and we proceed to make data visualization of relevant results. b) K-means clustering algorithm, to try to find out lecturer's clusters. There are a lot of variations of the k-means algorithm, [13] shows a comparative analysis of similarity metrics that we can apply in the k-means algorithm.

4. Results

Below we present the most relevant results, Fig. 3. shows the relationship between the number of activities planning and students' grades. As we see, while more activities were planned by the lecturer, the average course rate approval increase. We scale between 0 and 1 the activities, where a value near to one means that the lecturer planning his/her class hour by hour, and values near to zero means that the lecturer planning is not per class or hour, maybe the syllabus planning is by topic. Since the average class has two hours, we expect that values near to 0.5 (50%) mean an adequate syllabus scheduling. Nowadays, the average of activities is 40%. Hence, the syllabus scheduling at Salesian Technical University is near to the target of at least one activity per class. Maybe, 1% of increment in syllabus scheduling, sounds no enough, but this 1% is a very hard goal, we are working between 100 and 1400 groups per semester.

Fig. 4. shows clusters of lecturers, we probe clusters from 2 to 20, and k=5 obtains the best cluster quality results. The magenta samples are the lecturers who more plan their syllabus. The blue samples are the lecturers who do not plan enough their syllabus and their approval rates are low. Both, black and red samples are lecturers who are in transition to improve their syllabus scheduling. Finally, the green samples are special cases, because the majority of their approval rates are very high and their syllabus scheduling is under the mean. These results are used in the final stage "intervention treatment" of learning analytics and allow support desitions about awareness of correct syllabus scheduling.

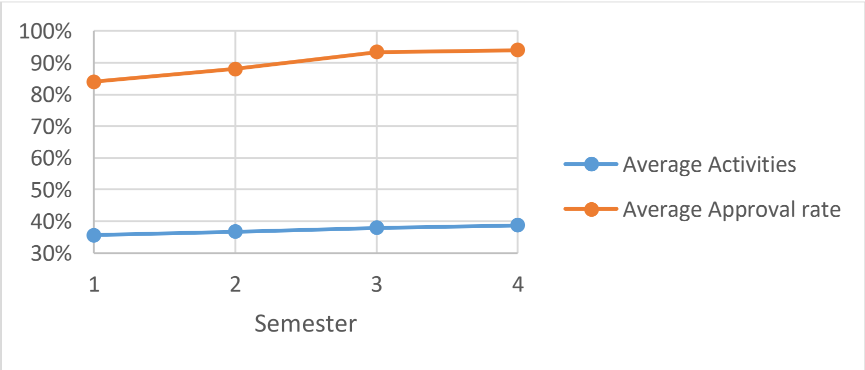


***Fig. 3.** Relationship Activities-Approval rate*

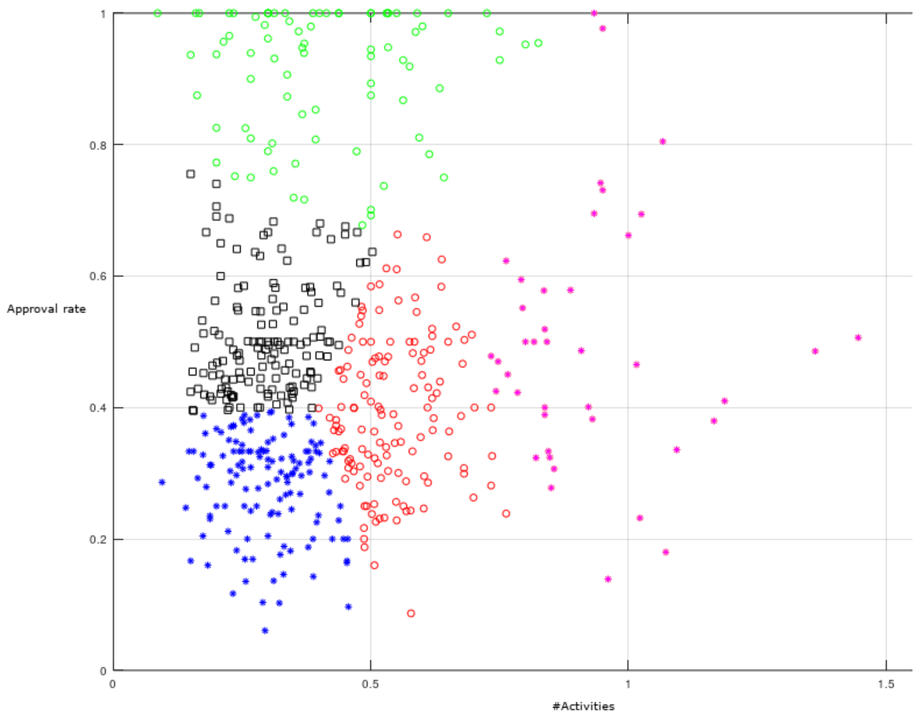


Fig. 4. *Clusters of lecturers*

5. Conclusions

Our results show that good scheduling of the activities, at least one per class, has a direct correlation with grades, in conclusion, while more activities were scheduled, the student's grades increase. Besides, we use a clustering model to detect how good is the syllabus scheduling per each lecturer. We show only a little application of our learning analytics process. This work summary four semesters of data. The Salesian Technical University tries to take advantage of the daily generated data. We consider that share information is necessary to start an understanding of new opportunities. Nowadays, people believe that learning analytics is possible only for online studies maybe they think that an online platform collects lots of information and they do not see their data sources, we consider that learning analytics is possible in any scenario where there is data.

REFERENCES

[1] Tokatlı, A. M., & Keşli, Y. (2009). Syllabus: how much does it contribute to the effective communication with the students? Procedia – Social and Behavioural Sciences, 1(1), pp. 1491-1494. https://doi.org/https://doi.org/10.1016/j.sbspro.2009.01.263
[2] Littlefield, V. M. My syllabus? It's fine. Why do you ask? Or the syllabus: A tool for improving teaching and learning. Society for Teaching and Learning in Higher Education, Calgary, Canada, 1999.
[3] Parkes, J., & Harris, M. B. The Purposes of a Syllabus. College Teaching, 50(2), 2002, pp. 55-61. https://doi.org/10.1080/87567550209595875

[4] Matejka, K., & Kurke, L. B. Designing a Great Syllabus. College Teaching, 42(3), 1994, pp. 115-117. https://doi.org/10.1080/87567555.1994.9926838
[5] Palmer, M. S., Bach, D. J., & Streifer, A. C. Measuring the promise: A learning-focused syllabus rubric. To Improve the Academy, 33(1), 2014, pp. 14-36.
[6] Fornaciari, C. J., & Lund Dean, K. The 21st-century syllabus: From pedagogy to andragogy. Journal of Management Education, 38(5), 2014, pp. 701-723.
[7] Bojorque R., Pesántez-Avilés F. Academic Quality Management System Audit Using Artificial Intelligence Techniques. In: Ahram T. (eds) Advances in Artificial Intelligence, Software and Systems Engineering. AHFE 2019. Advances in Intelligent Systems and Computing, vol. 965. Springer, Cham, 2020.
[8] Richmond, A. S., Morgan, R. K., Slattery, J. M., Mitchell, N. G., & Cooper, A. G. Project Syllabus: An Exploratory Study of Learner-Centered Syllabi. Teaching of Psychology, 46(1), 2019, pp. 6-15.
[9] Slattery, J. M., & Carlson, J. F. Preparing an Effective Syllabus: Current Best Practices. College Teaching, 53(4), 2005, pp. 159-164. https://doi.org/10.3200/CTCH.53.4.
[10] Friedman, A. Data science syllabi measuring its content. Education and Information Technologies, 24(6), 2019, pp. 3467-3481. https://doi.org/10.1007/s10639-019-09935-x
[11] Long, P., & Siemens, G. Penetrating the fog: Analytics in learning and education. Educause Review Online, 46(5), 2011, pp. 31-40.
[12] Yu, T., & Jo, I.-H. Educational Technology Approach Toward Learning Analytics: Relationship Between Student Online Behaviour and Learning Performance in Higher Education. In Proceedings of the Fourth International Conference on Learning Analytics and Knowledge, 2014 (pp. 269-270). Indianapolis, Indiana, USA: ACM. https://doi.org/10.1145/2567574.2567594
[13] Bojorque R., Hurtado R., Inga A. A Comparative Analysis of Similarity Metrics on Sparse Data for Clustering in Recommender Systems. In: Ahram T. (eds) Advances in Artificial Intelligence, Software and Systems Engineering. AHFE 2018. Advances in Intelligent Systems and Computing, vol. 787. Springer, Cham, 2019, pp. 291-299.

Effective Use of Crises Communication in Syria During the War Period

Valerii L. Muzykant[1], Fadi Mfarrej[2], Elena Yu. Burdovskaya[3], Elizabet V. Muzykant[4]
RUDN University, Russian Federation[1,2,3,4]

Abstract

In Syria, in the pre-war period, local and international organizations enjoyed an ideal environment of good legislative laws and growing consumer demands for different goods and services amidst economic openness to all countries of the world. While, in the post-war period, local and foreign organizations will compete together over many promising opportunities of reconstructions and investments. In order to succeed and work efficiently, all organizations need to raise and improve their level and practice of public relations as the most effective mean of organizing communication with their internal and external public. This requirement calls management of organizations to understand the system which they work according to (if it is open or close), determine nature and characteristics of each category of their public (if public effectively process and request information on a particular issue) and anticipate activities of public relations in the light of their organizational behaviour. This is the essence of this research.

Keywords: the war in Syria, communication programs, strategic communications, crisis PR

Research's Terminological Base: In order to identify the problem of this research, as well as to structure its hypotheses and questions, the terminologies used in all its fundamentals are analysed as follows: Public relations: A large number of existing studies in the broader literature have examined public relations. K. Fitch (2017) indicates that public relations management within any organization is part of its organizational structure. Some researches note that organizations are also interested in the function of public relations in order to build their corporate image among their public. K. Ying Mak (2016), demonstrated that there is no one ideal way to manage public relations in all situations as there are many differences between people, times and circumstances. So, the theory of Systems Model of Public Relations or any other theory can't provide any ready recipe about the best way to manage a certain situation under certain circumstances.

Basically, M. Aronczyk, L. Edwards, A. Kantola (2017), suggest that the essence of the Systems Model of Public Relations is that the management practices must be in general conformity with all different tasks undertaken by individuals (with the external environment and with the needs of the internal and external public of the organizations).

In general, they claim that the concept of public relations does not differ among organizations, and difference only occurs in practice when goals of public relations reflect philosophy of organization it expresses. G. Thompson (2016) took a long time to compile a comprehensive definition of public relations and classify its main ideas. Through his analysis of definitions, he found that public relations are a distinctive administrative function that helps to establish, supervise, and maintain mutual communication, understanding, acceptance and cooperation between any organization and its environment and public, including crisis communication. J. Johnston (2017) observed that public varied among those who actively seek and deal with information about their organizations because they serve their interests, and those who simply receive information without any effectiveness by them in their relationship with their organizations.

Discussion

Many researchers worked hard to reach definitive models for the practice of public relations that can be used as a reference by both students and experts. First, Press Agent/ Publicity Model. M. Toledano (2017), argues that conforming to this model, public relations aims to achieve fame and publicity for organizations by publishing their names in all possible ways. Information provided to the public is often insufficient or is based on certain facts or misleading to deceive these public. It also uses one-way communication from organizations to their public and doesn't use scientific researches, and if they are used, they are usually primitive like counting the presence in a certain activity. Second, Public Information Model. S. Davidson (2016), alleges that according to this model, public information is the most important objective. Experts of public relations in this model focus on the transfer of information and the dissemination of news honestly and objectively as much as possible through one-way communication from organizations to their public. Third, Two-way Asymmetric Model. A. Smallwood, B. Brunner (2018), claim that this model mainly depends on two-way communication, from organizations to their internal and external public, and from public to organizations. Purpose of public relations in this model is limited to planned and scientifically persuasion in order to convince concerned public of organizations' activities and to convert this persuasion into pro-organization behaviour. The process of communication in this model is unbalanced.

Public relations attempt to influence and convince public in the interest of organizations without attempting to modify their policies and programs in response to their views and wishes.

Fourth, Two-way Symmetrical Model. M. Ewing and D. Remund (2017), contend that public relations in this model aims to achieve mutual understanding between organizations and their public and communicate with it in two parallel directions. Public relations are concerned with persuading public and influencing it. Public in this model has power to influence organizations to adjust their policies, decisions and plans in order to meet their wishes and trends. This model uses formative researches and evaluation studies.

There have been numerous studies to investigate effective corporate communication.

To start with P. Argenti (2017), who pointed out that corporate communication combines internal administrative communication in its three forms (ascending – down – horizontal), organizations' communication with their external societies surrounding them and communication between management and its public, whether internal or external.

H. Amegbe, J. Owino and O. Kerubo (2017) concluded that corporate communication is not an act of improvisation, but a strategic vision that begins with planning within a unified message of organizations' identity. T. Roulet (2017), discovered that corporate communication is an administrative umbrella which includes: advertising, public relations, marketing, internal and external communication, crisis management and corporate responsibility. M. Hossain, M. Alamgir and M. Alam (2017) demonstrated that corporate communication assists organizations in times of crisis as communication experts in successful organizations work on preparing and forecasting preplant of crisis management in order to control and optimize them through rapid response using suitable media means.

Thus, the research **problem** is identified in analysing the types of public of MTN Syria is a part of MTN Group, a group of multinational private telecommunication companies; Bemo-bank is one of the largest private banks; Ministry of Tourism and information SANA through the use of Situational Theory, in addition to exploring the function, nature and efficiency of public relations' activities in them through the use of System Model and J. Grunig's Model, along with their adopted activities of corporate communication, and their level of efficiency in building a good relation between these four organizations and their public, as well as examining the efficiency of corporate responsibility and crises communication used in an integrated strategy in order to ensure their success in Syria in the pre-war period, during the war and in the post-war period.

Research's Empirical Base included the communities in which this research is applied can be identified as follows: quantitative analytical study: The community of this study is the public of MTN, Bemo, Ministry of Tourism and SANA. The researcher selected them using a random sample consisted of 800 respondents from all the four organizations distributed to 200 respondents from every organization. The researcher conducted the quantitative field study using the questionnaire on a random sample of the public of the four organizations from 2018-2019. Qualitative field study: The researchers applied this study through four focus interviews in Damascus with the four experts of public relations in MTN, Bemo, Ministry of Tourism and SANA during the period from the First of August 2018 to the Second of September 2018. Focus interview with MTN's public relations expert at 5/8/2018 in MTN's headquarter in Damascus. (M.K), the head of public relation department is 45 years old. He has a bachelor degree in Marketing. He has been working in MTN for three years. Focus interview with Bemo's public relations expert at 13/8/2018 in the banks headquarter in Damascus. (G.M), the head of public relation department is 40 years old. He has a Master degree in business administration. He has been working in Bemo for six years. Focus interview with Ministry of Tourism's public relations expert at 17/8/2018 in the ministry's headquarter in Damascus. (A.H), the head of public relation department is 50 years old. She has a bachelor degree in media and communication.

He has been working in the ministry for ten years. Focus interview with SANA's public relations expert at 27/8/2018 in the agencies headquarter in Damascus. (T.M), the head of public relation department is 49 years old. He has a bachelor degree in accounting.

He has been working in the agency for six years. Qualitative analytical study: The community of this research is the communication materials of public relations issued by MTN, Bemo, Ministry of Tourism and SANA. This research's sample consisted of seventeen communication materials issued by the department of public relations in the four organizations and included brochures, advertisements, promotional videos and press releases that were collected from the First of August 2018 to the Second of September 2018.

Research's Questions and Hypotheses raised a number of questions that can be divided into general questions of the whole research from which sub-questions are included concerning the qualitative analytical study (the questionnaire), the quantitative field study (the interview) and the quantitative analytical study (the content analysis). We studied general questions whether had MTN, Bemo, Ministry of Tourism and SANA worked according to the open or close communication system in Syria, in the pre-war period and during the war? According to which model of public relations have the four organizations worked in Syria, in the pre-war period and during the war? What have the kinds of the public and messages been in the four organizations in Syria, in the pre-war period and during the war? What have the levels of effectiveness and efficiency of public relations' communication activity been in the four organizations in Syria, in the pre-war period and during the war? What have the levels of effectiveness and efficiency of corporate communication been in the four organizations in Syria, in the pre-war period and during the war? What have the levels of effectiveness and efficiency of social responsibility been in the four organizations in Syria, in the pre-war period and during the war? What have the levels of effectiveness and efficiency of crises communication been in the four organizations in Syria, in the pre-war period and during the war? What have the expectations of the experts of public relations been in the four organizations about public relations and corporate communication in Syria, in the post-war period? And sub-questions: has the public of MTN, Bemo, Ministry of Tourism and SANA been able to properly seek the information about its organization in Syria, in the pre-war period and during the war? Has the public of MTN, Bemo, Ministry of Tourism and SANA been able to properly process the information about its organization in Syria, in the pre-war period and during the war? Has the public of MTN, Bemo, Ministry of Tourism and SANA been able to properly recognize its problems about its organization in Syria, in the pre-war period and during the war? Has the public of MTN, Bemo, Ministry of Tourism and SANA been able to properly recognize the constraints facing it when dealing with its organization in Syria, in the pre-war period and during the war, etc.?

Research's Difficulties: During the course of his research, the researcher encountered many difficulties. The most important of them are:

- The difficulty of reaching the whole eight hundred respondents mentioned in the plan of the research due to the circumstances of the Syrian war, causing displacement and internal and external asylum of thousands of people. In addition to the reluctance of many people to cooperate in precisely answering the questions of questionnaire that require effort and concentration. Furthermore, the lack of conviction of many people of the importance of scientific research in the circumstances of war, as they prefer to focus on their priorities of living and survival.
- The low sufficient cooperation of the experts of public relations in most of the four organizations to conduct the focus interview. This might be attributed to their fear of covering sensitive information in the critical period of the Syrian war, as well as their worry to jeopardize the corporate image and reputation of their organizations which might lead to the loss of more of their public.

Research's Statistical Processing: After collecting data from the field and reviewing it, the researcher encoded it, and then entered it to the computer for analysis based on the Statistical Package for the Social Sciences known as SPSS, using the following statistical test: Frequency and percentage for all variables. Mean for some variables.

Findings are presented in the main results: main results of the quantitative analytical study according to the questionnaire. *Information seeking*: MTN's public has infectively sought information about its services and activities in a low level of efficiency, while the public of Bemo has very actively sought information about its services and activities in a high level of efficiency. Ministry of Tourism's public has properly sought information about its services and activities in a good level of efficiency. In its turn, SANA's public has unstably sought information about its services and activities in a neutral level of efficiency (sometimes it has sought it, other times it has not). *Information processing*: MTN's public has infectively processed information about its services and activities in a low level of efficiency, while the public of Bemo has very actively processed information about its services and activities in a high level of efficiency. Ministry of Tourism's public has properly processed information about its services and activities in a good level of efficiency. In its turn, SANA's public has unstably processed information about its services and activities in a neutral level of efficiency (sometimes it has processed it, other times it has not). *Problem recognition*: MTN's public has infectively recognized problems when dealing with it in a low level of efficiency, while the public of Bemo has very actively recognized problems when dealing with it in a high level of efficiency. Ministry of Tourism's public has properly recognized problems when dealing with it in a good level of efficiency. In its turn, SANA's public has unstably recognized problems when dealing with it in a neutral level of efficiency (sometimes it has recognized problems, other times it has not). *Constraint recognition:* MTN's public has infectively recognized constraints facing them with it in a low level of efficiency, while the public of Bemo has very actively recognized constraints facing it in a high level of efficiency. Ministry of Tourism's public has properly recognized constraints facing it in a good level of efficiency. In its turn, SANA's public has unstably recognized constraints facing it in a neutral level of efficiency (sometimes it has recognized problems, other times it has not).

Level of communication involvement: MTN's public has involved negatively with it in a low level of communication involvement, while the public of Bemo has very positively involved with it in a high level of communication involvement. Ministry of Tourism's public has properly involved with it in a good level of communication involvement. In its turn, SANA's public has unstably involved with it in a neutral level of communication involvement (sometimes it has involved with it, other times it has not). *Activities of public relations*: MTN's public think that it has had negative and inefficient activities of public relations, while the public of Bemo think that it has had very positive and efficient activities of public relations. Ministry of Tourism's public think that it has had good activities of public relations. In its turn, SANA's public think that it has had unstable activities of public relations (sometimes it has had, other times it does not have).

Objectives of public relations: MTN's public think that it has had negative and inefficient objectives of public relations, while the public of Bemo think that it has had very positive and efficient objectives of public relations. Ministry of Tourism's public think that it has had good objectives of public relations. In its turn, SANA's public think that it has had unstable objectives of public relations (sometimes it has, other times it does not have). *Means of communication:* MTN's public think that it has negatively and inefficiently used means of communication, while the public of Bemo think that it has very positively and efficiently used means of communication. Ministry of Tourism's public think that it has used well means of communication. In its turn, SANA's public think that it has unstably used means of communication (sometimes it has used, other times it has not).

Results of corporate communication: MTN's public think that it has had negative and inefficient results of corporate communication, while the public of Bemo think that it has had very positive and efficient results of corporate communication. Ministry of Tourism's public think that it has had good results of corporate communication. In its turn, SANA's public think that it has had unstable results of corporate communication (sometimes it has, other times it does not have). *Public's level of satisfaction of corporate social responsibility programs:* MTN's public think that it has had negative and inefficient programs of corporate responsibility, and it has had a low level of satisfaction about them. The public of Bemo think that it has had very positive and efficient programs of corporate responsibility, and this public has been very satisfied about them. Ministry of Tourism's public think that it has had good results of programs of corporate responsibility, and this public has been satisfied about them. In its turn, SANA's public think that it has had unstable programs of corporate responsibility, and this public has had unstable level of satisfaction (sometimes this public has been satisfied about its programs of corporate responsibility, while other times it has not been). *Effective use of crises communication:*

MTN's public think that it has negatively and inefficiently used crises communication, while the public of Bemo think that it has very positively and efficiently used crises communication. Ministry of Tourism's public think that it has used crises communication very well. In its turn, SANA's public think that it has unstably used crises communication (sometimes it has used, other times it has not).

Characteristics of communication messages: MTN's public think that its communication messages have had negative and inefficient characteristics, and this public has had a low level of satisfaction about them. The public of Bemo think that its communication messages have had very positive and efficient characteristics, and this public has been very satisfied about them. Ministry of Tourism's public think that its communication messages have had good characteristics, and this public has relatively been satisfied about them. In its turn, SANA's public think that its communication messages have had unstable characteristics, and this public has had unstable level of satisfaction (sometimes this public has had the characteristics, while other times it does not have). *Behaviours allowed to interact with communication messages:* Both MTN's and SANA's public have thought that the communication messages of the company and the agency have just presented their ideas without any invitation to comment or to express opinions about them. On the other hand, both public of Bemo and Ministry of Tourism have assumed that the communication messages of the bank and the ministry have encouraged interacting and communicating with them in a practical way.

Conclusions

The research presents the complex analysis of PR and communication models implemented by state and non-state organizations with the aim of informing, persuading, seeking consensus or dialogue with their TA in the crisis conditions caused by the war.

The research evaluates the content of PR and corporate strategic communications in the conditions of a crisis, when media texts acquire significant distinctive signs, indicating that social responsibility and anti-crisis content of online and offline messages with a request for feedback are the most effective, regardless of organization status. In times of crisis, content of promoted message may not fully correspond with the declared values, which may be detrimental to the reputation of organizations. According to the results of the research, it is possible to predict the correctness of the communication goals set by targeting online and offline messages, which allow optimizing the resources available to organizations in a crisis. The practical implication of the research arises from the activities of PR and corporate strategic communications in the conditions of the crisis.

Acknowledgement

The publication has been prepared with the support of the “RUDN University Program 5-100”.

REFERENCES

[1] Amegbe H., Owino J. and Kerubo O., Behavioural Responses to Corporate Image Building Through Social Media Advertising: A Study Among Nairobi Students // Journal of Creative Communications, 2017. – vol. 12, 3: pp. 223-238.

[2] Argenti P., Strategic Communication in the C-Suite // International Journal of Business Communication, 2017. – vol. 54, 2: pp. 146-160.

[3] Aronczyk M., Edwards L., and Kantola A., Apprehending Public Relations as a Promotional Industry // Public Relations Inquiry, 2017. – vol. 6, 2: pp. 139-155.

[4] Davidson S., Public Relations Theory: An Agonistic Critique of the Turns to Dialogue and Symmetry // Public Relations Inquiry, 2016. – vol. 5, 2: pp. 145-167.
[5] Ewing M. and Remund D., Understanding and Addressing the Gaps: Generational Perspectives on Public Relations Leadership Development in the United States // Public Relations Inquiry, 2017. – vol. 6, 3: pp. 293-312.
[6] Fitch K., Seeing 'the Unseen Hand': Celebrity, Promotion and Public Relations // Public Relations Inquiry, 2017. – vol. 6, 2: pp. 157-169.
[7] Grunig J., A situational Theory of Publics: Conceptual History, Recent Challenges and New research, (3rd Ed.), London: International Thomson Business Press, 2017. – p. 84.
[8] Grunig J. and. Dozier M., Excellent Public Relations and Effective Organizations, (3rd Ed.), London: Routledge, 2016. – p. 146.
[9] Grunig J. and Dozier D., Excellent Public Relations and Effective Organizations, (3rd Ed.), London: Routledge, 2013. – p. 241.
[10] Johnston J., The Public Interest: A New Way of Thinking for Public Relations? // Public Relations Inquiry, 2017. – vol. 6, 1: pp. 5-22.
[11] Hossain M., Alamgir M. and Alam M., The Mediating Role of Corporate Governance and Corporate Image on the CSR-FP Link: Evidence from a Developing Country // Journal of General Management, 2017. – vol. 41, 3: pp. 33-51.
[12] Smallwood A. and Brunner B., Engaged Learning Through Online Collaborative Public Relations Projects Across Universities // Journalism & Mass Communication Educator, 2017. – vol. 72, 4: pp. 442-460.
[13] Roulet T., Good to be disliked? Exploring the Relationship between Disapproval of Organizations and Job Satisfaction in the French Context // Journal of General Management, 2017. – vol. 42, 4: pp. 68-79.
[14] Toledano M., Advocating for Reconciliation: Public Relations, Activism, Advocacy and Dialogue // Public Relations Inquiry, 2016. – vol. 5, 3: pp. 277-294.
[15] Thompson G., Towards a Theory of Rent-seeking in Activist Public Relations // Public Relations Inquiry, 2016. – vol. 5, 3: pp. 213-231.
[16] Ying Mak A., Teaching International Public Relations: An Update Report Among Educators // Journalism & Mass Communication Educator, 2016. – vol. 72, 2: pp. 168-182.

Effects of Cooperative Active Learning Experiences on Achievement, Attitudes, and Behaviours in Biology

Amnah Alraddadi[1], Audrey O'Grady[2]
University of Limerick, Ireland[1,2]

Abstract

It has been reported that with age, learners' interest in science is reduced [1]. Learners' attitudes towards science and how pupils learn science content considerably influences their tendency towards attainment and their ability to retain science information, inside and outside of school. Vogel and Wanke [2] state that an attitude is "a summary evaluation of an object or thought". Koballa and Glynn [3] describe attitudes as the expression of positive or negative affects towards objects, and this differentiates attitudes from other expressions, such as beliefs, values, or opinions. The aim of this research is to determine the impact of the implementation of cooperative learning on student's attitude and behaviour towards biology. Cooperative Learning (CL) concerns instructional methods in which a small group of learners with various levels of ability work together to achieve mutual goals. The study took place in Ireland and it involved pre-service teachers in their second year of their Biology teacher education programme and students from secondary school (junior cycle). In order to achieve the research aims, quantitative (student questionnaire) and qualitative methods (pre-service teacher interview) were applied. The participants were ten pre-service teachers who received training workshop on using CL, along with their 402 junior cycle students. The findings indicate that the majority of junior cycle students in this study showed positive attitudes towards biology after the implementation of cooperative learning methods.

Keywords: Cooperative, learning, Biology, attitudes

Introduction

In the last two decades, many research studies have investigated learners' attitudes towards science in science education [4, 5, 6, 7]. The importance of attitudinal studies, primarily attitudes towards science, is not a new field in science education [8]. Many of the studies on attitude towards science have mostly focused on science in general rather than addressing specific disciplines within the sciences [9]. This can confuse learners' attitudes because science is not one homogeneous course [10]. However, there are some studies that examine this term in specific science disciplines, such as chemistry, physics, and biology. For instance, Bennett [11] evaluated secondary students' attitudes towards chemistry; Krogh and Thomsen [12] did some similar studies on physics; and Nasr and Soltani [13] assessed students' attitudes towards biology.

Method

Mixed methods research bridges the gap between quantitative and qualitative research [14]. The aim of mixed methods research is not to replace any approach, but to take advantage of the strengths of both while reducing their weaknesses. The diversity of mixed methods research can add strength to the collected data [15]. The aim of this research is to measure the effect of active cooperative learning in biology on student's (Junior Cycle) attitude. This study collected quantitative and qualitative data through questionnaire and personal interviews (see table 1.1). The student pre- and post-surveys were used to evaluate students' attitudes of Biology before and following a CL intervention programme.

Table 1.1 *The breakdown of the number of undergraduate students involved in the survey according to gender*

	Junior cycle biology students
Number of Female responses	211 (52.5%)
Number of Male responses	191 (47.5%)
Total number of responses	402

Intervention Programme (Jigsaw Techniques)

In this study the researcher used the jigsaw technique which is one of the most effective CL methods in the intervention programme. The jigsaw strategy is a method of planning classroom activity where pupils rely on each other for success. Jigsaw techniques are used for many purposes in teaching and learning [16], so it has gained the attention of researchers, teachers, and school directors [17]. Jigsaw IV, developed by Holliday [18], where each group in this technique consists of five or six heterogeneous members; each group member is given a topic to learn and then they discuss the material with students from other groups who worked on the same information-called an "expert group." Students from the expert area return to their team and present their information to other group members. Finally, after the expert members finish their explanation, the whole group is given a quiz to check their understanding.

Results

This section shows the main findings from the analysis of the results of pre- and post-surveys for the CL groups. The students in the CL groups engaged in the cooperative learning lessons (jigsaw method) and completed a post-survey at the end of the intervention programme. The main aims of the pre- and post-surveys were to determine whether the intervention programme has changed students' attitude and behaviour towards Biology.

Practical Work in Biology

Table 1.2 shows that the percentage of agreements of students' attitude toward practical work. At the beginning of the intervention programme, most of the students agreed on the positive item (2) and disagreed on the negative items (5, 7, and 8) of practical work (see Appendix 1). The analysis of individual items on the pre- and post-questionnaires showed that students had a very positive attitude toward the importance of carrying out practical work in order to understand biology module (increased from 66.6% to 83.9%). The level of disagreement of negative statements such as "the anxiety about doing practical work with other members" increased from 63.5% to 85.4%, "doing biology practical work is a waste of time" increased from 84.3% to 96.8%, and "learning biology practical work is useless in daily life" from 54.2% to 82.2%.

***Table 1.2** CL group attitude toward Practical Work in Biology before and after the implementation of the study (Paired-sample T-test)*

Item	pre-survey			post-survey				
Item	Strongly Agree (5) Agree (4)	Disagree (2) + Strongly Disagree (1)	Uncertain (3)	Strongly Agree (5) Agree (4)	Disagree (2) + Strongly Disagree (1)	Uncertain (3)	Mean Pre/ post	P-value Pre-post
1	66.6%	13.5%	19.8%	83,9%	5.2%	11.4%	3.81/ 4.03	0.003
2	20.85	63.5%	15.6.%	3.1%	85.4%	11.4%	2.35/ 1.85	0.0005
3	9.3%	84.3%	6.2%	2%	96.8%	1%	1.83/ 1.64	0.001
4	18.7%	54.2%	27.1%	3.1%	82.2%	14.5%	2.41/ 1.96	0.0001

The students' responses showed that most students in the CL group increased their attitude toward practical work following the intervention programme. It was clear that there was significant difference in students' attitude toward practical work.

Importance of Biology

According to the results shown in Table 1.3, the level of agreement for item one (Knowledge of Biology is necessary to understand other subjects and phenomena) increased from 71.8% to 87.5%, and in item three, from 59.3% to 79.1%. The result showed that there was a significant difference in students' attitude toward the importance of Biology.

***Table 1.3** CL group attitude toward Importance of Biology before and after the implementation of the study (Paired-samples T-test)*

Item	pre-survey			post-survey				
Item	Strongly Agree (5) Agree (4)	Disagree (2) + Strongly Disagree (1)	Uncertain (3)	Strongly Agree (5) Agree (4	Disagree (2) + Strongly Disagree (1)	Uncertain (3)	Mean Pre-post	P-value Pre-post
1	71.8%	8.3%	19.8%	87.5%	4.1%	8.3%	3.84/ 4.19	0.006
2	78.1%	1%	20.8%	80.2%	2%	17.7%	4.05/ 4.11	0.617
3	59.3%	8.3%	32.3%	79.1%	4.1%	16.6%	3.70/ 3.95	0.033

Self-concept in Biology

The last subsection in students' attitude toward Biology was self-concept in Biology (see Table 1.4). When the agreement, disagreement, mean score, and the p-value from the pre-questionnaire were compared with the post-questionnaire, it was clear that there was a significant difference. The mean scores in positive items from pre-questionnaire were 4.00 (*item* 1), 3.23 (*item* 3), and 3.41 (*item* 4) while the mean scores of the same items from post-questionnaire were 4.31, 3.44, and 3.77 with the p-value 0.0005, 0.0003, and 0.0001 respectively. The percentage of agreement in positive items (1, 3, and 4) increased from 80.2%, 33.3%, and 54.2% to 93.7%, 54.1%, and 76%, and the percentage of disagreement in the negative item (*item* 2) increased from 68.7%to 89.5%.

Table 1.4 *CL group attitude toward Self-concept in Biology before and after the implementation of the study (Paired-samples T-test)*

Item	**pre-survey**			**post-survey**				
Item	**Strongly Agree (5) Agree (4)**	**Disagree (2) + Strongly Disagree (1)**	**Uncertain (3)**	**Strongly Agree (5) Agree (4)**	**Disagree (2) +Strongly Disagree (1)**	**Uncertain (3)**	***Mean Pre/ post***	**P-value**
1	80.2%	6.2%	13.5%	93.7%	1%	5.2%	4.00/ 4.31	0.0005
2	16.7%	68.7%	14.6%	4%	89.5%	6.2%	2.27/ 1.92	0.0004
3	33.3%	18.7%	47.9%	54.1%	18.7%	27%	3.23/ 3.44	0.0003
4	54.2%	17.7%	28.1%	76%	9.3%	14.5%	3.41/ 3.77	0.0001

In general, students from the experimental group increased their attitude toward practical work, impotence of Biology and self-concept in Biology after applying the intervention programme on the CL groups.

Discussion and Conclusion

There was a very significant change in students' attitude toward Biology in the post-survey results. The author believes that the CL lessons have helped learners to change their attitude toward Biology by giving the students opportunity to communicate, interact, and gain positive interdependence in their work group. The results show that the implementation of cooperative learning methods on biology class has advantages on students' attitude. The students' responses illustrated that most students in the experimental group showed an increased attitude toward practical work, importance of Biology and self-concept in Biology following the intervention programme. Süleyman [19] noted that students in the CL group improved more in positive attitudes toward the subject than the students in the traditional method group. This might be due to the presence of assistance and support within the group, active involvement, and higher chances of success that are associated with cooperative learning technique. Tuan *et al*., [20] stated that there is a strong relationship between students' science attitude and motivation, and to achieve a high level of motivation, we should stimulate learning environments because it has a higher connection with student's attitude toward science.

Eilks [21] reported that students in jigsaw classrooms have positive opinions toward science lessons because they have the opportunity to work in groups and as individuals.

Jigsaw methods increase learners' attitude toward science, positive cognitive achievement, improves their communication skills, and improves the teaching quality of science.

REFERENCES

[1] Osborne, Jonathan, Shirley Simon, and Sue Collins. "Attitudes towards science: A review of the literature and its implications". *International journal of science education* 25, no. 9 (2003): pp. 1049-1079.
[2] Vogel, Tobias, and Michaela Wanke. *Attitudes and attitude change*. Psychology Press, 2016.
[3] Koballa Jr, Thomas R., and Shawn M. Glynn. "Attitudinal and motivational

constructs in science learning”. In *Handbook of research on science education*, pp. 89-116. Routledge, 2013.
[4] Barmby, Patrick, Per M. Kind, and Karen Jones. “Examining changing attitudes in secondary school science”. *International journal of science education* 30, no. 8 (2008): pp. 1075-1093.
[5] Kim, Minkee, and Jinwoong Song. “The effects of dichotomous attitudes toward science on interest and conceptual understanding in physics”. *International Journal of Science Education* 31, no. 17 (2009): pp. 2385-2406.
[6] Nieswandt, Martina. “Attitudes toward science: A review of the field”. In *Beyond Cartesian Dualism*, pp. 41-52. Springer, Dordrecht, 2005.
[7] Osborne, Jonathan, Shirley Simon, and Sue Collins. “Attitudes towards science: A review of the literature and its implications”. *International journal of science education* 25, no. 9 (2003): pp. 1049-1079.
[8] O. E. C. D. “factbook 2013: economic, environmental and social statistics”. *Organization for Economic Cooperation and Development, Paris* (2010).
[9] Salta, Katerina, and Chryssa Tzougraki. “Attitudes toward chemistry among 11th grade students in high schools in Greece”. *Science Education* 88, no. 4 (2004): pp. 535-547.
[10] Spall, Katie, Stephanie Barrett, Martin Stanisstreet, Dominic Dickson, and Edward Boyes. “Undergraduates’ views about biology and physics”. *Research in Science & Technological Education* 21, no. 2 (2003): pp. 193-208.
[11] Bennett, Judith. “The development and use of an instrument to assess students’ attitude to the study of chemistry”. *International Journal of Science Education* 23, no. 8 (2001): pp. 833-845.
[12] Krogh, Lars B., and Poul V. Thomsen. “Studying students’ attitudes towards science from a cultural perspective but with a quantitative methodology: border crossing into the physics classroom”. *International Journal of Science Education* 27, no. 3 (2005): pp. 281-302.
[13] Nasr, Ahmad R., and Asghar K. Soltani. “Attitude towards biology and its effects on student’s achievement”. *International Journal of Biology* 3, no. 4 (2011): p. 100.
[14] Onwuegbuzie, Anthony J., and Nancy L. Leech. “Enhancing the interpretation of significant findings: The role of mixed methods research”. *The qualitative report* 9, no. 4 (2004): pp. 770-792.
[15] Bryman, A., and E. Bell. “Business Research Methods (Vol. fourth)”. *Glasgow: Bell & Bain Ltd* (2015).
[16] Doymus, Kemal, Ataman Karacop, and Umit Simsek. “Effects of jigsaw and animation techniques on students’ understanding of concepts and subjects in electrochemistry”. *Educational technology research and development* 58, no. 6 (2010): pp. 671-691.
[17] Ballantine, Joan, and Patricia McCourt Larres. “Cooperative learning: a pedagogy to improve students’ generic skills?” *Education+ Training* 49, no. 2 (2007): pp. 126-137.
[18] Holliday, Dwight C. “The Development of Jigsaw IV in a Secondary Social Studies Classroom”. (2000).
[19] Aydin, Süleyman. “Effect of cooperative learning and traditional methods on students’ achievements and identifications of laboratory equipment’s in science-technology laboratory course”. *Educational Research and Reviews* 6, no. 9 (2011): p. 636.
[20] Tuan, Hsiao-Lin, Chi-Chin Chin, Chi-Chung Tsai, and Su-Fey Cheng.

"Investigating the effectiveness of inquiry instruction on the motivation of different learning styles students". *International Journal of Science and Mathematics Education* 3, no. 4 (2005): pp. 541-566.

[21] Eilks, Ingo. "Experiences and reflections about teaching atomic structure in a jigsaw classroom in lower secondary school chemistry lessons". *Journal of Chemical Education* 82, no. 2 (2005): p. 313.

Appendix 1

	Item	**Statement**
Practical work in Biology	Item 1	I need to carry out practical work in order to understand biology module.
	Item 2	I feel anxious when I am doing biology practical work because I have to work with other members.
	Item 3	Doing biology practical work is a waste of time
	Item 4	What I learn from biology practical work is useless in daily life
Importance of Biology	Item 1	Knowledge of biology is necessary to understand other subjects and phenomena.
	Item 2	Understanding biology makes our life easier.
	Item 3	Biology is helpful in solving the problems of everyday life.
Self-concept in Biology	Item 1	Knowledge of biology changes my opinions about how the natural world works.
	Item 2	In biology class, I feel anxious.
	Item 3	I feel more relaxed in a biology class than in any other class.
	Item 4	I learn biology quickly and easily.

Environmental Education for Climate Change: From Historical and Experimental Natural Science to Modern Interdisciplinary Didactics

Marina Minoli[1]
National Biologists Order – Royal Society of Biology, UK – Scientific High School Marconi, Italy[1]

Abstract

Integrated elements of natural science history were useful to construct didactic interconnections with modern scientific researches about effects of climate change in biological equilibrium and plants homeostasis condition. Principal goal of this didactic itinerary for High school was to realize historical and interdisciplinary activities presenting also some effects of different environmental factors in model organisms. Actually, young students are often informed in fragmented way about environmental problems, without impact with historical and experimental studies. In this project were planned and realized critical thinking analysis about Natural equilibrium concept: from James Hutton' studies to Gaia hypothesis of James Lovelock, precursor of modern bio geoscience with ideas of systems studies of Earth. In "historical researches students working group" were realized presentations about biography and about Von Humboldt exploration' trips. High school students have read different historical original scientists' documents working in collaborative way, analysing interdisciplinary aspects of climate changes, comparing old and new idea, modern discoveries. All rielaborated activities were presented in Learning Digital platform about different topics of bioscience elements for environment. The collaboration with plants' physiologist has permitted to amplify didactic itinerary and to understand some effects of different environmental stress conditions (variations of temperature and high salt concentration) in metabolism of plant model organism Arabidopsis thaliana (levels and activities of vegetable hormones and second messenger calcium concentration). Molecular and interactive bioimaging of experimental effects have showed in High school classes, dynamics fluorescent microscopy images to observe and to educate interpretation how different stimuli modificate calcium concentrations in some structures of Arabidopsis thaliana. All strategies were useful to realize innovative didactics with interdisciplinary approaches to open also a modern element of Environmental Humanities in a dialogue between human and social disciplines.

Keywords: Environmental science; learning innovative strategies, interdisciplinary learning, History of Natural science, Molecular imaging, Arabidopsis thaliana, Natural equilibrium concept

1. Introduction

In Secondary High School the environmental topics are often realized with little space in curricular didactics, especially for time limits and narrow disciplinaries settings. There is probability that students could be informed in partial and superficial way, without impact with idea and environmental experimental approaches of scientists. The mass media currently disseminate a lot of news about issue of climate change, in several case not related to scientific researches in progress or to evolution of innovative studies based on integration of knowledge.

The goal of this didactic project was realized in High School classes at different levels innovative itineraries to educate overcoming culture of image about environmental issues in which young people are often subjected. Innovative didactics research activities to avoid interpretative superficiality educating with critical thinking's also creating collaborations with international scientific community.

Students of different High School classes are divided in two large thematic groups: *historical environmental group* and *modern environmental researches group* with student-coordinator in each group. Into two group students have chosen between different topics to realize with teacher' guide, rielaborated researches and communicative works analysing some scientific documents: from parts of text in "Theory of Earth" published by scientist James Hutton in which he combined the need to establish a balance between what happen today and what happened in the past at different levels in inorganic and organic organization on the Earth, to nine points of "*International declaration of the Memory of Earth*" (UNESO 1991), to Gaia hypothesis of James Lovelock and elements of Von Humboldt' book *Kosmos*.

2. Methods

Innovative strategies of the itinerary were the interconnection between ancient and modern idea about integrated vision of Nature in a systemic relationship between organic and inorganic compounds. From human history with analysis of important elements James Hutton' biography, Alexander Von Humboldt', James Lovelock' to understand evolution of environmental science, also realizing with *strategy of role game* in which some students of different historical group have chosen to interpretation one scientist: J. Lovelock, J. Hutton' or A. Von Humboldt. Each group has written communication parts for presentation some elements about biographies and important idea of different scientist into school community with *debate strategies* and *confutation* of different proposals.

In "*modern environmental research group*" students have realized different phases of some researches: in first phase analysing "*ecologic footprint concept*" using also www.footprintnetwork.org useful to obtained information about classification of International countries, in second phase realizing researches about cellular stress condition effects in plants and animals to understand some different factors of climate change in homeostasis organism equilibrium. To answer the question how to evaluate the impact of climate change on plants teacher-researchers have involved a vegetal physiologist expertise in realizing interesting presentation using model organism *Arabidospis thaliana*, in particular to evaluate effects of stress in ionic calcium concentration in different parts of plant or levels of some vegetal hormones important for plant' grow. There are in fact principal signalling molecular in stress plants conditions: abscisic acid, ethylene, ion calcium. Climate change determines biological stress in plants with biochemical, physiological, genetics consequences (modification in genes expression and modification in cellular metabolism); students are very interesting to participate in active way at modern experimental approaches realized using model organism to observe environmental signals in plant' transduced into responses by second messenger ionic calcium. It is possible to realize in scientific laboratories different experiments to follow in real time dynamics in vivo plant organism to analyse responses to different stimuli with Molecular bioimaging (High light, high temperature, pathogen salts stress, osmotic stress). Presentation of different experimental approaches have realized with a lot of interactive biological images and video in which was possible to observe in vivo the evolution phases of experiments with Arabidopsis thaliana. The fixing molecular bioimaging observations were reanalysed during second phase of didactic itinerary by students writing interpretative and comparative reports for each image. All activities about Arabidopsis thaliana were inserted by students in *Learning Digital Platform* and in *interactive scientific poster*, both presented into *school community* sharing innovative knowledge with students of others classes.

3. Results

Different integrated learning and IBSE strategies were realized in environmental project: from historical didactics research approaches to modern experimental impacts, from biography' *individual game* to cooperative group activities in which all students have specific role (coordinator group, articles translate specialist, informatics specialist for interactive poster, editor specialist for elaboration communication of different activities and researches, also control written texts). From individual with specific skills for different works to communication social activities for community, different activities realizing sharing all work's products in Environmental Innovative *Interactive Collection Platform* was useful for terminal evaluation of project by biology teachers. At the end of project were presented into community a report of different activities and all students of classes involved in these didactics itineraries have answered some questions about all aspects of projects, historical and experimental important elements with also possibility to explain rielaborated idea about future impacts on society of elements knowledge on environmental science to promote interest in local community.

4. Conclusion

Interdisciplinary approaches associated also with elements of modern *Environmental Humanities,* Environmental Ethics, were useful to create a dialogue about different research methods, contamination between human and social disciplines, helping students to work with motivation, analysing results of experiments, sharing in *creative working* different results of activities. Others didactic IBSE actions were realized also with elements about results of European project *EPITREE* (epigenetics researches in vegetal plasticity relationship water disponibility for plants). Researches related *Epigenetics science* in *plants plasticity* of the phenotype in short, medium and long time with methylation of epigenome. Didactic historical analysis about evolution of principal idea about environment and equilibrium concept in Nature, biographies didactics researches with *debate methodology, interdisciplinary learning* in High School classes and modern scientific communication activities sede realized also sharing into school community results of environmental project.

Innovative teaching and integrated learning approaches about topics of climate evolution in which natural science historical analysing has important didactic role were creating in IBSE methodology with positive didactics impact for all Scientific High school community. Modern didactics itinerary has created interconnections with International scientific community involving scientist with innovative researches about effects of climate change using model organism, integrated activities useful to promote cognitive and soft skills for conscious students about some modern complex aspects of *environmental science*.

REFERENCES

[1] Follows M., “Ten things that affect our climate”, Science in School, Heidelberg, EMBL, 21/6/2019.
[2] Von Humboldt A., “Kosmos”, Oxford University Press, London, 1998.
[3] Latini G. *et al*., “Lexico and Clouds: Words for climate change”, Turin University, 10/2019.
[4] Costel E. S. “Didactic options for the Environmental Education”, Social and Behavioural Sciences, 180, pp. 130-1385, 2015.
[5] Minoli M., “Apprendimenti ragionati delle scienze ambientali per i cambiamenti climatici”, New Secondary School magazine, Studium Editor, Rome, in Press 2020
[6] Thor K., “Calcium-Nutrient and Messenger”, Front Plant Science, UK, 25/4/2019.

Flipped Inclusion: An Anthropocentric Ergonomic Model

Felice Corona[1], Annalisa Ianniello[2], Tonia De Giuseppe[3]
University of Salerno, Italy[1,2,3]

Abstract

The experimental research of the Flipped Inclusion model, conducted by the University of Salerno, following the conceptual paradigm ergonomic anthropocentric, declines the concept of inclusion in a micro-meso-and macro systemic perspective, using cyclical modular paths of cooperative interdependence focusing on flipped and non-linear teaching actions aimed at solving the cultural tendencies connected to disoriented post-modern society. Starting from the needs and the involvement of the person, the Flipped Inclusion translates the international standard ISO through the immersion and framing of problematic conceptual issues, the development and implementation of solutions, following the four sequential-transformative design phases of the Flipped Inclusion (Exploring-Conceiving -Designing-Testing). The aim is to provide critical interpretation tools capable of promoting inclusive prosocial profiles, ergonomically redesigning the operating procedures and inclusive socio-relational contexts, in the optics of the promotion of anthropocentric co-constructed processes.

Keywords: learning, inclusion, ergonomics, anthropocentrism

1. Introduction

The drying up of the concept of human community [1], as shared transcendence and intersubjective communion, typical of the mobile and disoriented post-modern society [2], is configured as the reflection of postmodern metaphysical individualism. The anthropology of the atomized individual [3], enveloped in logical aporias, operates in the principle of total and divine self-sufficiency.

The uncritical adherence to pre-established dogmas translates into the inability to refute widespread symbolizations and to produce divergent universes, to the point of inhibiting new transformative solutions and producing acquiescent forms of discernment. [4]

The interhuman bond, which is embodied communicativeness, risks both depleting the dialogical value of a foundational alterity, and of inducing prejudicially nihilistic sense productions [5].

The unveiling of the axiological value of the person, individual substance of a relational nature [6], allows us to glimpse the epicentre of a neo-anthropology of the community, which heals and reconfigures the cultural presuppositions of global capitalism, starting from the dialogic re-humanization between universes values [7].

It unfolds, in this sense, the trajectory of humanist anthropocentrism, tendentially ethical, so-called noble [8], which promotes an effective renewal “aimed at reconfiguring pedagogical knowledge and educational practices” [9], in the context of a design ergonomic-inclusive existential.

2. The Flipped Inclusion Model and Educational Research

The experimental descriptive-transformative research [10] of the Flipped Inclusion model carried out at the University of Salerno, in line with the ergonomic-anthropocentric conceptual paradigm, aims at the de-construction and re-construction of the person, the principle and outcome of each pedagogical reflection [9], in view of a generative and re-generative pro-social transformation of the quality of human relationships, of the connective tissue of the community.

With an anthropocentric ergonomic approach, Flipped Inclusion, as an exploratory study, design and experimentation of complex adaptive systems, aims at the trans-formative efficiency that is determined through the implementation of technological systems, applied in a prosocial perspective [11]. The model tested proposes a dynamic, circular, generative and maieutic work organization of relational communion, with computational logics [12]. One of the aims is to promote prosociality, investing in social nature and in media-educational peer-communication, through the promotion of an anthropomedial empowerment, which transcends individualisms [13].

The ergonomic-educational interventions of flipped inclusion presuppose the involvement of people in the planning and control of their own activities. With the aim of achieving the set objectives [14], each intervention develops in a systemic perspective, in that "*knowledge of a work system is inextricably linked to the study of the interactions between the parts that constitute it*" [11].

Retracing what the International Organization for Standardization [15] reiterated regarding the principles of ergonomics as basic guidelines for the design of work systems, flipped inclusion follows a cooperative approach throughout the process of exploration, conception, design and experimentation. It also invests in the didactic transposition [16] of the theory of operant conditioning and of Goffman's Frame analysis [17] through the identification of stimulation anchors of the selective processes, declined in steps of: 1) Key, 2) Frame, 3) Framing, 4) Framework [18]. In this sense, the educational value of simplexity teaching [18], rooted in levels of learning for decomposed problems [19], is reaffirmed. In flipped inclusion the work process, structurally ordered and organized in a deconstructivism perspective [20], follows a procedurally of the interaction, "*considered in its sequence (times and spaces) between man, equipment, materials and information present in a system, carefully thought out to give due importance to the human factor*" [21].

Flipped Inclusion combines the concept of inclusion in a micro-meso-eso-and macro-systemic perspective [16] and the value of the didactic-educational logic of the Flipped Classroom [22].

The Flipped Inclusion model is organized into 4 transformative macro-phases (*Exploring*; *Conceiving*; *Designing*; *Testing*) which follow the six design phases of the ISO [15] (Formulation of goals-requirement analysis; Design concept; Detailed design; Realization, implementation and Validation-Analysis and allocation of functions and Evaluation).

1) The ergonomic phase of the Formulation of goals (requirement analysis) corresponds to Exploration phase (problem finding) [20]. Conceptual nodes (Key) are collected, interpreted and problematized, which reflect "misunderstood experiences, recessive feelings, new and unexpected thoughts, typical of the" private space of the self [23].

In making use of the intrinsic motivational momentum, deriving from the process of active involvement, Flipped Inclusion positively predisposes to learning, with a view to an authentic anthropocentric enhancement of resources, potential and differences. The ergonomic pedagogical-inductive methodology used in this phase is Inquiry Learning [24], a process “based on the investigation of problems, critical group discussion and the search for new solutions in a constructivist perspective” [25]. By stimulating the acquisition of knowledge through investigation, participatory action and the formulation of questions in a phenomenological perspective, the trajectory of a disseminated and embodied community of pluralities unfolds.

2) The Idea phase of Flipped Inclusion, follows the Design concept of the ISO norm [15] and is based on the conceptual circumscription of the macro-problematic areas previously identified and inspected [16]. This is the phase of the problem setting and analysis, in which “the key word becomes a concept, with sequential chaining and reinforcements” [10]. Through the ergonomic Discovery Learning methodology, the student discovers the conceptual relationships of a given domain of knowledge, “enhances the retention of information by virtue of its autonomous organization and transformation” [26].

3) The Detailed design of the International Organization for Standardization [15] is reiterated in the Design phase of Flipped Inclusion “which represents the set of the key word which has become the concept (Frame), to which is added the challenge problem on to which the resolving research is intended (Framing)” [2]. By specifying the interrelationships of the meanings investigated, the aim is to plan the actions necessary for the creative resolution of the problems analysed (problem solving and creative thinking). In order to pursue inclusive equity, in the perspective of enhance the potential of contemporary anthrophos, ergonomic-anthropocentric mastery learning is adopted [27], through an individualized and diversified preparatory path of objectives ordered by increasing complexity.

4) The Realization, implementation and validation ISO [15] is present in the decision taking phase of the Experiment of Flipped Inclusion (step that allows the shared, re-defined and progressive resolution of explored, circumscribed and problematized conceptual nodes (Framework).

Using the methodology of Experimental Learning, the systematic reflection of the lived experience unfolds in a recursive cyclicity, in which knowledge is configured as the product of a previous experience of which it is the result [28]. In a continuous transaction of anthropocentric cognitive, ethical and emotional insights, the acquired experience becomes cognitive heritage, in a dynamic process of identifying the purpose with the objective, no longer originated by a simple instinct, for the personal lived experience.

The ergonomic-anthropocentric phases of the Analysis and allocation of functions and of the ISO Evaluation [15], in the perspective of the Flipped Inclusion model, are configured as transversal to the process phases. To structure and consolidate the interactive circuit of co-responsible human actions, related to the development of community moral action, Flipped Inclusion invests in a democratic management of knowledge, centered on the role rotation system, with a view to taking forms, unpublished faculties and possibilities. In order to manage the complexity of the intervening variables in progress and to rebalance the processes through systematic and non-extemporaneous feedback, Flipped Inclusion makes a constant evaluation and self-evaluation check in the pre (monitoring) – post (processing) carrying out of the micro-meso-eso and contextualized macro designs inclusive, with ergonomic evaluation form organized according to standard evaluation rubrics by role, objective (communicative/cognitive and cognitive/social and prosocial skills and knowledge/competences) and phases [16] with ergonomic standard evaluation rubrics organized by role, objective (communicative/cognitive skills and knowledge/competences and cognitive/social and prosocial goals) and phases [16].

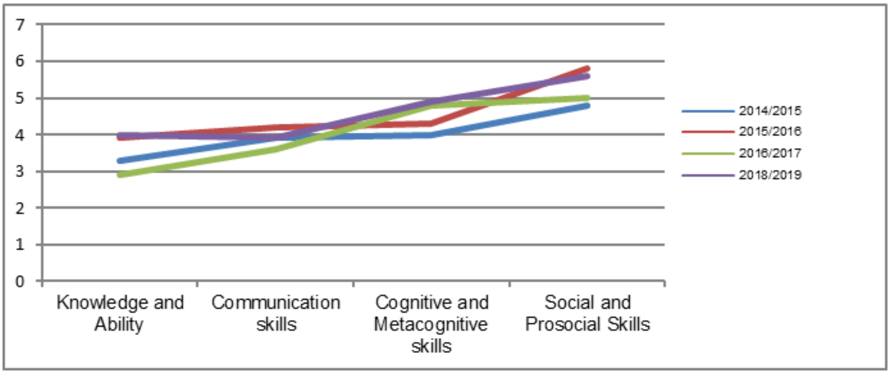


Fig. 1. *Research trend 2014/2019*

3. Conclusion

The significant prevalence of a positive trend of the data collected on 2260 learners in the 2014/2019 research years, the result of the tabulation of qualitative and quantitative analyses organized with a view to promoting ergonomically co-constructed anthropocentric processes, through an evaluation and self-assessment, of the knowledge and skills, of communicative, cognitive and metacognitive, social and prosocial skills.

The processes activated in research on the flipped inclusion model, in tracing the postmodern logic in an anthropological-paradigmatic key, confirm the importance of an inclusive transformative didactic action. In fact, Flipped Inclusion, focusing on proactive anthrophos, as the protagonist of the co-built training event, aims at an educational re-construction. The flipped inclusion therefore promotes a capitalization of the communities, as places of reality with increased spaces and times, in which being is completed in con-being in the making. Investment in the person, as an ontological synthesis of the ergonomic project in the hermeneutics of being, is the key element that must be educated to experiment with systemic inclusiveness, in a joint, exclusive, fusional and inclusive union.

REFERENCES

[1] Mancini, R. "L'uomo e la comunità", Biella, Edizioni Qiqajon, 2004.
[2] De Giuseppe, T. "Flipped inclusion. L'impianto teoretico tra bisogni emergenti e prospettive epistemologiche", Roma, Aracne, 2018.
[3] Lévinas E. La traccia dell'altro, Napoli, Pironti, 1979.
[4] Lévy, P. "L'intelligenza collettiva. Per un'antropologia del cyberspazio", Milano, Feltrinelli,1996.
[5] Budka, P., Kremser, M. "CyberAnthropology-Anthropology of CyberCulture", in Contemporary issues in socio-cultural anthropology: Perspectives and research activities, Vienna, Loecker, 2004, pp. 213-226.

[6] Boezio, De duabus naturae, in J. P. Migne (ed.) Patrologiae Cursus Completus. Parigi, Series Latina, 1847.
[7] Kozinets, R. V. “Communal Big Bangs and the Ever-Expanding Netnographic Universe”, Thexis, 2005, 3, pp. 38-41.
[8] Andreozzi, M. “Etiche dell’ambiente. Voci e prospettive”, Milano, LED Edizioni Universitarie, 2012, p. 38.
[9] Ferrante, A. “Pedagogia e orizzonte post-umanista”, Milano, LED Edizioni Universitarie, p. 73.
[10] Corona, F., De Giuseppe, T. “La didattica flipped for inclusion”, Bari, Progedit, 2017, pp. 133-136.
[11] Frasca,P. “Ergonomia e lavoro: evoluzione di un’idea rivoluzionaria dei nostri tempi”, 2006, p. 4 http://www.tecnostress.it/wp-content/uploads/2010/02/ERGONOMIA-E-LAVORO.pdf
[12] Bronfenbrenner, U. “Ecologia dello sviluppo umano”, Bologna, Il Mulino, 2002.
[13] Engell, L., Hartmann, F., Voss, C. “Körper des Denkens. Neue Positionen der Medienphilosophie”, Fink, Munchen, 2005.
[14] Corlett, E., Wilson, N., John, R. “Evaluation of human work: a practical ergonomics methodology”, USA, CRC Press,1995.
[15] International Organization for Standardization “ISO 6385 – Ergonomics principles in the design of work systems”, Bruxelles, CEN, 2016.
[16] Corona, F., De Giuseppe, T. “La Flipped inclusion, tra impianto teoretico e didattica sperimentale di aula aumentata per una didattica inclusiva”, Trento, Centro Studi Erickson, 2017.
[17] Goffman, E. “Frame Analysis”, Roma, Armando,1974.
[18] Sibilio, M. “La didattica semplessa”, Napoli, Liguori, 2014.
[19] Berthoz, A. “La semplessità”, Torino, Codice, 2011.
[20] Derridà, J. “De la grammatologie”, Paris, Éditions de Minuit, 1967.
[21] Cenni, P. “Applicare l’ergonomia”, Milano, FrancoAngeli, 2003, p. 30.
[22] Bergmann, J., Sams, A. “Flip YOUR Classroom Reach Every Student in Every Class Every Day”, USA, International Society for Technology in Education, 2012.
[23] Khan, M.M.R. “Lo spazio privato del sé”, Torino, Bollati Boringhieri, 1992.
[24] Kuhn, T.S. “La struttura delle rivoluzioni scientifiche”, Torino, Einaudi, 1962.
[25] Linn, M. C., Davis, E. A. & Bell P. “*Internet environments for science education*”, NJ, Lawrence Erlbaum Associates, pp. 29-46.
[26] Bruner, J. “The Process of Education”, Harvard, University Press, 1961, p. 130.
[27] Bloom, B. S. “Stability and change in human characteristics”, New York, John Wiley & Sons,1964.
[28] Kolb, D. A. “Experiential Learning”, NJ, Prentice Hall, 1984.

Identification of Risk Factors and Drugs Abuse Phenomenon in Adolescents Aiming at Designing Health Education Strategies

Ledis E. Burgos[1], Martha E. Montoya[2]
Universidad de Córdoba, Colombia[1,2]

Abstract

Many unhealthy behaviours often begin in adolescence, this represents significant challenges to public health issues (Jaik, Reheana, Ahmed, Finkestein, & Zufilgar, 2016); These unhealthy behaviours such as smoking, drinking and using illicit drugs are closely related to morbidity and mortality (Martinez, 2012). In Colombia, adolescent drug consumption abuse has increased lately, hence the need for designing and implementing educational strategies to prevent and reduce drug consumption, as well as the associated risk factors. The objective of this study is to identify the risk factors associated with drug consumption abuse in adolescents from Casalud Foundation in the municipality of Monteria, the only institution authorized to attend restitution and rights protection processes in adolescents. This study is a cross-sectional retrospective descriptive research with a mixed method approach for the methodology. The results corresponded to the statistical analysis done at 135 clinical histories of treated adolescents in 2018. It was evidenced that the most prominent risk factors were those related to the person, the family, and school and friend's context. These factors identification becomes essential for addressing the interventions. According to the gathered results and the particular case, actions should be focused on families as the first protective factor, on the person by encouraging them in the decision-making process and their lifelong learning skills and on the recognition of adolescents as subjects of rights. In Conclusion, these results were in agreement with Losada (2017) who after evaluating and knowing the educational needs and prevention actions of a group, considered necessary to understand and tackle the drug phenomenon from the health education perspective into two contexts, one directed to general population, and the other to specific cases of people at high risk of falling into drug abuse, or already being drug abuser, in order to prevent them from continuing doing so.

Keywords; Risk factors, health education, drugs, adolescents

Introduction

In Colombia, drug use has increased, not only because people consume them, but also because the substance market is increasingly wide and diverse. Approximately three million people have used illicit drugs at some time in this country [1]. Drug use disorders are constituted as a serious public health problem in Colombia, which is especially affecting adolescents [2].

From a biological point of view, the consumption of psychoactive substances in childhood and adolescence decisively affect brain development and maturation. The consequences of the consumption of these substances is reflected in the behaviour and in many vital activities such as: the processing of emotions, the consolidation of memory and learning, decision making, coordination of muscle movements and the balance sense [3]. The early use of drugs not only promotes its continuous consumption and incremental use of other hallucinogenic substances, but is also associated with numerous adverse social consequences, including poor academic performance, dropout, criminal behaviour, violence, aggression and other risk behaviours for human health and society in general [4].

Therefore, it is necessary to design and implement prevention strategies which aim to reduce drug consumption, as well as the risk factors associated with it [5]. Risk factors can be defined as an individual characteristic, situational condition or environmental context that increases the probability of drug use or abuse (initiation) or a transition in the level of involvement of the drug (maintenance). It is relevant when developing a prevention program based on an appropriate theoretical model and know the specific risk factors of the community in which the program will be applied [6].

Based on the above, this study seeks to identify risk factors in drug abuse in adolescents with the aim of designing health education strategies based on theories and explanatory models in the prevention of drug dependence such as social learning and Bandura's social cognitive theory and the problem behaviour of Jessor and Jessor.

Methodology

The present research is descriptive cross-sectional retrospective with mixed approach. The statistical analysis was developed in the Excel Program using 135 medical records of adolescents who entered a process of restoration of rights associated with drug use at the Casalud Foundation in the city of Monteria, Colombia in 2018. In addition, research was used retrospective documentary. The risk factors for the abuse of psychoactive substances proposed by Petterson (1992), which constitute four domains related to the context, family, school, individuals and friends, were taken as reference. These factors allowed to explore the relationship of this specific population with drug abuse by providing empirical elements that facilitate the design of coherent health education strategies that are adjusted to the realities of adolescents.

Results and Discussion

Table 1 shows the percentage frequency of family risk factors associated with drug use in the population studied.

Table 1. *Family Risk factors associated with the use of Psychoactive Substances*

	Absolute frequency	% Relative frequency
• Family background		
Psychoactive Substances Consumption	19	14%
Abandonment	41	30%
Deprived of liberty	3	2%
None	72	53%
Family Type		
Extensive	23	17%
Recomposed	49	36%
Single parent (Mother)	30	22%

Single parent (Father)	3	2%
Extensive extended	8	6%
Full nuclear	21	16%
None	1	1%
• Family relationships		
Good	20	15%
Medium good	50	37%
Conflict	50	37%
Distant	13	10%
Null	1	1%
No information	1	1%

Source: Clinical records, 2018

The previous table shows family relations that are fairly good (37%) and conflictive (37%) are evident; a type of family recomposed (36%) and history of abandonment (30%). These percentages agree with Cedro who says that the family is supportive or overwhelmed for the beginning of consumption, as well as Madu and Matla; Caballero *et al*., and Madruga [7]; which state that family conflict, whether between the father and the couple or the father and the offspring, is related to the use of substances in adolescents.

Continuing, in table 2, the individual risk factors are assessed.

Table 2. *Individual risk factors/peers associated with drug use*

	Absolute frequency	% Relative frequency
• Reason for admission		
Behaviour problems	85	63%
Domestic violence	13	10%
street life	16	12%
Home escape	8	6%
• Gender		
M	117	87%
F	18	13%
• Substance		
Marijuana	106	79%
Bazuco	12	9%
Inhalants	17	13%
• Poly-consumer		
SI	94	70%
NO	41	30%
• Age		
9	1	1%
10	4	4%
11	5	7%
12	17	20%
13	21	36%
14	43	67%
15	18	81%
16	21	96%
17	5	100%

Source: Clinical records, 2018

The results place the risk factor behavioural problems (63%) as the first reason associated with consumption, in accordance with Namicela who related consumption with acts of violation of norms [7]; In addition, there is an increase in consumption between the ages of 13 and 14, associated with the male gender (87%). Finally, marijuana (79%) was evidenced as the main substance of consumption, as Rioux explains [8] "the early use of cannabis would also be associated with crime".

Table 3, allows to recognize the level of risk of consumption in the adolescent population.

Table 3. *Drug detection test*

Dast-10	Absolute frequency	Absolute Accumulated Frequency	Cumulative relative frequency
I	1	1	1%
II	6	7	5%
III	124	131	97%
IV	4	135	100%
Total	135		

Source: Clinical records, 2018

Showing that 97% of adolescents who entered are at risk III which means a high risk of consumption.

Complemented the analysis table 4 allows to show those risk factors of the context.

Table 4. *Context risk factors associated with drug use*

	Absolute frequency	% Relative frequency
Socioeconomic		
1	104	77%
2	28	21%
3	2	1%
4	1	1%
17	5	100%

Source: Clinical records, 2018

Obtaining (77%) of adolescents belonging to socioeconomic stratum 1, (28%) to socioeconomic stratum 2 and those remaining at 3 and 4.

Finally, table 5 relates to the type of schooling of adolescent consumers.

Table 5. *School risk factors associated with drug use*

	Absolute frequency	% Relative frequency
Scholarship		
primary school	32	24%
high school	102	76%
None	1	0%

Source: Clinical records, 2018

Observing that (24%) is in primary school and secondary schooling (76%), showing a direct relationship between educational level and consumption Cruz, Gómez and Rincón [9].

In health education it is necessary to make a diagnosis based on the factors that act on the community or group to intervene, selecting the most effective methods under a methodological design according to their needs [11]. That is why it is necessary to prioritize risk factors, identifying how adolescents can learn new behaviours and unlearn or weaken those that are already in them, strengthening self-efficacy, acquisition and maintenance for the change in the adolescent's future behaviour without forgetting the social part in which he lives and develops.

That is, to prevent and intervene in drug addiction, it is necessary to integrate to the groups that intervene in the field and to keep a greater control over the determinants with the aid of an instrument: The education for health [12].

The design of health education programs in adolescents with drug use actions should be framed in strengthening healthy lifestyles. Based on the results of this research, it is proposed as a health education strategy, a comprehensive prevention model that simultaneously intervenes with the individual, his family and the community where he develops.

REFERENCES

[1] "Reporte de Drogas de Colombia", Ministerio de Justicia y del Derecho, Observatorio de Drogas de Colombia (ODC). Bogotá: Legis.

[2] Ferrel, F. L. "El consumo de Sustancias Psicoactivas como indicador de deterioro de la Salud Mental en Jóvenes Escolarizados", Pyschología: Avances de la Disciplina, 10 (2), 2016, pp. 43-54.

[3] "Lineamientos de prevención del consumo de Alcohol y Sustancias Psicoactivas", Ministerios de Salud y Protección Social, Bogotá, 2018.

[4] Kenneth W Griffin, S. R. "Patterns of adolescent tobacco and alcohol use as predictors of ilicit and preception drug abuse", 2019.

[5] Peñafiel, E. "Factores de Riesgo y Protección en el consumo de Sustancias en Adolescentes", 32, pp. 147-173, 2009.

[6] Ahumada-Cortez, J. G., Gámez-Medina, M. E., & Valdez-Montero, C. "El consumo de alcohol como problema de salud pública", *Ra Ximhai*, *13*(2), pp. 13-24, 2017

[7] Judith S. Brook, K. P. (2015). Risk and Protective Factors for Substance Use and Abuse. (Springer-Verlag, Ed.) Textbook of Addiction Treatment: 2279 International Perspectives, (s.f.)

[8] Namicela Maldonado, J. L. (2016). Conductas delictivas y su relación con el consumo de sustancias psicoactivas en los adolescentes internos del Centro de Adolescentes Infractores, varones de Loja (Bachelor's thesis).

[9] Knight, L. "Consumo de marihuana: percepción de riesgo en adolescentes", 2018

[10] Cruz-Ramírez, V., Gómez-Restrepo, C., & Rincón, C. J. "Salud mental y consumo de sustancias psicoactivas en adolescentes colombianos", Health & Addictions/Salud y Drogas, 18(1), 2018.

[11] Dueñas Becerra, J., "Educación para la salud: Bases Psicopedagógicas", Rev. Cubana Educ. Med. Sup, 1999 13(1) pp. 92-8.

[12] Diaz Fernández, R y Sierra, María., "Análisis teórico de sobre prevención de drogodependencias en el marco de la educación para la salud: Factores de Riesgo y Protección", Acciones e Investigaciones sociales, 2008 26 pp. 161-187.

Implementing CLIL Technology in the Educational Process of Engineering University

Irina Galitsyna[1]
Ryazan State Radio Engineering University named after V.F. Utkin, Russian Federation[1]

Abstract

The paper describes the development and application of main strategies of CLIL technology in Ryazan state radio engineering university in the process of close collaboration of teachers working at the department of Foreign Languages with the teachers from the faculty of Computer Engineering and the faculty of Electronics. Current trends of globalization and internationalization lead to search new technologies of more successful learning, CLIL being one of them. The article describes the basic strategies of CLIL implementation into the environment of engineering institutions, the factors favouring successful subject acquisition by means of foreign language are considered. The main objectives of CLIL technology being applied in higher engineering education are to give future specialists a competitive edge, increase their self-confidence on a global level and facilitate their entering international professional community. The article also considers the main principles of CLIL implementation into academic environment.

Keywords: Content and language integrated learning (CLIL); consistent learning; professional competency; communication; language acquisition

1. Introduction

Modern society nowadays features several increasingly important trends in the sphere of education such as the trends for integration, internationalisation and globalisation. In case of Russian Federation, the State program “Development of Education” defines its first and main aim as the development of such qualitative education that is characterised by global competitive ability of Russian students to participate in international research and scientific projects, be ready to defend and discuss the results of their research and of their practical activity in international conferences; actively communicate with the colleagues from global community.

To implement this, aim a student should have substantial knowledge in the field of his professional interests as well as the ability to express everything he wants by means of some other language, in our case, English one. Russian higher educational institutions provide different programs and introduce wide variety of disciplines to learn foreign language (FL). In the article we would like to discuss methods and ways to study FL that we apply in the academic process of Ryazan state engineering university.

Our practical experience shows that in majority of cases FL as a university discipline is often separated from other professional disciplines being taught at the university. Huge attention is given to grammar rules and training grammar structures without real texts and real situations, paying only little attention to professional side of students. But when we look at English for Professional studies discipline, we can easily realize that FL here should be a kind of medium, not the aim in itself, to facilitate students understanding of professional disciplines. FL should be a means of cooperation between language learning and content learning. The best way to achieve this cooperation, in our opinion, is to use CLIL approach.

The article provides main teaching methods used in the process of education, considers the principles of CLIL elaborated by the author and applied in engineering university.

2. Principles and Methods of CLIL in Higher Education

CLIL being the acronym for Content and language Integrated Learning has quite a number of interpretations, the most known is the definition of Coyle, Hood and Marsh considering CLIL as a dual-focused educational approach where an additional language is used for learning and teaching of both content and language [1]. Thus, it can be viewed as a specific method of FL teaching and learning. Simultaneously, this technology is seen not only as a method in itself but a kind of instruction that unites content and language. CLIL nowadays makes use of a complex of methods and strategies that promote creative thinking, critical learning, increase motivation of students to acquire new fields of their professional studies, strengthen their professional competences.

Here the main emphasis is laid on deep professional learning by means of foreign language, supporting the idea of bilingual learning. The expectations based on the didactic character of this technology are twofold: on the one hand, learning based on CLIL technology gives the students greater competitive edge by developing cognitive flexibility and cross-cultural competences; on the other – it develops student’s skills of effective communication in everyday and academic contexts by means of their second language opening larger opportunities for employment and career building. It’s also worth mentioning that CLIL helps to achieve practically all so-called 21 century skills, viz. collaboration, communication, critical thinking and creativity.

Firstly, used in the practice of primary and secondary school teaching CLIL has shown high efficiency to integrate pupils in the social environment of a new country, consequently, leading to the idea of introducing CLIL into the process of academic learning.

The majority of researchers [1], [2], [3] basically point out two approaches to CLIL implementation in the process of academic studies the first being called content-driven approach where professional disciplines are given the main emphasis. The second approach called language-driven approach makes use of a FL first which serves as a background for acquiring professional skills. In our opinion, the second approach is more applicable in the process of academic learning in current conditions of higher educational institutions and is being applied in the academic practice of Ryazan state radio engineering university. Here it’s worth mentioning that these approaches are quite arbitrary and are often intercepted or used together.

CLIL technology has been implemented in our university for practically 10 years allowing us to receive results and make certain conclusions. Here we implement CLIL technology for master and post-graduate courses on “Computer engineering” and “Electronics” faculties. Main directions involved in collaborate program are “Computing machines, complexes, systems and nets”, “Computer-aided design”, “Programming engineering”, “Electronics and nanoelectronics”. Language – driven approach is considered the most suitable here as the teachers of FL and professional disciplines have limited hours dedicated to their disciplines. In the first year of study at master courses the students have the discipline “Foreign language for professional studies”, where the academic program is developed by the teachers of FL together with the teacher of professional disciplines. By the moment the students enter master educational courses the majority of them have their English as B1-B2 level which is enough to start teaching them applying CLIL technology. More than that, they have higher motivation to study their professional disciplines by means of FL as they already realize future career opportunities in labor market and their higher competitiveness in international conferences and discussions. The teachers of professional disciplines involved in this technology have decent knowledge of FL and show their desire to make use of multiple foreign information resources for master students.

The course of learning is organized according to the main principles [4], [5], viz. 4Cs working as the basis for the technology.

1. Content. This principle is considered to be the fundamental one while implementing CLIL technology in the process of learning. There is no language without professional content, and, on the contrary, there is no content without language acquisition. Content here is the basis for using language skills, it allows the teachers establish diverse connections between the disciplines and take account of specific language learning methods used while teaching professional disciplines. Class in FL in our case complements and enriches the knowledge received by students in their professional disciplines. It opens new possibilities to use this knowledge in the process of reading and watching vast amount of information given in FL.

2. Communication. By communication we mainly mean here learning new information in professional sphere by means of foreign language. FL here is understood as the means of communication and connection, only the medium to get new knowledge but not the final aim of study. The aim of “Foreign language for professional studies” discipline in CLIL technology is not to learn FL itself but to learn more professional information using the language other than native. Students working with content (it may be texts for reading, documentaries for discussion) given in FL can immediately use their new knowledge in their practice thus advancing their skills both in professional discipline and second language. In this case we speak primarily about fluency as it is far more important than grammar accuracy as making errors is natural while learning both professional subjects and language. Communication skills both in native and foreign languages strengthen students’ confidence and again, increase their motivation to participate in international events and discussions.

3. Cognition. Here we understand cognition as the ability to think, speculate over a certain idea equally confident both in mother tongue and in FL. Students being young people are eager to perceive the world around them using all means they have at their disposal. In this respect the second language opens new prospects for them in the process of learning. Mastering a FL is important as it allows them to find and grasp authentic information they may need. It is generally assumed that it is the close connection of language with thought that leads to effective learning.

4. Cultural interaction. English language nowadays has already become a kind of “lingua franca” for scientists. When we speak about engineering education it becomes clear that English here is a universal language uniting professional together and allowing them to gain higher results using collaborate skills and knowledge. Students in this respect have great opportunity to learn and understand the origins of this language and its culture and get interested in its cultural peculiarities or different view on the same things.

In the course of learning both professional disciplines and foreign language according to CLIL technology we used the methods of active learning that stimulate independent search of the problem, finding the solution to the problem stated as well as decision-making made by students. These include various presentations, creating posters for further discussion, class games and simulations, different case-studies, individual projects, working in collaborative learning groups, etc. These methods surely provide deeper understanding of a certain discipline by means of FL acquisition.

3. Conclusion

As a conclusion we should note that CLIL technology is quite prospective and effective way of integrated learning professional disciplines together with foreign language. Language acquisition becomes more conscious as it is applied in different spheres of future professional activity. In the course of study all learners have the opportunity to use vast diversity of language professional resources that leads to better student orientation in foreign language environment. Aforementioned theses allow us to make the conclusion about the efficiency of implementing CLIL technology in the academic process of engineering university.

REFERENCES

[1] Coyle D., Hood. P, Marsh D. Content and language integrated learning. Cambridge, UK: Cambridge University Press. 2010, p. 84.

[2] Darn S. Content and Language Integrated Learning. 2006. https://www.researchgate.net/publication/234652746_Content_and_Language_Integrated_Learning_CLIL_A_European_Overview>https://www.researchgate.net/publication/234652746_Content_and_Language_Integrated_Learning_CLIL_A_European_Overview.

[3] Fortranet-Gomez I. CLIL in Higher Education. Towards a Multilingual Language Policy. Bristol, UK: Multilingual Matters. 2013, p. 304.

[4] Coyle D. Future challenges and ways forward for CLIL characterization, implementation, and training. Content and Language Integrated Learning in Monolingual Settings. editor/María Luisa Pérez Cañado. Madrid: Springer-Verlag Berlin, 2018.

[5] Wilkinson R., Zegers V. Realizing Content and Language Integration in Higher Education. Maastricht, Netherlands: Maastricht University Language Centre. 2008, p. 241.

Necessity and Proposal of Fourth Developmental Stage Education of the Montessori Method in Japanese Science University

Miyori Shirasuna[1], Yamagishi Masaki[2]
Toyohashi University of Technology, Japan[1,2]

Abstract

"YUTORU Education" was taught at elementary and junior high schools in Japan from 2002 to 2010. It was an experience-oriented educational policy for Japanese students to train spontaneous thinking skills, modifying the "Knowledge-packed education" that had been conducted since the 1970s. Educational institutions in Japan have reduced the learning time and content of elementary and junior high schools, aiming at the growth of both study and spirit in children, and students have received an "education that fosters the ability to live". The last generation educated throughout the course of compulsory education is now 24 years old – 2nd-year master's students, on their way to becoming a working people with a positive attitude towards studying in college. However, today's students tend to be very vulnerable to mental pressure especially for boy students in science majors. Because they received affirmation from others in their desire for education, they were also sensitive to denial, strong in self-revelation, and anxious about the need for authentication in the real world, and the inconsistency between their age and mental independence Their moratorium is often long because they can't get away. We believe that metacognition and one-on-one dialogue with science high school and university students and teachers are useful as support in their life choices in study and research. The Montessori method considers that the fourth stage of development, is not important, that is, education at the 18-24 stage of development. We think that it is stage to recognize, and that developmental support at this stage is important. It is time to reconsider this stage in the field of education in Japan, which will continue for the next 10 years until the generation who received the last "YUTORU Education" in 2012 is a member of society.

Keywords: science university education, Montessori method, moratorium, self-development, certification desire

1. Introduction

For about 10 years, since 2002, the Ministry of Education of Japan revised the conventional cramming education and introduced "YUTORI Education: Cram-Free Education" [1]. The purpose of this education is to provide students with the "fostering the ability to live" and increase the time for acquiring "thinking skills", and introduced the class system, which was open from Monday to Saturday, was changed from Monday to Friday. and general subjects other than major subjects. The generation who attended elementary through junior high school, which is the compulsory education period in Japan, in this "YUTORI Education" are now in the second year of a master's program or working. Although they have a strong desire a self-assertive and desire for recognition, they tend to step into society without being able to integrate themselves. These tendencies are particularly strong for science students, and it is difficult to adapt to society and business due to the decrease in basic skills due to the drastic reduction of class time in Japanese language, arithmetic and mathematics, and the spread of the Internet and SNS. This education mimics that of Western countries. Especially the third stage of the “Montessori Method” [2] is similar to “Active Learning”. Unlike many other teaching methods that do not discuss education for people 18 or older, the Montessori Method is rare in that it defines a fourth stage, from 18 to 24 years, but does not require education at this stage [3]. However, we believe that support in the fourth stage of education as the final stage of development is important in the educational progress of Japanese aged 15 to 24 years, especially in science study.

2. YUTORI Education

The YUTORI Education generation were born in 1996-2003, and as of 2019, those aged 16 to 23 are eligible. After World War II, education in Japan was greatly reformed, and the YUTORI Education system was tried and improved on several times. In Japan, what was introduced in 2002 is generally called the “YUTORI Generation” [4]. This education system aimed at cultivating “fostering the ability to live” and increased the time to acquire “thinking ability” compared to the past crammed education in Japan, a two-day weekly system (from Monday to Friday), and general subjects other than major subjects [5]. Due to the two-day work week system, class hours were greatly reduced, with language, arithmetic and mathematics affected the most. For example, the number of KANJI learned, which is unique to Japanese culture, was reduced, and in arithmetic, the method of finding the trapezoidal area was reduced and the pi was simplified to 3 [6], [7]. And this caused various problems for students.

3. YUTORI Education

As an advantage of YUTORI Education, the increased number of vacations allows students to work on lessons tailored to their individual interests. The purpose of the introduction, and at the time of the introduction, bullying and school refusal were temporarily reduced, and the number of people who took care of others increased. And so on. These are in line with the intentions of the Japanese Ministry of Education.

However, fostering the ability to live and finding and solving issues independently were not linked. The school denied comparisons with other students to maintain student self-esteem and introduced both absolute and teachers’ subjective assessments in communication, so that students have developed a dual standard thinking tendency between reality and ideal. The leader among the students has disappeared.

The tendency of students to go to cram school has increased due to the decrease in academic ability due to the reduction of classes with essential content. Along with that, the tendency to go to private classrooms has increased. In addition, Students spent less time teaching and teaching with their closest adult parents [7], [8]. There were also many problems with academic ability. For example, teachers were struggling with the contents of the “general subject” and could not achieve the stated goal of “acquiring their thinking skills”. In addition, because the number of Japanese language classes was reduced. As a result, because students did not develop the ability to think in mother’s language, they could not do basic thinking in other subjects [4].

4. Science Students in the YUTORI Generation

In YUTORI Education, in arithmetic and mathematics, which are the basis of science subjects, the unit of the trapezoid area calculation method was omitted, and pi=3 was given. The method of calculating the area of a trapezoid is indispensable for introducing thinking that is the basis of graphic problems, and it lack has caused problems such as the inability of science university students to calculate the area of trapezoids and sectors.

Further, these students did not understand the process of substituting integers with the assumption that pi is an infinite rational number. For these reasons, as a result, there are many students who do not understand the essence of things and have completed compulsory education without basically learning to think about things [10] [11].

However, contrary to the idea that the science thinking of the YUTORI Generation is not nurtured, enrolment rate in science is increasing. The influence of the Japanese government's promotion of science and the media is also conceivable, but it seems to be somewhat different from the reason why students before the YUTORI Generation became interested in the nature of science subjects [12].

5. YUTORI Education and Montessori Method

No example of YUTORI Education by the Japanese government is given, and we can imagine that it was modelled on the teaching methods of Western countries, we think that the teaching method has a strong similarity to the Montessori Method. First, the stage of child's development was to follow the Japanese education system, and in "YUTORI Education", Japanese government aimed to acquire "investigative power" and "thinking power". A place to "search and explore" was needed. In this regard, YUTORI Education is similar to Montessori Method. In Japan, Montessori Method is often used in early childhood education because it does not match school education, but the third stage as an educational method is closest to "Active Learning" recommended by the Ministry of Education, Culture, Sports, Science and Technology in recent years [13].

6. Necessity for Support Education in the Fourth Stage of Development

It will take 10 years for the last generation of YUTORI Educated students to graduate.

Currently, the second year of working adults or two master's course students have received YUTORI Education in all compulsory education courses. We treat full-YUTORI Generations and those around them as educators, and recognize the need for fourth-stage educational support through dialogue with them.

Montessori describes the urge that adolescents have to evaluate themselves from the outside. She uses the term "valorisation". She believed that what the children in the third stage were working on was the building of the adult self in society. She wrote very little about the fourth stage of development, the age of 18-24. She envisioned "the young adult" who had been through Montessori Method up to the third stage, as ready to fully embrace cultural and scientific research [4]. She argued that there was no need to arbitrarily limit the number of years in university-level research, as cultural research could continue throughout a person's life.

However, in the Japanese YUTORI Generation, students move up to the fourth stage without the education to the third stage she advocated. Not having the Montessori Method, students did not establish the "sense of justice and personal dignity" that we desire in the young adults, but the "sense of justice and personal dignity" of this period became instead so-called "adult situation" and "repression from adults". Students would become “irritated” and might erupt in a claim for justice or as a reaction to adults, and further lead to “confidence without backing or reason”. In other words, the mental aging peculiar to the YUTORI Generation is a prolonged third stage, and a slow and long decline.

7. The Need for Support Education in the Fourth Stage of Development: Especially for Science Students

Moratoriums like Chapter 6 are particularly common in Japan for colleges of technology and colleges of science. Japan has a low science girls’ population among developed countries [14]. This tendency is even stronger in environments with a high proportion of men, as men tend to communicate only conclusions to others when compared to girls.

In addition, the third stage is consistent with the terms of junior high and high school education in Japan, but “KOSEN: colleges of technology” are 15 to 20 years old and do not match the educational development stage. KOSEN is a Japanese-specific science education institution that provides students with specialized education in engineering, technology, and merchant shipping, and aims to train practical engineers [15]. At KOSEN, students spend five years in an “isolated” environment, as they spend time in only boys and like-minded people. They have less chance to exchange opinions with those with different opinions and thoughts, so they acquire biased thinking. We think that students should be educated in the fourth stage at KOSEN. Many KOUSEN students go on to science universities, and science college students from coeducational high schools have the same syndrome as those from colleges of technology. In this paper, we will call this the “The Science Boy’s Syndrome”.

The Science Boy’s Syndrome is in line with the popular YUTORI Education term of the Internet and SNS of the YUTORI Generation. Their compulsory education time was spent in the “unreal world” on the net, not as learning or experience in the “real world”.

Therefore, their communication methods are different from those before the YUTORI Generation. For example, there is a sense of familiarity and a sense of understanding in communication on SNS, and communication in smartphones is a reality, and the real world is an unreal world. Montessori did not develop the fourth stage in detail, because most children are growing up before they enter the society at the age of 18, and they grow up to the stage of learning instead of being given. We think that it is. In other words, we should be such places and facilities. However, when students who were underdeveloped in the third stage or had the Science Boy’s Syndrome entered the fourth stage, they often worry that they don’t know what to do or stop growing. They cannot find their purpose and themselves in college. As teachers of higher education in science, we think it is necessary to support boy students with The Science Boy’s Syndrome.

8. Conclusion

Support Education in the Fourth Stage of Development and The Science Student Boy’s Syndrome of The YUTORI Generation: Dialogue

We propose “dialogue” as appropriate support for the syndrome of boy science students of the YUTORI Generation. Although mass education for people age 18-24 is difficult, it can be implemented through “discussion” in group work at colleges and universities, seminars in laboratories, and individual research guidance. We also think that “dialogue” is useful as an appropriate support method for the YUTORI Generation who is The Science Boy’s Syndrome.

As mentioned in Chapter 6, the students are not cutting themselves off and have a desire to communicate with others because they seek communication in the unreal world. Furthermore, in the unreal world, such as SNS, they have strong desire for authentication and self-disclosure.

Their target is “dialogue with adults other than family members in the real world”, and support for developing from “YUTORI Generation science student syndrome” to Montessori the young adult is needed. We believe it is effective, and think we should practice it positively and measure the response. We realize that by making rapport between teachers and students based on their personal wisdom, they will be able to accept the real world. It will be 10 years until the YUTORI Generation graduates from educational institutions, including universities, but the establishment of a holistic self-image through dialogue with adults other than family members in the real world and our educators, can lead to “a sense of justice and a sense of personal dignity”. We hope to cultivate this sense of self-esteem through dialogue and continued support for a fourth stage of education for students suffering from the science student syndrome of the YUTORI Generation.

REFERENCES

[1] The Ministry of Education of Japan, “Curriculum revision – Revision of the curriculum of elementary and junior high schools in 1975”, https://www.mext.go.jp/b_menu/hakusho/html/others/detail/1318313.htm, Reference day 20/01/2020, (In Japanese).

[2] American Montessori Society, “Why-Choose-Montessori”, https://amshq.org/Families/Why-Choose-Montessori, Reference day 20/01/2020, (In Japanese).

[3] Montessori, Maria, “From Childhood to Adolescence”, 1994, Oxford, England: ABC-Clio.

[4] Msahiro Kaminaga, “Achievement is an illusion”, MORIKITA, 2008, pp.3, pp. 46-53.

[5] The Ministry of Education of Japan, “History of the five-day school week”, https://www.mext.go.jp/a_menu/shougai/week/index_b.htm, Reference day 20/01/2020, (In Japanese).

[6] Noriaki Nakano, “My Thoughts Concerning Education in Japan Today”, The Japanese journal of primary education, 2016, No.17, pp. 172-177, (In Japanese).

[7] Syukan-Shincho, “Tell students that pi is “3.14”, SHINCHO, 2001, No. 46, Vol. 16, (In Japanese).

[8] Kei Tamura, “Educational Choice and Endogenous Economic Growth: Problems with YUTORI Education and the Effectiveness of Educational Policies”, 2013, Japan Economic Policy Association, No. 10, Vol. 2, pp. 3-15, (In Japanese).

[9] Hiroshi Toda, “Review of “YUTORI Education” and the ideal way of study”, Legislation and investigation, 2009, No. 295, pp. 65-74, (In Japanese).

[10] Nihon Keizai Shimbun, “Pi=3.14 and trapezoidal formula are again added to the educational guidelines in elementary school textbooks”, 30/03/2010.

[11] Asahi Shimbun, “What is education to improve academic ability?”, 08/07/2007, (In Japanese).

[12] Mainichi Newspaper Science Environment Department, “RIKEI HAKUSYO: People who support this country quietly”, 2003, KODANSYA, p. 94.

[13] Masaki Moriyama, “Development of tactile methods for the learning of some concepts related to humanity and society”, 2019, Well-being Lab, No. 2, Vol. 1,

pp. 7-23.
[14] Isa Natsumi and Ayumu Chinen, “Gender differences in academic ability and motivation in science subjects”, 2014, Japan Labor Studies Magazine, pp. 84-93, (In Japanese).
[15] KOSEN National Institute of Technology, https://www.kosen-k.go.jp/english/, Reference day 20/01/2020.

Primary School Mathematics: Can Holistic Methods Be Combined with the Traditional Method?

Lara Albanese[1]
Associazione Culturale Googol Parma, Italy[1]

Abstract

Although in many cases mathematics is considered a rigid discipline, in reality there are many ways to achieve the same result and for this reason teaching mathematics can be implemented through various approaches to assist individual child predispositions, two of these methods worth mentioning are Steinerian and Montessorian methods. Field research shows that children benefit greatly from the use of Montessorian materials for mathematics as well as from Steiner's rhythms which prove that integration with the traditional method not only increases the skills and knowledge of children but also their appreciation for maths and sciences in general, for both main stream children and children with specific needs. Even some artistic representations harmoniously display some examples of mathematical problems: such as Escher's painting of the tiles at the Alhambra, Gaudi's magic squares and Munari's machines. A key role is played by outdoor activities. Learning immersed in nature, feeling emotions, cooperating with others if desired facilitates the learning process. Today, thanks to modern technologies and neuroscience research, we are able to identify the most suitable learning mechanisms for each child and make mathematics truly accessible to everyone. This process can only take place with the knowledge of the different methods and learning systems (teacher training) as well as through the knowledge of mathematics itself. In addition to the research results, various didactic materials and methodological examples will be shown during the presentation

Keywords: Montessori materials, Steiner Waldorf schools, analogical method, outdoor education, mathematics in nature

In most cases, the school proposes an abstract method for mathematics, sometimes making use of practical examples, which are almost always represented graphically and only rarely proven in practice. The main reference for learning mathematics is therefore the textbook and learning take place with thought and never with the hands and with the heart. Our experience (which brings us in contact with children between six and ten years for more than five hundred hours every year) has led us to believe that an emotional and practical approach improve the learning of science, mathematics and geometry and allows include every child. Even a multicultural (ethnomathematics) approach can in many can help a good relationship with mathematics, geometry and scientific subjects in general.

More than a hundred years ago Maria Montessori proposed a new approach, in which each topic was presented and acquired through the use of materials and the setting up of spaces suitable for learning. Today in Italy this method is sometimes adopted also by public schools, but unfortunately it is not widespread. Many years passed before

Montessori’s materials [1] were accepted into “normal” schools. Among this are, for example, the base ten blocks.

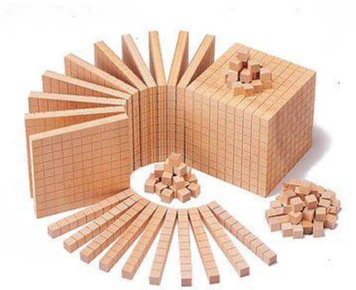


Fig. 1. *Montessori base ten blocks*

However, the approach used at school commonly remains an abstract approach interspersed with rare practical activities, always suggested by the teacher and never chosen by the child. In this sense, one of the main characteristics of mathematics and geometry is forgotten: the extraordinary possibility of achieving the same result through extremely different paths. For example, there are over three hundred different ways to prove Pythagoras’ well-known theorem. [4]

Today, the possibility of training, exchange, and creation of teaching materials have increased extremely thanks to globalization. With appropriate teacher training, it is possible to encourage the use of multiple methods and allow teachers to offer children a variety of ways to approach mathematics.

In this way, each child has the opportunity to choose the most congenial method for him. For years, the Googol association, in collaboration with the University of Parma and numerous other public and private organizations, has been providing training and updating courses for teachers and educational proposals for boys and girls. The analysis of the results obtained undoubtedly leads to highlighting the effectiveness of a method that allows children to choose between different approaches. The only obstacles to this path are the cost of materials (a printed book certainly costs less), the commitment required of teachers in the training phase, sometimes the low scientific and mathematical knowledge of primary school teachers. The use of different methods and the abandonment of the textbook as the only reference in fact require teachers to have a thorough knowledge of the subject. However, these weak points are easily overcome. In the first place, scientific subjects find more and more space in teacher training courses.

Furthermore, the use of new technologies allows a rather inexpensive realization of educational materials. For example, the use of the 3D printer for the realization of Montessori materials can drastically beat costs.

But what are the methods useful in primary school and how to propose them to classes at the same time? Firstly, it is necessary to adapt the space to the use of these methods. In addition to the textbooks on shelves, it is necessary to have large shelves that can accommodate the materials. It is the responsibility of the teacher to choose the suitable materials for the topic that is being proposed to children in that period. We believe that the outdoor activities should be associated with the activities inside. The outdoor space can be the school garden or a public park not far for city schools, or the countryside itself for schools outside the city.

Already from the first grade, the teacher introduces the first topics with a simple chat, preferably that involves emotions and presents some materials that can be used to achieve some simple objectives. Children are also informed of the rules and methods to be used to use the materials. Each material is then presented to each child, but each child will be able to use it or not, also because many of them lead to an understanding of the same topic. A multimethod approach requires clarity of the goal for both the teacher and the child. For example, a goal could be to add and subtract objects less than twenty. At this point, each child can turn to any of the proposed methods or even, if he deems it appropriate, to propose new ones.

Here are some examples for making the first numerical operations.

The gnomes of operations. Some gnomes of different colours often used in Steiner schools [3]. These characters allow you to introduce the “character of operations” together. For example, the gnome of the + is a very fat gnome who eats a lot, that of the – loses things on the street and is very thin. These concepts are very important because they add meaning to the mechanism of making accounts. Always in the Steiner-Waldorf schools the rhythms are used to number and learn the first multiplication tables.

Fig. 2. *The gnomes of operations (Steiner Waldorf Schools)*

Montessori materials. There are many Montessori materials useful for introducing numbers and operations [2]. At the basis of all is the idea that the child must touch the numbers in the belief that learning takes place in the first place with his hands. For example, children come into contact with the “Red and Blue Numbers Rods”. The length of the rods varies from one decimetre to one meter. The numeric rods alternate blue and red. The activity consists in putting the rods in order from the longest to the shortest and in associating the number. The transport of the rods carried out not by taking them at random, but by lifting them at the ends. To carry the rod of ten, the first-grade child must open his arms wide. The longer length will be associated with greater effort.

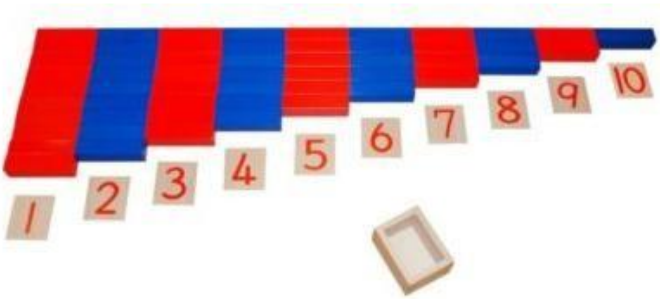


Fig. 3. *Montessori Number Rods*

The line of 20 by Camillo Bortolato. With this method, boys and girls, without much theory, find themselves performing visually and effectively additions and subtractions.

This absolutely concrete method is very congenial to children who do not like abstraction.

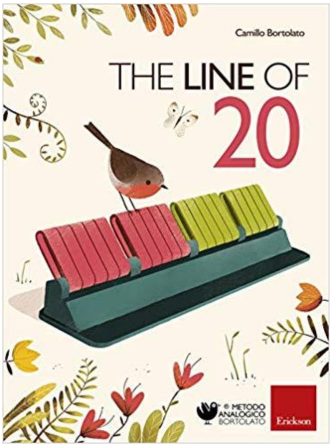


Fig. 4. *The line of 20 by Camillo Bortolato*

Suanpan

Here is a method for doing operations by invoking the calculation with the five fingers.

Still used a lot in Chinese primary schools, we usually offer suanpan, associated with simple cards that offer mathematical operation on one side and the solution on the other.

Children easily learn to carry out operations even with very large numbers, feeling great satisfaction. Similarly, Japanese sorodan can be proposed.

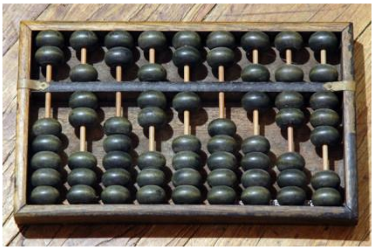


Fig. 5. *The Chinese suanpan*

All these examples lead to the achievement of the same goal through very different activities that involve more or less hands and more or less thought. Depending on their predispositions, the children will choose to use one or the other method, but will perform the same operations that may possibly be written in the notebook.

Similar activities can also be offered in outdoor space.

For example, here is a way to measure with a decimetre of self-made wood. We take a piece of wood and saw it (with a small wooden hacksaw) exactly the length of the decimetre. At each centimetre we tie a nice thread of coloured wool.

Fig. 6. *The wooden decimetre*

Instead of ordering the numerical rods we can instead order the pine cones.

Fig. 7. *Pine cones in ascendant order*

Or do calculations with natural materials.

Fig. 8. *Natural additions*

Nature is a great math book. It is the duty of adults to offer children the opportunity to do math in nature. Even city schools certainly have a nearby park, or an easy-to-reach natural location. And if this were not the case, there is also an environment to be discovered full of cars to count, of three-light traffic lights, of pedestrian crossings that are parallel segments!

In the natural context, mathematics presents itself to children as a necessity, a spontaneous language that we adults have the task of promoting and not erasing. This spontaneous theatre that the natural environment offers to mathematics is in fact sometimes overlooked by teachers. The aversion to mathematics of many adults, including educators, has its roots in this mechanism. Being outdoors is not a reward to be reached for having carried out mathematical problems in the classroom, but it is the exposure necessary for the human brain to face logic-mathematics spontaneously, correctly and pleasantly.

Our research carried out in five years of activity with over 2000 primary school children leads to the conclusion that a multi method approach leads to the achievement of didactic objectives in mathematics of 97% of the class against 80% of an approach based on learning with textbook. It should be noted that we have included in the research also children with cognitive disabilities with individualized study plans modulating, in this case, the objectives.

By limiting the analysis of the achievement of cognitive objectives with children with disabilities, in this case it is highlighted that this approach involves:

1) Achievement of objectives equal to 99% for dyscalculic children
2) achievement of 95% targets for autistic children.
3) Rating for math and geometry in the class group of 100%.

REFERENCES

[1] Montessori, M. “The Montessori Elementary Material”, Andesite Press, 2017, p. 452.

[2] Montessori, M. “Psycho-arithmetic vol. 20b”, Montessori Pierson publishing company

[3] Carlgren, F. “Education Towards Freedom”, Floris Books, 2008, p. 272.

[4] Albanese, L. “Multiple languages of mathematics and children with disabilities” pp. 152-154 in New perspectives in science education, Libreriauniversitaria.it Edizioni, 2014

[5] Albanese, L. “Tutti i numeri del Mondo”, Sinnos, 2013, p. 48.

[6] Albanese, L. “Lo scatolone della matematica, Bambini, Edizioni Junior (4/2009)

[7] Gould, T. “The little book of math outdoors”, Bloomsbury Publishing, 2013.

[8] Robertson, J. “Messy Maths: A playful, outdoor approach for early years”, Independent Thinking Press, 2017, p. 252.

Seismic Evaluation, Prediction and Prevention: A PBL Study in Higher Education

Tânia Pinto[1], António Guerner Dias[2], Clara Vasconcelos[3]
Faculdade de Ciências da Universidade do Porto, Portugal[1,2,3]

Abstract

The purpose of this study was to investigate if Problem-Based Learning (PBL) allows students to improve their questioning skills and knowledge construction, through a scenario about seismic evaluation, prediction and prevention. Despite of its worldwide application and in almost any type of curriculum, there are few studies that integrate PBL in geoscience at higher education. Geology and Environment (GE) deals frequently with problems that reflect Earth's systems uncertainty and unpredictability. This research intended to contribute to a shift in teaching and learning methodologies in higher education, promoting PBL as a methodology capable of having a positive effect on students. The present study involved a total of 33 students, from a GE course, in a Portuguese public faculty, divided in an experimental group (n=16), submitted to a PBL approach, and a comparison group (n=17), taught through the traditional teaching method. An Intervention Program (IP) was developed for the experimental group, along 4 weeks. Using mixed methods, triangulation methodology type, two investigation phases were drawn to collect data. In the qualitative nature study, the students of the experimental group raised questions that were registered in a monitoring sheet, analysed according to a predefined categorization procedure based on question cognitive level achieved. The quasi-experimental study was conducted in order to analyse the knowledge construction about seismic evaluation, prediction and prevention. In this study, a validated prior and post-test problem solving was carried out. The data obtained with the qualitative analyses showed that students were able to formulate questions, mostly high cognitive level ones, like "meaning-oriented" and "relational". The results from the quasi-experimental study showed the two groups were equivalent in terms of knowledge in the beginning of the study. After the IP, in the design "within subjects", there were significant differences, with the experimental group performing a better than the comparison group. No significant differences were found "between subjects". Nevertheless, the educational potential of PBL showed the contribution to the improvement of students' complex abilities and competencies such as questioning and knowledge construction, both relevant in academic training towards 21st century challenges.

Keywords: Problem-Based Learning, Scenarios, Geology and Environment, Higher Education, Questioning

1. Introduction

In Portugal, the reorganizations introduced by the Bologna Process in higher education call for an actual paradigm shift, as this is merely a rudimentary shift [1]. PBL, comprising socio-constructivist roots [2], emerges as a teaching methodology capable of responding to the claims laid down, as this changes the dynamics of the teaching-learning process, where the student takes on a major active role in this process, while stimulating collaborative learning [3], [4]. PBL distances itself from other methodologies, since this results from a combination of unique aspects, where one of its distinguishing features includes the fact that meshing with the problem starts before the so-called formal study, unlike what takes place with a traditional curriculum, which measures the ability to apply knowledge after a given program content is lectured for such purpose [3].

Thus, this study sought to research whether the PBL methodology allows improving students' learning, from the Geology and Environment (GE) curricular unit in higher education, in terms of (i) developing questioning skills and (ii) learning scientific concepts related to seismic evaluation, prediction and prevention. The following specific goals were outlined: (i) to examine the type of student questioning in view of the problem scenario of seismic evaluation, prediction and prevention; (ii) to examine construction of substantive knowledge, by implementing a new teaching methodology (PBL), compared to the traditional methodology of teaching the GE curricular unit.

2. Methodology

Methodological triangulation was chosen, with a non-random selection of participants. Two groups of students were established: an experimental group, to which an Intervention Program (IP) would be applied based on the PBL methodology; and a comparison group, which would be subject to the GE curricular unit's traditional approach.

A research plan was set in two stages. The first called for a qualitative study, to attempt to respond to the research question "How can a problem scenario contribute toward developing questioning skills?", geared to students subjected to IP. At this stage, the content analysis technique was used, in keeping with a closed categorization procedure, according to a published systematization [5]. The study's second stage was of a quantitative (quasi-experimental) nature, seeking to respond to the research question "Does PBL favour students' learning of scientific concepts in the sphere of GE?", by turning to non-parametric statistical tests. In this case, the outlined null research hypothesis (H_0) was, "There is no difference in substantive knowledge development between the students of the experimental group and those of the comparison group" and the alternative hypothesis (H_1) was, "Students of the experimental group subjected to the PBL methodology differ from those of the comparison group in terms of substantive knowledge development".

2.1 Intervention Program

The IP covered 4 sessions of 2 hours each, over a 4-week period, in the theory and practical aspect of the curricular unit GE. In the first session, students were all informed on the goals thereof, as they consented to data collection.

2.2 Sample

The convenience sample comprised 33 students attending the curricular unit GE, at a Portuguese public university. The experimental group comprised 10 males and 6 females, whose average age was 21.6. The comparison group consisted of 9 females and 8 males; whose average age was 19.9. Regarding their academic training year, the experimental group included 7 students (43.8%) in the second year and 9 students (56.3%) in the third year; the comparison group comprised 9 participants (52.9%) in the second year and 8 participants (47.1%) in the third year. These were students in three academic fields: Biology, Geology and Science and Environmental Technology.

2.3 Data Collection Instruments and Procedure

As part of this study, the following data collection instruments were used: (1) a monitoring sheet intended for recording problem questions raised by GE students; (2) knowledge test previously validated by two experts. In the case of the experimental group, it was provided not only with a monitoring sheet, but also with a set of documents (scientific articles or chapter of books) which could be used as a basis for aiding in bibliographical research.

2.3.1 Qualitative Study

The scenario presented was based on the case of the Loma Prieta (U.S.) quake, in 1989. For starters, a short documentary was projected in order to foster curiosity and students' questioning on this topic. Students were then confronted with a problem situation on the monitoring sheet given out, where new earthquake-related variables were integrated in a fictional dialogue between two friends, expanding the extent of the facts to be considered. Next, students were asked, in a group setting, to ask any questions they deemed appropriate toward resolving each problem situation put forth.

Said collection was followed by the start of a closed procedure that involved categorizing the problem questions asked by students, using, as reference, models available in literature.

2.3.2 Quantitative Study

Participants were all given the knowledge test on the first day of GE class and in the last session. In order to conduct the inferential statistical analysis, different non-parametric statistical tests were used: the Mann-Whitney test, to compare two independent groups; and the Wilcoxon test, to compare paired samples (change from pre-test to post-test).

3. Results and Discussion

3.1 Qualitative Study

It was noticed that the number of productive or highly cognitive questions asked by students stood out from questions that were reproductive or showing a low cognitive level. Regarding highly cognitive questions, students asked questions from every subcategory, with greater emphasis on “relational” and “meaning-oriented” questions.

Students' main question points included aspects related to basic concepts of seismology, as well as establishing of relations among factors that can influence the occurrence of an earthquake and its effects on populations and landscapes. Also noteworthy are the questions showing particular interest regarding the possibility of minimizing seismic risks in protecting populations, preventing damage in inhabited areas as well as the possible ability to actually predict this phenomenon of Earth geodynamics.

The results obtained coincide with studies conducted [6], as relevant questions in PBL are of an investigative nature, which should, at least, require understanding [7].

3.2 Quantitative Study

Prior to implementing IP, the initial situation of students in the experimental and comparison groups, with regard to mastery of conceptual contents linked to seismic evaluation, prediction and prevention, was gauges by applying a knowledge test (pre-test), according to an intergroup research design. In relation to results obtained throughout the pre-test, after applying the Mann-Whitney test, no statistically significant differences (U=130.0; p=0.845) were considered to exist between the groups. This result showed that the groups' levels of academic knowledge were similar prior to applying the IP. In the post-test, the application of the Mann-Whitney test once again pointed to non-significant differences between the groups (U=110.0; p=0.363).

Next, an analysis *within subjects* was conducted, by applying the Wilcoxon test, in order to gauge the change in scientific knowledge in the sphere of seismic evaluation, prediction and prevention (Table 1).

Table 1. *Change in intragroup learning (paired samples)*

Group	n	Post-Pre=Dif.	SD	*W*	*p-value*
Experimental	16	8.13	7.80	124.5	.003
Comparison	17	4.53	7.62	122.5	.029

Key: SD – standard deviation; Post-Pre=Dif – final point average (post-test) minus the initial point average (pre-test); W – Wilcoxon test; p-value – significance probability

It is also noticed that the difference in averages between the post- and pre-test (Post-Pre=Dif) is greater in the experimental group relative to the comparison group. That is, it can be considered that the change in learning is more significant in the experimental group than in the comparison group. In view of the results obtained, there is statistical proof that the results are different in the two groups, in terms of students' substantive knowledge development before and after implementing the IP.

4. Conclusions

The study presented herein pointed to several signs that allowed regarding PBL as a methodology capable of fostering highly cognitive questioning while entailing gains in terms of scientific knowledge in the field of GE, compared to a more traditional teaching methodology.

REFERENCES

[1] Lopes, H., & Menezes, I. "Transição para o processo de Bolonha: Significações de docentes e estudantes da Universidade do Porto", Educação, Sociedade e Cultura, 48, 2016, pp. 93-125. Retrieved from http://hdl.handle.net/10216/102349

[2] Vasconcelos, C., & Almeida, A. "Aprendizagem Baseada na Resolução de Problemas no Ensino das Ciências – Propostas de Trabalho para Ciências Naturais, Biologia e Geologia", Porto, Porto Editora, 2012.

[3] Allen, D., & Tanner, K. "Approaches to cell biology teaching: learning content in context – problem-based learning", Cell Biology Education, 2, 2003, pp. 73-81. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC162197/pdf/03-04-0019_p073.pdf

[4] Majoor, G., & Aarts, H. "A role for problem-based learning in higher education in the developing world", In H. Berkel, A. Scherpbier, H. Hillen, & C. Vleuten, Lessons from Problem-Based Learning, Great Britain, Oxford University Press, 2010, pp. 249-257.

[5] Carvalho, C., & Dourado, L. "A formulação de questões a partir de cenários problemáticos: um estudo com alunos de Ciências Naturais do 3º ciclo do Ensino Básico português", In Atas do Congresso Internacional Galego-Português de Psicopedagogia, Braga, Universidade do Minho, 2009, pp. 2615-2628.

[6] Amado, M. “Aprendizagem baseada na resolução de problemas (ABRP) na formação contínua de professores de ciências, Interações, 39, 2015, pp. 708-719.
[7] Palma, C., & Leite, L. “Formulação de questões, educação em ciências e aprendizagem baseada na resolução de problemas: um estudo com alunos portugueses do 8º ano de escolaridade”, In Atas do International Conference PBL 2006 ABP, Lima, Pontíficia Universidad Católica del Perú, 2006.

The Engagement of Schools in Healthcare: An Experience in Piedmont Region (IT)

Sabrina Grigolo[1], Sabrina Massola[2], Michele Grio[3], Lorenzo Mina[4], Pierluigi Giambarresi[2], Sandro Marro[2], Flavio Boraso[5], Leonida Fossati[6]

Project Manager ASLTO3, Italy[1]

Nurse, ASLTO3, Italy[2]

MD, ASLTO3, Italy[3]

Health Assistant, ASLTO3, Italy[4]

GM ASLTO3, Italy[5]

Teacher, IIS Galilei-Ferrari, Turin, Italy[6]

Abstract

National Co-ordinating Centre for Public Engagement (UK) describes the public engagement as “the myriad of ways in which the activity and benefits of higher education and research can be shared with the public. Engagement is by definition a two-way process, involving interaction and listening, with the goal of generating mutual benefit” [1]. In 2018 NICE published a specific pathway to explain the public engagement in the healthcare system. “Ensure local communities, community and voluntary sector organisations and statutory services work together to plan, design, develop, deliver and evaluate health and wellbeing initiatives (see “develop collaborations and partnerships” and “involve people in peer and lay roles” in this pathway). Community engagement encompasses a range of approaches to maximise the involvement of local communities in local initiatives to improve their health and wellbeing and reduce health inequalities [2].

A new activity related to the learning programme has been implemented by ASLTO3, the Public Health Authority based in Collegno (TO, Italy) and IIS Galilei-Ferrari (TO, Italy) in order to strengthen the health perspective in 40 students attending the course in biomedicine.

The programme started with the public resuscitation events for more than 8000 pupils per four days in an ecosystem approach in which a lot of associations, institutions including the military arms, civil protections, etc., have been involved by ASLTO3 under the umbrella term “health protection”. Each student has been assigned to a healthcare worker specialized in the logistic issue, or “welcome procedure”, audio, press, etc.

The main result from the student’s point of view is to be a co-author in the “learning by doing” approach for the pupils.

Keywords: Public Engagement, health education, health promotion, first aid

Introduction

Out-of-hospital cardiac arrests are the catastrophic events of life, and one of the key factors to improve the outcome in these events is to promote the willingness of people to attempt cardiopulmonary resuscitation (CPR) [3].

There are recommendations from the international scientific community, led by the European Resuscitation Council (ERC) and the American Heart Association (AHA), that endorse the training of non-medical staff in the use of automatic external defibrillators (AED) as well as the implementation of these devices in public spaces where crowds of people occur, such as airports, sports centres, schools, public transports, stations and shows [4].

A multicentric descriptive study in which a sample of children from 6 to 16 years of age without previous BLS or AED training was involved, has underlined that public-access defibrillation (PAD) programmes, placement of AEDs in public areas as well as mass media (movies, news, social networks, etc.) have increased the public (including children) knowledge of AED and the awareness of the importance of early defibrillation in case of CA. In order to design effective BLS/AED school-based training programmes aimed at ensuring a large number of present and future first responders in public places where AEDs are deployed, it is necessary to know the children's baseline level of knowledge and skills [5].

Beck S. *et al*., affirm that the students who were trained by peer-instructors showed comparable skills in BLS than the students who were trained by professional instructors.

The performance in the assessment was similar between the two groups: 40.3% (n=471) of the students in the peer-led group and 41.0% (n=466) in the professional-led group passed the examination. The students who were trained by peer-instructors showed comparable skills in BLS than the students who were trained by professional instructors. The sample size was too small to demonstrate the non-inferiority of the peer-led training [6].

No study investigated if students also improve their teaching-skills, when getting involved in teaching BLS to schoolchildren. Early involvement in teaching improves long-term motivation to teach and understand the principles of teaching and learning supports medical students to become more effective communicators and learners [7].

The aim was to evaluate if students improve their teaching-skills and soft skills in an informal setting, when getting involved in teaching BLS to schoolchildren in an engagement approach.

Engagement Approach

The National Co-ordinating Centre for Public Engagement (UK) describes the public engagement as "the myriad of ways in which the activity and benefits of higher education and research can be shared with the public. Engagement is by definition a two-way process, involving interaction and listening, with the goal of generating mutual benefit" [8]. In 2018 NICE published a specific pathway to explain the public engagement in healthcare system. Ensure local communities, community and voluntary sector organisations and statutory services work together to plan, design, develop, deliver and evaluate health and wellbeing initiatives (see 'develop collaborations and partnerships' and 'involve people in peer and lay roles' in this pathway). Community engagement encompasses a range of approaches to maximise the involvement of local communities in local initiatives to improve their health and wellbeing and reduce health inequalities [9].

The inclusion of schoolteachers as a key element of schoolchildren BLS training has been endorsed by international initiatives like Kids Save Lives, which emphasise the teacher role as facilitator and/or trainer due to their pedagogic abilities. Previous studies have reported that teachers have willingness to provide this instruction and it seems that even a very brief BLS training program might be enough to improve their knowledge, skills and self-confidence [10].

Methods

Participants

A volunteer sample of 32 students was recruited for this study attending the IIS Galilei Ferrari. 6 girls and 26 boys aged 16-17.

45 no profit organisation experts of BLSD, first aid, 10 public authority including also the military organisation, 10 wards of Rivoli, Susa and Pinerolo Hospitals of ASLTO3, were engaged to manage the trainings in "a no formal setting".

360 teachers and 8000 pupils from nursery school to college during a "Week of Heart – Reanimation Cardiovascular" committed by European Parliament on 2012 have been involved in this experience.

Training Setting

Each teacher and his/her class have a specific pathway defined on the criteria related to a kind of the pupils, the association and topic. An average of 10 different associations was related to each teacher.

Engagement Method of IIS Galilei Ferrari

A call for action before the events has been realized by ASLTO3 and IIS Galilei Ferrari in order to engage the students in the organisation of public events.

5 groups were defined as the following activities:

- Reception and welcoming,
- Logistic aspects,
- Press and communication,
- Engagement process,
- BLSD Training for the pupils.

Each student took part at the event in the square as support the formal trainers and experts.

Customer Satisfaction and Engagement Assessment

A questionnaire was administered at the end of the experience of the public event in the city square. 4 local authorities were involved by ASLTO3 in the organisation of "Evviva in the square": Avigliana, Orbassano, Collegno and Pianezza for 10000 pupils.

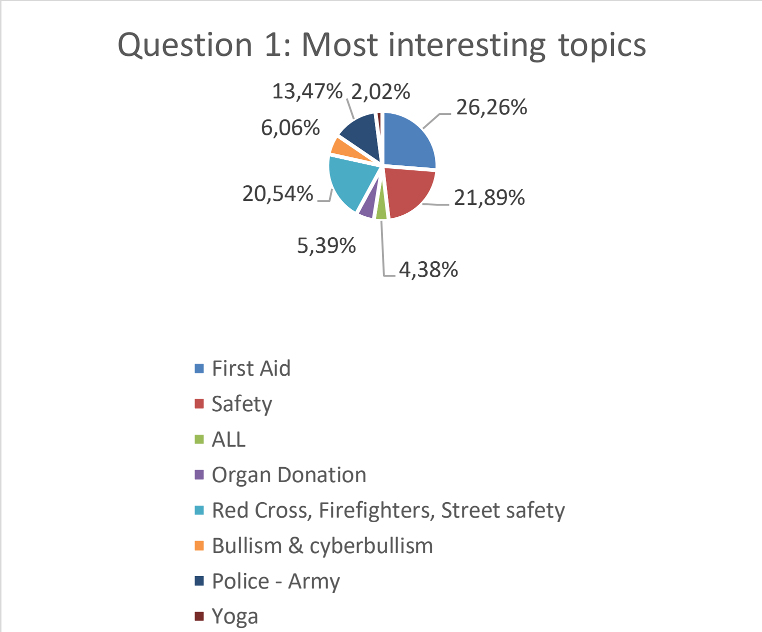
112 questionnaires have been collected by ASLTO3.

Results

Schools are seen as an ideal environment to involve citizens in BLS training. It is not clear; however, which professionals are more suitable for teaching schoolchildren. The evidences confirm that the peer education seems a strategy which is able to mediate the language between the pupils and carers or BLSD lays experts.

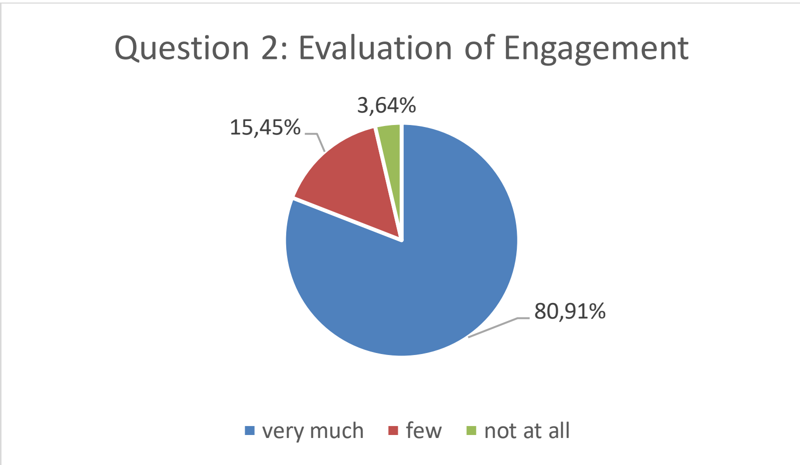
As you see in Table 1, the most important topic was the "first aid" for 26% and 21% the Red Cross Ambulances and their equipment, cyberbullies, and safe drive.

Table 1.



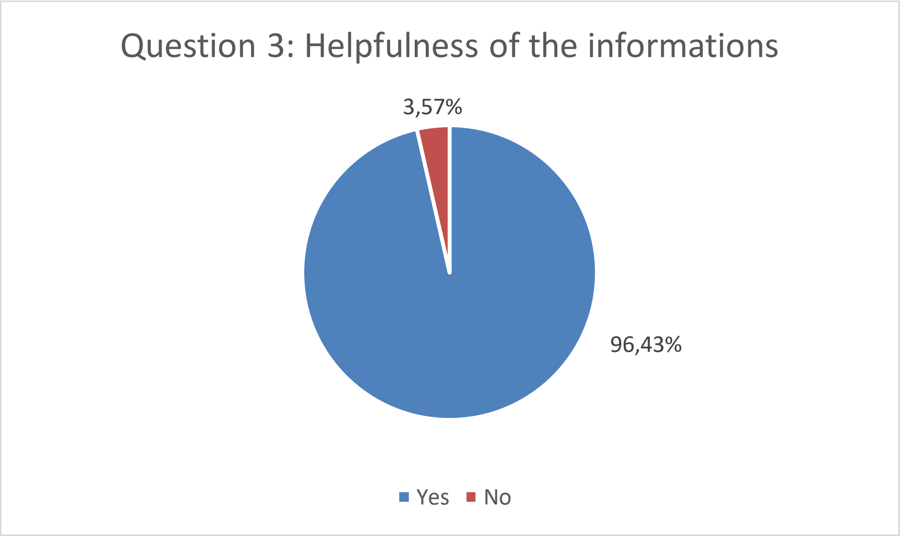
More than 80% of the participants felt engaged by "Evviva ASLTO3" team before and during the event.

Table 2.



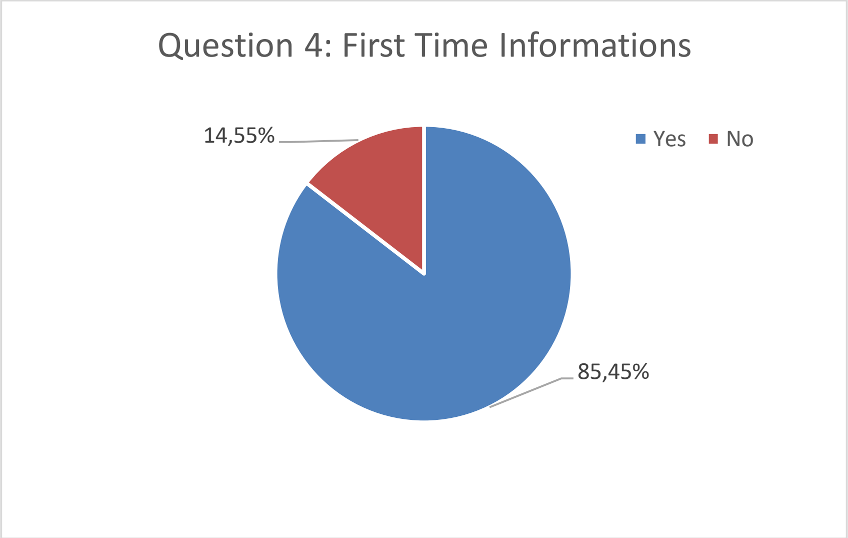
More than 96% of the participants confirm the helpfulness of the information received during the "Evviva ASLTO3" events.

Table 3.



More than 85% of teachers confirm to be better informed on the topics of “Evviva ASLTO3” at the end of the event.

Table 4.



A voluntary survey was organized for the students of IIS Galilei Ferrari, members of no profit organisations and healthcare’s in order to collect comments on Evviva after three months in January 2020.

31 healthcare’s and 21 members of no profit organisations sent their comments.

Conclusions

Brief hands-on training helps to improve knowledge and self-confidence in BLS and CPR skills of future schoolteachers. BLS training should be implemented in the curricula for schoolteachers to promote the engagement of these professionals in effective BLS training of schoolchildren as supported by initiatives such as Kids Save Lives.

Ethics

Participation was voluntary and no personal incentive for engagement was given. The study was approved by the health local public authority and respected the privacy and data protection lay.

Conflicts of interest statement

The authors declare that they have no conflicts of interest related to the present study.

Acknowledgments

We would like to thank all the people (students, parents and educational team) who have participated in our study.

REFERENCES

[1] https://www.publicengagement.ac.uk/about-engagement/
[2] NICE, Community engagement overview, May 2018.
[3] Shinya P., Takeshi Morimoto T., *et al*., Effects of BLS training on factors associated with attitude toward CPR in college students, Resuscitation 80 (2009), pp. 359-364.
[4] Soto J., Abelairas-Gómez C., Barcala-Furelos C., Garrido-Viñas R., *et al*., Automated external defibrillation skills by naive schoolchildren. Resuscitation, September 2016; 106: pp. 37-41.
[5] *Idem*.
[6] Beck S., Issleib M., Daubmann A., *et al*., Peer education for BLS-training in schools? Results of a randomized-controlled, noninferiority trial. Resuscitation (RESUSCITATION), Sep 2015; 94: pp. 85-90.
[7] Beck, Stefanie; Meier-Klages, Vivian; Michaelis, Maria; Sehner, Susanne; Harendza, Sigrid; Zöllner, Christian; Kubitz, Jens Christian Teaching school children basic life support improves teaching and basic life support skills of medical students: A randomised, controlled trial. Resuscitation (RESUSCITATION), Nov 2016; 108: pp. 1-7. (7p)
[8] https://www.publicengagement.ac.uk/about-engagement/
[9] NICE, Community engagement overview, May 2018.
[10] Cristina Jorge-Soto, Maite Abilleira-González, Martin Otero-Agra, Roberto Barcala-Furelos, Cristian Abelairas-Gómez, Łukasz Szarpak, Antonio Rodríguez-Núñez, Schoolteachers as candidates to be basic life support trainers: A simulation trial Cardiology Journal 2019, Vol. 26, No. 5, pp. 536-542.

The Place Attachment and the Involvement of an Education Based on Pro-Ecological Values

Claudia Marian[1], Monica Marian[2], Oana Mare Roșca[3]
Technical University of Cluj Napoca, Romania[1,2,3]

Abstract

The feelings and values that people develop in relation to their birthplace and residence place may be important factors in their involvement in pro-environmental behaviours; this is done if the attachment to the place meets the pragmatic criteria of an ecological functioning. The present study started from an analysis of the value system (air quality, water, landscape, tradition, food, tourism, warmth and hospitality of the locals) based on which is built the attachment of the inhabitants of a Romanian locality (Breb locality) with an ecotourism specific, as well as an analysis of the vulnerabilities perceived by them (placing garbage platforms near the houses, management of the pail resulting from the artisanal manufacture of alcohol, etc.). The results of the study applied to a group of 150 people, indicate a very high level of attachment built on emotional foundations to the detriment of a pragmatic attachment, in which important eco-touristic resources such as water and air quality are not considered priorities by this people. In this sense, the ecological education can intervene with the informational and formative supplementation of the valid ecological criteria, which is addressed to those with the average educational level, who have shown the highest level of attachment to the place.

Keywords: place attachment, water quality, resources

1. Introduction

Environmental education aims to train citizens to respect and conserve the environment, so as to reach internalization the relationship of mutual dependence that exists between individual and the environment in terms of general principle of functioning, but specifically, to internalize the subjective connection that it is established between the man and his very concrete environment of life, the emphasis being placed more and more on the human dimension involved in the management of natural resources.

Many studies on ecological education take into account more complex variables than strictly the informational level of citizens regarding the role of ecological behaviour, the risks and threats that arise, etc. and shift the interest towards more discrete aspects of identity [1], emotional involvement, motivational factors, so that the impact of any formative approach is amplified. In this sense, in the study topics of the last two decades, environmental education makes a frequent association with attachment to the place, a coordinate that combines the cognitive, affective and motivational valences of human functioning. Defined as “positively experienced bonds, sometimes occurring without awareness, that are developed over time from the behavioural, affective, and cognitive ties between individuals and/or groups and their socio-physical environment” (Bonaiuto *et al*., 1999) [2], the attachment to the place turned out to be on the one hand the consequence of some causalities related to the socio-demographic registers (age of the person, period of residence, studies, possession of a home, etc.) social (social connections and connections existing in areas) and by the physical coordinates of the place (nature, resources, landscape, perceived degree of naturalness of a place, etc.) [3]; at the same time attachment to the place is responsible for a number of behaviours, including pro-environmental ones [4].

Gunderson and Watson (2007) [5] identified functional and emotional bases for attachment. Affective or emotional attachment is a socially constructed response that involves a deep tie to place, to the extent that this place becomes important as part of one's identity, moods and emotions are an important component of an individual's personal relationship with a particular place. Included here are: history of personally-significant social interactions associated with a place, such as a tradition of spending family holidays or undertaking particular place-based activities of naturalness, culinary specificity, etc. On the other hand, attachment to a place also includes a certain pragmatism in which material resources matter, how that place is able to satisfy human needs. All components have essential impact on place dependence: an individual or group assessment of the quality of a specific setting to facilitate and support user-specific goals or desired activities.

2. Research

2.1 Study Objectives

The present study was carried out in a village in the north-west of Romania (Breb, Maramures region), whose ecological tourism is specific, which is based on an offer related to the beauty of the landscape, the use of popular culture, traditional food, local crafts, etc. factors that are known to increase the level of attachment to the place and in their turn, are supposed to stimulate the pro-ecological responsibility [6]. Maintaining this local specificity as the source of economic profitability, is possible only with the condition of preserving and promoting a traditional type of agriculture (cultivation of small areas of naturally fertilized land, the simple rotation of crops, animal traction, etc.) that respects the principles of non-pollution, non-invasive practices and measures for the environment, and keeping a balance between the different types of activities carried out locally (agriculture, pasture, tourism, etc.). Due to this local specificity, in the place management plan, here more than elsewhere, an important role in achieving these conditions is the permanent education of the inhabitants, awareness of vulnerabilities and risks for the environment and the acquisition of good ecological practices.

The study aims to evaluate some of the important social variables for an efficient ecological education: a. The level of attachment to the place as a motivational value of the involvement in ecological activities, b. Evaluating the value criteria for an ecological tourism that the inhabitants have, c analysis of their perceptions related to the vulnerabilities and risks existing for the environment and d. how these variables interfere.

As values criteria were taken into account: air quality, water quality, landscape, healthy food, traditions, tourism, warmth and hospitality of the locals, and as vulnerabilities were analysed some of the concrete problems that locals face and which have the risk of diminishing the quality of water and soil with negative impact on ecological tourism: placing garbage platforms near the house, managing the pail resulting from the artisanal manufacture of alcohol, use of pesticides and chemical fertilizers, grazing in a sustainable way.

2.2 Methods of Study

The analysis of the level of attachment to the place was based on a questionnaire with 17 Likert scale items on 7 steps. Nine of these items targeted an emotional attachment that emphasizes: genealogy, historical events, traditions, stories, quality of social relationships, elements of personal identity, community connection, safety, etc. (e.g., “I feel like the Breb is a part from me” or “My family has its roots here”) and the other 8 items referred to a pragmatic/functional dimension of attachment to the place, the type of resources it offers for housing, material realization, etc. (e.g., “Breb offer enough opportunities to stay here” or “I can make material living in Breb”) (items taken and adapted from the questionnaires of Gross and Brown (2006), Klatenborn & Bjerke (2002), Brown & Raymond (2007) [7], [8].

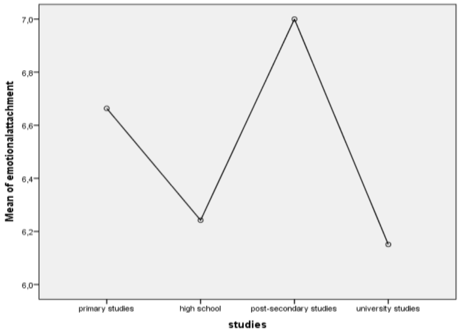
Similarly, on a scale of 1 to 7, the subjects were asked to evaluate how important certain criteria (water, air, etc.) are for the ecotourism in Breb and how necessary are the interventions to remedy certain ecological vulnerabilities in the locality. These quantitative data were supplemented with qualitative information obtained through unstructured interviewing of the inhabitants, mainly on issues related to the concrete ecological problems they face. Data processing was performed using the statistical program spss, variant 17, using indicators such as mean, difference between means, analysis of unifactorial variant (Anova) and correlation index. The group of subjects consisted of 150 people, inhabitants of Breb, having different ages, born or “adopted” by the village, various educational levels, with jobs/not in Breb.

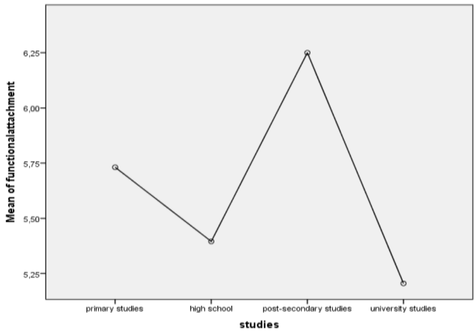
2.3 Results Obtained

The analysis of the general level of attachment to the place is a high one, with an average of 6 points (out of 7) for the analysed lot. A differentiated evaluation on the two categories taken into account shows a statistically significant advance (p=0.000) (the test t=139.45) for the emotional attachment (m=6.45) instead of the functional/pragmatic one (m=5,55). This advance appears very evident in the speech of the locals who openly show their attachment to their own area, they are very proud of it, bringing as an argument that their locality is visited and appreciated by a very large number of tourists, many personalities (evoked in constantly Prince Charles who has a property in the area) many foreign tourists and an increasing trend of demand. A closer analysis reveals that neither type of attachment is statistically significantly influenced by the age of the respondent subjects ($F_{emotional}$=1,997, p=0,070 si $F_{pragmatic}$=0,902, p=0436), but what is obvious is that the highest values were registered for both categories of attachments for the age category between 50-70 years. The gender of the subjects has not statistically significantly influence on the level of pragmatic attachment to the place, women as men manifesting a close level (F=2,784, for a p=0,97); on the other hand, the level of emotional attachment to the place is significantly higher for women. (F=6,719, p=0.010) than for men. Similarly, being born in the locality determines a much higher level of emotional attachment than for those who were not born in Breb (F=7.495, p=0.007) but does not significantly influence the level of pragmatic attachment.

One factor that significantly influences both types of attachment to the place is the pragmatic factor of the workplace; the fact that the inhabitants benefit from a job in the village determines a significant increase of both the emotional attachment (F=16,226, p=0.000) and the functional attachment (F=14,619, p=0.000). This should be included in the creation of a realistic management plan for the area – in order to achieve a greater involvement of the inhabitants, including in the practices of environmental conservation, it becomes important to build local jobs.

The values of the two types of attachment – emotional and pragmatic – have proved to be very sensitive to the influence of the educational level ($F_{emotional}$=4,025, p=0,009; $F_{functional}$=9,0347, p=0,000) Four educational categories were taken into consideration: primary, high school, post-secondary and university studies.





Graphic 1. *Influence of education level on emotional attachment*
Graphic 2. *Influence of education level on functional one*

As can be seen in the graphs above, the categories with the lowest level of attachments are those with high school and university studies; these two categories, of peoples which have a potential yet unconfirmed (opening up unexplored possibilities of high school and university) determine a decrease in the level of attachment for the place in both the emotional and the pragmatic ones; instead, the construction of an educational situation with a focus on a field of work (post-secondary studies) determines an increase of the attachment to this place. To complement this general trend, as a general tendency results from individual discussions, there is a great temptation of young people – high school graduates but also from university to leave the village and to try, at least transiently, an internship abroad, with a declarative desire, to return later to the village.

From the perspective of the educational influence for the pro-ecological values, the actions of information, awareness, training should be addressed with priority to those who have a higher level of attachment to the place but whose level of training is lower.

In scanning the types of values with economic impact that the residents of Breb recognize as being important for their village, from a list presented, some values had a direct ecological role, others not: air quality, water quality, landscape, traditions, healthy food, traditional food, tourism, human quality (warmth and generosity of the locals), their task being to evaluate, on a scale from 1 to 7 how important they are to them. At the principle level, all these criteria were quoted with very high scores, their averages varying between m=6.77 and m=6.95. These values are in a relation of positive and statistically significant correlation ($p<0.01$) with the high level of emotional and pragmatic attachment for all values *except air and water quality*, which do not appear to be among the value criteria that correlate with the level of attachment to the place (neither the pragmatic nor the emotional one). From the perspective of ecological education, it is surprising that a motivational value such as that of attachment to the place does not seem to be influenced by the real ecological variables, those with long-term effects.

At a first observation, we could say that the two types of variables, the ecological and the tourist ones, have a separate dynamic, the results indicating the existence of a conceptual separation between them, and also the fact that in the collective mind the quality of the water and the air are not assimilated the concept of ecotourism. Of course, this can be a working hypothesis that is to be deepened. These results can also be partially explained by the fact that in the process of building an eco-tourism network in the area, the residents benefited from a series of training activities/attestation courses in which the focus was mainly on the tourist values which they have been assimilated by the locals, leaving the ecological criteria that are in fact essential for the type of activity carried out. The educational perspective, and in this case requires further measures to deepen the importance of ecological variables for a quality ecotourism.

The analysis of the influence that the value of the analysed criteria has on the variation of the level of attachment to the place, shows that the increase of the value assigned to a criterion, determines a statistically significant increase of the attachment level for the own area, for the tourist criteria, and not for the ecological ones, as shown table no1. The reciprocal relationship is also valid - increasing the level of attachment to the place stimulates the development of value criteria for tourism, in a circular feed-back relationship.

	air quality	water quality	landscape	traditions	healthy food	traditional food	tourism	hospitality of people
Emotional attachment	F=0,891 p=0,403	F=1,097 P=0,353	F=5,003 p=0,002**	F=1,253 p=0,278	F=5,861 p=0,000**	F=6,964 p=0,000**	F=4,129 p=0,003**	F=6,704 p=0,000**
Pragmatic attachment	F=1,278 p=0,206	F=1,459 p=0,228	F=7,162 p=0,001**	F=4,418 p=0,012**	F=6,376 p=0,000**	F=5,075 p=0,002**	F=6,574 p=0,000**	F=6,144 p=0,000**

*** $p<0.001$*

Table 1. *The influence of the variation of the value of some tourist and ecological criteria on the level of the emotional and functional attachment*

In pragmatic terms, ecological education must set as objective the awareness of the value of air and water quality at a deeper level than the theoretical one, in which to introduce and accentuate their brand dimension, related to identity and which has a tangent with the emotional and functional values of the subjects.

An important objective of the present study is that of the analysis of social cognitions related to ecological variables, mainly of the place and role of water as a fundamental criterion for ecotourism but also of the way in which the knowledge about the water is articulated or is disjointed with the behaviours and attitudes of the inhabitants in front of this problem (there are no reported vulnerabilities related to air quality, in the area there are no sources of pollution that affect its quality).

The context of this study is as follows: the water problem is a very sensitive one for the community, it is the source of many conflicts because the exponential increase of the number of eco-touristic pensions in the area, but also the reduction of the water volume of the groundwater imposed the supplementing of the old water network, with a new one that captures the water upstream; the new network is qualitatively inferior to the old one and it provides water only for a part of the village, so that, in the dry summer periods, the population faces a lack water, or with insufficiently filtered water that cannot be used. In these conditions, many households are tempted to restore water from their own wells that have been abandoned and neglected in recent decades.

Returning to the data obtained in the context of the ecological importance of the water in the area: the results seem to be contradictory to each other: recognizing the quality of the water as an important value on the one hand (average = 6.86 out of 7 points) corroborated with the existence of a real problem, it does not logically articulate with the perception of an average vulnerability when it is considered that "The quality of the water in Breb is one corresponding to a quality ecotourism” (average = 4.71 out of 7 points), or with high quotas of the item “For community development it would be necessary adopting rigorous measures to maintain water quality in the locality” (m=6.33) nor with the low values recorded by the item “No significant changes are needed in the tourism management policy in Breb” (m=3.79) These values are not statistically significantly correlated with the level of attachment to the place, (neither the pragmatic nor the emotional one), the concepts not being included in the same mental scheme.

The request for measures to improve the water quality are statistically significantly influenced by the age category of the respondents (F=2,710, p=0.040), the highest request being given by the age category between 21-50 years and those in the range 61-70 years. The same need is not significantly influenced by having a job in the locality (F=0.525, 0=0.456) nor by the level of education (F=0.345, p=0.793) (factors that influence the level of attachment to the place).

The analysis of the behaviours attached to water quality conservation also indicates contradictions; as sources of water pollution and contamination, the specific field studies mainly incriminate the location of the manure platforms near the houses (very common situation in the area) and the discharge of marc into the rivers (the production of alcohol is also large, almost every household using its fruit production – apples, plums – for this purpose, in volumes that exceed the category of strictly artisan production in traditional alcohol distillation installations. The use of pesticides and fertilizers, the non-intensive grazing, are not reported as major vulnerabilities in ecological studies on the locality.

Despite these results, the perception of the population is contradictory, the results obtained at the items “The garbage platforms near the houses affect the quality of the water and the soil” and “The discharge of marc in the rivers does not significantly affect the quality of the water” register low values in relation to other priorities indicated (m=4.75 for the first item and m=3.63 for the second) and the answers given to the item “Manure storage near water sources is an issue that should be remedied for the development of quality tourism” has an average low (m=3.89) garbage does not seem to be perceived as a water quality problem.

The perception of the seriousness of this problem is sensitive to the influence of the level of education of the population (F=2,841, p=0.040), the people with post-secondary level of education perceive the least problem, while those with the university level realize the most acute. The correctness of the appreciation of this problem also has significant influences on the level of attachment to the place, not only the pragmatic but also the emotional one. To a greater extent, but respecting the same tendencies, the pike is also stronger than the manure of the factors of vulnerability for water quality. All these answers demonstrate an insufficient causal connection of the concepts involved and a poor understanding of the mechanisms of connection between maintaining water quality and the influence of pollution sources.

3. Conclusions

Ecological education should start primarily from explaining causal connections between vulnerable behaviours, mechanisms of producing imbalances and the effects they have on the environment, otherwise, what is assimilated at the theoretical level it remains useless in practical terms. Another level of training should start from the application of the system of pro-ecological values and last but not least, education must start from the formation of correct general attitudes, of the type of pragmatic attachment, not just of the emotional attachment to the place of belonging so that to become motivational factors for the whole formative approach.

REFERENCES

[1] Bernardo, F. Palma-Oliveira, J.M. “Place Identity: A Central Concept in Understanding Intergroup Relationships in the Urban Context” in *Casakin H., Bernardo* F., “The Role of Place Identity in the Perception, Understanding, and Design of Built Environments”, Benham Science Publishers, 2012, pp. 35-46.
[2] Dębek, M. Janda-Dębek, B. “Perceived Residential Environment Quality and Neighborhood Attachment (PREQ & NA) Indicators by Marino Bonaiuto, Ferdinando Fornara, and Mirilia Bonnes – Polish adaptation” Polish Journal of Applied Psychology 2015, vol. 13 (2).
[3] Lewicka, M. “Place attachment: How far have we come in the last 40 years?” Journal of Environmental, Psychology, 31, (2011) pp. 207-230.
[4] Moore, R.L., Scott, D. “Place Attachment and Context: Comparing a Park and a Trail Within” Forest Science 49(6) 2003.
[5] Lin, C-C. Lockwood, M. “Forms and sources of place attachment: Evidence from two protected areas”, Geoforum 53 (2014) pp. 74-81.
[6] Chenga, T.-M. Wub Homer, C. Huang Lo-Min, “The influence of place attachment on the relationship between destination attractiveness and environmentally responsible behaviour for island tourism in Penghu, Taiwan” Journal of Sustainable Tourism, 2013 Vol. 21, No. 8, pp. 1166-1187.
[7] Kaltenborn, B. Williams, D. “The meaning of place: attachment to Femundsmarka National Park, Norway, among tourists and locals” Norwegian Journal of Geography, vol. 56, 2002, pp. 189-198.
[8] Ram, Y. Bjork, P. Weidenfeld, A. “Authenticity and place attachment of major visitor attraction”, Tourism management, vol. 52, 2016, pp. 110-122.

Universal Innovative Model for Cultural and Historical Heritage Management

Stoyan Denchev[1], Tereza Trencheva[2], Diana Stoyanova[3]
University of Library Studies and Information Technologies, Bulgaria[1,2,3]

Abstract

The explosive development and the enormous opportunities offered by modern Information Technologies create real preconditions for expanding the possibilities for cultural communication between different countries, regional state structures and peoples, and for the effective realization of the processes related to the manifestation of their cultural diversity. In the context of the "information environment" phenomenon, innovative technologies can and should enhance their "presence" in the following areas:

- *Total digitization of the tangible and intangible cultural monuments;*
- *3D modelling of movable and immovable cultural monuments;*
- *GIS mapping and digitization of cultural and historical sites and objects;*
- *Virtual and mixed reality realization.*

Today, it is definitely accepted that an important sign of civilization of any state or community of countries is the formation of a policy not only for the preservation of cultural heritage, but also for its effective socialization, with the following obligatory goals: identification of cultural values, their physical protection and their socialization in contemporary societies.

This paper presents the results of a scientific research on the use of the "information environment" phenomenon as a universal model for cultural and historical heritage management. The PEST analysis performed by the research team gives us a reason to claim that the three main components of the information environment, namely: information collections, information technologies and the human factor, are most relevant to the structural and functional characteristics of the investigated matter. This fact immediately leads us to the concept of effective management of the cultural and historical heritage through the synthesis of a specific information model for its management.

Keywords: cultural heritage, 3D modelling, GIS mapping, digitalization, virtual reality, mixed reality

Introduction

At the beginning of the second decade of the 21st century, the need for culture and cultural values is one of the leading global issues. Not only because cultural and historical heritage bears important information about different ethnicities or reflects current events in history, but also because it is a mark of the life and culture of different peoples and has valuable meaning for the identity and diversity of people on earth. The stages of its socialization are essential elements in the process of comprehending the cultural heritage and turning it into a powerful resource for the spiritual and sustainable development of different societies. In this complex and multifaceted process, information technologies play a leading role, creating new opportunities for access to cultural values in the context of UNESCO global doctrine on sustainable development [4].

With the use of information technologies, access to cultural content is expanded, which contributes to overcoming the problems of poverty, social exclusion, digital divide, etc. Information technologies also have a direct application in education at various levels, in particular in the university educational and information environment. We are witnessing how the university environment is changing in line with the pace at which the world is changing, but at the same time it is best suited for the development and collaboration of traditions with innovation [5].

1. The relationship between information society, modern information environment and university information environment

Information is one of the fundamental but at the same time debatable concepts, both in modern science and in real social practice. This raises the need to examine it in its various aspects from the point of view of science, technology and social practice. In order to explain the relationship between **information society, modern information environment and university information environment**, it is necessary to analyse their components*:* ***information collections, information technologies and the human factor***.

As it is well known in theory, information environment has three basic and interconnected components: information collections, information technologies and the human factor. **The human factor** is the unifying one for all three, but the totality of the other components provides the social infrastructure for the publicly useful realization of information processes within a specific subject area [2].

Information society is based on the concept of building a constantly evolving global information system encompassing human resources, information technologies, information infrastructure, services, ideas and projects, a system that is open to everyone and benefits everyone. In Information Society, the production, dissemination and use of an information resource are the main economic, political and cultural activities [1].

The differences between **global information environment** and **university information environment** stem from the specific character of some of the following components:

- **Information collections** – An important feature of the information collections is that, in addition to information recorded on modern magnetic media, in most cases individual collections (in paper form), containing the complete files of the information arrays are stored. [4]
- **Information technologies** – In general, modern information technologies can successfully be used for the needs of the management and educational processes at any university. [6: p. 18]
- **The human factor** – reflected mainly in the interactions between the different categories of academic and administrative staff as well as between them and the equipment of the environment. These interactive processes permeate the information environment end-to-end and are both technical and social in nature [4].

The educational system, and particularly the one higher education is based on, has the primary task of both generating and disseminating new knowledge [3]. In this regard, the university information environment is the focus of education, science, culture, technology, economics, industry, art, etc. Educational institutions are called upon to help preserve “knowledge” in the conditions of technogenic evolution and the increasing globalization of ideas, communications and markets. Their mission is to provoke and inspire society to knowledge, creativity and innovation. Only in this way can knowledge be applicable in the information society and implemented in the information environment.

2. Some specific methods for cultural and historical heritage management in the "information environment"

In contemporary educational context, a key moment is the introduction of new technologies in cultural heritage training. This complex and multidirectional process requires interdisciplinary approaches to achieve in-depth understanding of the existing knowledge and creates the necessary capacity to discover, explore, preserve and promote new findings and values [6].

Modern information technologies are an example of the introduction of innovative approaches into the process of dissemination of knowledge about cultural and historical heritage in an information environment. They provide the variety of methods and means by which individual and societal differences can easily, quickly and cheaply be overcome. The promotion of rich cultural and historical heritage through the potential of information technologies is a proven, working formula for the proper use of technologies in the process of perception, study and preservation of cultural heritage.

As we already marked, in the context of the "information environment" phenomenon, innovative technologies can and should enhance their "presence" in the following areas:

- **3D modelling of movable and immovable cultural monuments**

The opportunities offered by modern information technologies make it possible to enrich the options for access to elements of cultural heritage in an attractive and proper way, taking into account the individual needs of people. In recent years, there have been increasing opportunities for the application of mixed reality. The creation of virtual reconstructions, through **3D models**, enriches the forms for providing a learning environment and improves the pathways for information provision. Today, the increasing amount of data available to researchers requires methodologies to be adapted. The use of 3D digital technology helps archaeological reconstruction in many ways. It is essential that digital tools provide a means of standardizing and comparing individual datasets that juxtapose visual material together with geographical, textual, architectural and quantitative information. The resulting three-dimensional models allow the researcher to treat the city holistically as a complex phenomenon involving spatial, material and cultural determinants [7].

- **GIS mapping and digitization of cultural and historical sites and objects**

Digital technologies are playing an increasing role in protecting immovable cultural assets as well. Using mobile devices with **GIS software** is the common way to determine their exact location. The archaeological sites registered in this way are positioned very precisely on the cadastral plans and on topographic maps. Thus, they are protected against possible future infrastructure projects or other investment intentions [6].

- **Total digitization of tangible and intangible cultural monuments**

Digitization of the cultural heritage is essential in the period of information society building. Generating digital content helps to support the overall process of preserving Europe-wide cultural heritage. Citizens' access to world cultural heritage is also improving, and the development of the electronic information industry is being stimulated. The opportunities for digitization of cultural heritage contribute to the sustainable development of culture as a guarantee for the formation of the value system of the individual and are an indicator of a better quality of life.

In this sense, digitization can successfully serve to overcome a number of regional problems by stimulating cultural tourism and achieving educational goals, in particular in the university information environment and more generally in the information environment. Free access to cultural values, digitized with modern methods and providing high quality copies, is made available [8].

- **Virtual and mixed reality realization**

In the context of globalization, a decisive condition of the principle of continuous progress of mankind is the multifunctionality of technologies. Every day we witness how the new integrative tools are successfully coming into use and help to overcome problems related to access and utilization of the information environment. Guaranteed advancement for the knowledge of the future is predetermined by the past, by the way we become aware of it and turn it into social experience. Cultural and historical heritage is increasingly expanding its presence in the virtual world and therefore requires the use of modern means of presentation [5].

Virtual and mixed reality do not deprive people of their rights and ideas, but blend in with their understanding and ideas about life.

Virtual and Augmented Reality, the so-called mixed reality, is also used in education and the promotion of cultural heritage. Presenting the cultural and historical heritage with virtual reality (VR) technology and augmented reality enables users to interact with the content in an intuitive and exciting way. It is a technology that extends the human perception of reality at the expense of complementing the visible and tangible world with real-time digital information [1].

Conclusion

The dynamically developing policies of UNESCO and the Council of Europe play a leading role in making cultural heritage a resource for sustainable development. They form models of organization and management, the modern structural framework of species and categories of heritage, encourage national states to be responsible for the conservation of heritage located within their territory, link education and training with research activities and the requirements of modern social environment. Last but not least, they stimulate the process of generating new ideas and approaches for the application of information technologies in the presentation of cultural heritage.

Acknowledgements

This research would not have been possible without the financial assistance of the following project: “Application of the mixed reality in the training and promotion of the cultural heritage for the purposes of 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.

REFERENCES

[1] Peteva, S. Denchev, I. Trenchev. Mixed reality as new opportunity in the preservation and promotion of the cultural and historical heritage. Proceedings of EDULEARN 19 Conference, Palma, Mallorca, Spain, 2019, pp. 2451-2456.

[2] S. Denchev, T. Trencheva, “Intellectual Property as a Basic Part of the University’s Information Literacy”, Conference Proceedings: 2nd International Conference on Education and Management Science (ICEMS 2016), DEStech

Publications, China, 2016, pp. 74-78.
[3] M. Traykov, M. Trencheva, R. Mavrevski, A. Stoilov, I. Trenchev, Using Partial Differential Equations for Pricing of Goods and Services // Scientific Annals of Economics and Business, vol., 63(2), pp. 291-298, 2016.
[4] K. Mincheva, Kamelia Planska-Simeonova. Scientific research in the field of visual competency Proceedings of the 11th International Conference on Education and New Learning Technologies, 2019, pp. 5110-5117.
[5] Tsvetkova, E., I. Peteva, I. Pavlova. Attitude of Bulgarian Library Specialists Towards Use of Library Resources for Mobile Learning. *In:* Proceedings of 11th International Conference of Education, Research and Innovation – ICERI 2018, pp. 838-842.
[6] Valchev, T. Searching of Culture Heritage Monuments – Archaeological Field Surveys in Yambol Region. In: Knowledge society and 21st century humanism on the 16th International Scientific Conference, 2018, pp. 1108-1119.
[7] Trenchev I., Mavrevski R., Traykov M., Stoykov D. Mathematical approaches for creation of complex 3d models and their application in education. *In:* Conference Proceedings ICERI2019, pp. 4909-4914.
[8] E. Zdravkova. Media literacy as a key competency for the safe and effective use of media, In Conference Proceedings: 12th International Conference on Education, Research and Innovation, ICERI 2019, pp. 7467-7473.

Using Science and Creativity in Interdisciplinary Liberal Education

Alex Kizuk[1]
University of Lethbridge, Canada[1]

Abstract

The Liberal Education Program at the University of Lethbridge, Alberta, Canada, has a long history of interdisciplinary science teaching. Recently, however, our Program has expanded into a School of Liberal Education serving all students regardless of major. The School is now under the Vice-President's Office whereas previously it was a program in Arts and Science. This paper discusses the role of science teaching in our Creativity and Innovation Across Disciplines course, Liberal Education 3300. In this third-year course, the instructor engages 60 students per semester in an interdisciplinary exploration of thinking outside of the box. The students represent all majors and minors of study. The course is grounded in the Humanities and has a humanitarian base. But all of the main tools that the students use to think creatively are based in the logical and empirical foundations of the scientific method. This course in creativity and innovation represents a teleological synthesis of the Humanities' and Scientific orientations. [1]
Our School of Liberal Education believes in creating innovative learning environments within which all students can inquire into both new and settled interconnections between various silos of knowledge. In this course, students train in logical, step-by-step critical thinking and then present solutions to real world problems. This methodology combines conceptual rigor with genuine innovation. This is attested by the years of accumulated final projects of very high quality as well as the overall popularity of the course. Moreover, it is precisely these skills that employers of our graduates are primarily looking for in today's market. The paper will discuss methods and findings related to interdisciplinary teaching and learning, creativity and innovation, and the grounding benefit of the scientific method in such pedagogy. Though this paper is primarily experienced based, relevant research on science teaching and creativity is addressed. [2]

Keywords: Science teaching, creativity, innovation, pedagogy, social benefit.

Abstract's References:

[1] *This can be seen in the juncture of the main textbooks: Ness, R. B.* Innovation Generation: How to Produce Creative and Useful Scientific Ideas*, Oxford, OUP, 2012. and LaFasto, F. M. J. and Larson, C.* The Humanitarian Leader in Each of Us: 7 Choices That Shape a Socially Responsible Life*. Thousand Oaks, Sage, 2011.*

[2] *See: Czerniak, C. M. and Johnson, C. C.* Interdisciplinary Science Teaching. Handbook of Research in Science Education*, Volume 2, New York, Routledge. 2014, pp. 395-412 and Liversidge, T. "Creativity and Innovation in Science Teaching and Learning" in Cochrane, M., Kerfoot, B., and Thomas, J.* Teaching Science. *Thousand Oaks, Sage, 2009, pp. 160-188.*

1. Introduction

I joined the Liberal Education Program at the University of Lethbridge some years ago because the domain specific area of my research and teaching (English, Canadian Literature) had become ingrown and out-of-touch with what I felt my students learning needs actually were. As a graduate student back in the 1990s, I had attended seminars in Semiotics at the International Summer Institute of Semiotics Studies in Toronto. There I developed an interest in interdisciplinary studies while learning from scholars like Michel Foucault, Karl Pribram, Jacques Derrida and others. These studies proved invaluable when I came to develop Liberal Education courses whose content includes texts of a multi-disciplinary and cross-disciplinary nature. My Literature survey courses used to begin with *The Odyssey* and end with *The Waste Land.* Now the same surveys begin with discussions of Newton's *Principia*, Hobbes' *Leviathan*, Descartes' *Discourse on Method*, ending with Einstein, Heisenberg, and Schrodinger's cat. Or, if I had been pulled over for speeding at the beginning of my career, and the police officer said "Do you realize that you were going 130 kilometres per hour", I might have argued that as a professor of literature, a privileged doyen of high culture, I should expect a certain degree of leniency and be let off with a warning. Now, if I am pulled over and the officer tells me I was speeding at 130 kilometres per hour, I might say, "Great. Now I'm lost".

Generally, we see Liberal Education as both an alternative to and a value added to domain-specific programs that students (and parents) regard as being aimed primarily at eventual gainful employment. Our philosophy has been discussed recently in *Liberal Education and the Idea of the University: Arguments and Reflections*. [1] Here Kareem and Magid Youssef argue that the traditional dichotomy between creativity and science needs to be unpinned from the concept if utility. Without creativity, science would be "denuded of imagination and creativity of expression". Rather the goal should be to teach Liberal Education as "both as an art and a science … equivalent and complimentary forms of production of knowledge" (247-8).

2. Methods

The course-outcomes of each Liberal Education course and the Program in general have an immediate, an accreditation, and a life-long learning description: (a) learning-continuity across the various undergraduate and graduate degrees enhanced by cohort ambience among the students, (b) the proper asset of our degrees as avenues to meaningful employment and engaged living, and (c) the sort of long term feedback that psychologist and libertarian educational reformer Roger Schank has being writing about for decades, most recently in *Teaching Minds*. [2] In Schank's long experience as a science educator, it is the cognitive strategies that he modelled and facilitated in his teaching that students most productively responded to months and even many years later. It was not the content-based instruction that inspired them and gave them tools with which to succeed, but what Schank calls cognitive-based learning. Schank is an iconoclast, but he does have a point. The teaching of science in 21st Century schools must respond to student dissatisfaction with the quality and direction of their tertiary educational experiences. This is where creativity comes in. This is where a creative framework (cognitive-based learning) in science courses comes in.

At the University of Lethbridge, we decided not to attempt to replace status quo silos of knowledge, which is not a realistic goal due to the high cost of retooling the professoriate, but to use the structural materials of Liberal Education that already existed in our institutional history to create bridges between the silos. We hope to foster a more coherent degree-long learning experience and ultimately prepare graduates for the rapidly changing world that they will encounter after their studies. In this commitment, we hope to cultivate interaction, cohort ambience and subject-world continuity for students. In this we try to promote what is called a “Bohmian dialog” between instructors and students and between students themselves. [3]

I turn now to Liberal Education 3300, Creativity Across Disciplines, in which the values and method of science are taught in a creative framework. This course is offered every year in the Fall and is extremely popular among students from all majors across campus. Science students especially seem to appreciate learning how to think creatively in the logical, step-by-step terms that they know from their other courses. I brought a set of pedagogies for Creative Writing courses with me when I came into The School of Liberal Education at The University of Lethbridge. In order to create a multi-disciplinary course in creative thinking per se, I availed myself of methods used in Innovation-themed courses often offered in the field of Business and Management. The course Harnessing Creativity for Organizational Growth at the UBC Sauder School of Business, is just one example. I turned then to the literature on creativity in the fields of education and psychology. From these studies, my main take away was an appreciation that there exists a plethora of tools available to the instructor of creativity and innovation. [4]

Enumerating these tools is beyond the scope of this paper. In psychology, I found particularly useful the cognitive anatomy of creative cognition that the influential positive psychologist Mihaly Csikszentmihalyi has famously dubbed *flow*. [5]

The course assembled from these studies is divided into two parts. The first consists of training in a schema of creative problem-solving. The main textbook for the course is Roberta Ness’s *Innovation Generation: How to Produce Creative and Useful Scientific Ideas*. [6] Ness is a practicing researcher in women’s health and the Dean of the University of Texas School of Public Health, I adapted her practical tools for teaching science creatively into a course that teaches science-based creative schema to students from all majors, thereby forming a merger between the humanitarian and the empirical.

The first part of the course consists of training in the use of these tools. [7] There is also an accompanying exercise workbook. [8] The second part consists of usually 7-8 groups of students who have self-selected to use the skills learned through practice to mount a final presentation of an innovative idea that has a humanitarian component. [9]

Group-work is a prominent teaching and learning strategy in almost every creatively-motivated course aimed at helping “a zone of proximal development” among instructors and students of all majors. [9] This presentation is weighted at the lion’s share of the final grade and is the final measure of how well the students have internalized the skills and tools practiced and tested.

3. Results

Our School of Liberal Education is still a young entity and we have much to learn.

The course I describe herein has been, due to its continuing popularity, a positive element in the School’s institutional recognition. Students from all majors continue to be enthusiastic about the final presentations, and the quality of the work the student do is outstanding. This course adapts creativity training to the scientific method. Conversely, it adapts scientific methodology to creative pursuits. Following on Csikszentmihalyi’s *flow* experience, teachers and students develop “an enthusiasm for and sense of empowerment around novel ideation”. [10] The final group presentation grounds the student in the sense of a problem-solving task well done and prepares them to be creative employees and entrepreneurs in the future.

4. Discussion

Ness emphasizes the urgency of using creativity in health science teaching, “Whether innovation training occurs in premedical curricula, medical/health sciences schools, or postdoctoral training programs, I believe it is worth implementing.” [11] I agree with Ness that creativity instruction is already a valuable means of “enhancing scientific innovation.”

As teachers, we all have courses that go swimmingly and others that sink to the bottom. I was lucky this time. More work needs to be done in evaluating, testing, and disseminating the results of teaching science creatively. In our small, fledgling School of Liberal Education we already need more sections with new and different instructors, not only to meet the demand, but to help us all move toward a more diverse and interactive future.

REFERENCES

[1] Dharamsi, K., and Zimmer, J. W. *Liberal Education and the Idea of the University: Arguments and Reflections,* Delaware, Vernon Press, 2019, pp. 247-8.
[2] [2] Schank, R. *Teaching Minds: How Cognitive Science Can Save Our Schools, New York,* Teachers College Press, 2011.
[3] As Bohm says, this is a kind of group problem-solving that “is really aimed at going into the whole thought process and changing the way the thought process occurs collectively”. Bohm, D. *On Dialogue,* Road Hove UK, Psychology Press, 2004, p. 10.
[4] For example, books of tools for teaching creatively such as any of the works of Edward de Bono, the grandfather of creative thinking techniques, or newer works like Michael M. *Thinker toys: A Handbook of Creative-Thinking Techniques*, New York, Ten Speed Press, 2006. See also the popular online course by Puccio, G. “The Creative Thinker’s Toolkit,” The Great Courses, Chantilly, Virginia, 2014.
[5] Csikszentmihalyi, M. *Flow: The Psychology of Optimal Experience*, New York, Harper, 2008.
[6] Ness, R. B. *Innovation Generation: How to Produce Creative and Useful Scientific Ideas,* Oxford, OUP, 2012.
[7] Goodman, M. L. and Dickerson. A. *Creativity in The Sciences: A Workbook Companion to Innovation Generation*, Oxford, OUP, 2012.
[8] See note 4.
[9] Liversidge, T. “Creativity and Innovation in Science Teaching and Learning,” in Liversidge, T. *et al*., *Teaching Science,* London, Sage, 2009, 160-85, 170.
[10] Ness, R. B. “Teaching Creativity and Innovative Thinking in Medicine and the Health Sciences.” *Academic Medicine*, Vol. 86, No. 10 / October 2011, 1201-03. 1003.
[11] *Ibid*.

Why Do Students Fail to Learn and Use Central Science Concepts or Simple Mathematical Notions?

Jean-Pierre Thibault[1]
University of Bourgogne Franche-Comté, France[1]

Abstract

Learning new highly formal scientific concepts such as force and energy or using mathematical concepts means, most of the time, understanding clear-cut relational concepts and/or perfectly defined algorithms. Once we understand them, no problem should arise using them. As we know, this is far from being the case. Students often fail to learn and apply scientific concepts in all the contexts, or for all the objects, they should be applied. Quite surprisingly, this is also the case for basic algorithms such as addition. We will illustrate these difficulties in these two conceptual domains. In the domain of physics, we will focus on the distinction of the notion of force and energy, describing a trajectory of developing, suggesting that what young children misunderstand can be predicted on the basis on the variables at play in a typical physical display. In fact, given the nature of the objects displayed in the problem (animate or inanimate), the location of the object, the status of the animate participant, students' answers regarding force and energy might change. These variables will be discussed obstacles to learning arising from world knowledge. In the field of mathematics, arithmetic problem solving is often described as the selection of the relevant algorithm in order to solve the problem. Here, we will suggest that the nature of objects and more broadly the world knowledge associated to these objects influences the way participants choose an algorithm, despite the fact that these properties of objects are mathematically irrelevant and should not influence solving procedures. Math experts and math teachers are usually unaware of these influences regarding mathematical performance, that, in fact, also influence math experts in the case of simple problems, which witnesses their pervasiveness. Overall, these examples suggest that even abstract knowledge might not be completely abstract and independent of the objects they are operating on. We will argue for the necessity to include them in the teaching strategy because they are cognitive obstacles to learning.

Keywords: abstraction, physics, mathematical knowledge, obstacles to learning, world knowledge

Introduction

In highly formalized domains such as mathematics, or physics, or even morpho-syntax, a high level of competence means that people use a set of relevant dedicated formal devices. For example, in mathematics, if one understands what is at stake in an arithmetic word problem, he/she should be able to use the relevant algorithm in which the relations between quantities would be a perfect translation of the relations between the objects and entities that are referred to in the word problem. In scientific fields such as physics, understanding notions such as force and energy suppose that people are able to translate these concepts in terms of object properties and relations between objects in a way that is consistent with the scientific concepts. For morpho-syntax, the story is the same: competent speakers in a given language should be able to translate semantic relations between entities in the appropriate morpho-syntactic devices.

One important feature regarding these three domains is that the correct use of the relevant notions, formal devises, should not depend on the nature of the objects that are involved in a sentence, a math problem or a physical device. However, by contrast, our main claim is that mathematical solving procedures, or answers regarding physical concepts depend on the nature of the involved objects in a problem, that is, how we count depends on what we count. Before we come to math and physics, let's illustrate with morpho- case. It is now well-known that the way children between 3- to 8-years of age understand morpho-syntactic cues like the passive voice depends on the presence of semantic features that are syntactically irrelevant. For example, passive sentences with action verbs ("to hit") are easier than sentences with cognitive verbs ("to see") [1], [2], or semantically reversible sentences are more difficult than semantically irreversible ones. In the field of word arithmetic problem solving, it has been shown that both children and adults are biased towards specific solving strategy solutions depending on the nature of the objects targeted in the word problem

Influences of irrelevant world knowledge in math

Studies have shown that non-mathematical semantic information related to the entities described in a problem influences lay solvers' performance [3], [4], [5].

Recent data show that isomorphic mathematical problems featuring weight quantities or duration quantities (see Table 1) did not elicit the same solving procedure. For both problems' types, the same two solving procedures were available. The first one is "14-5=9; 5-2=3; 9+3=12). This solution relies on a composition of subsets. The second is "14-2=12", which starts with one total and subtracts the difference between the total and the non-shared dictionary or duration (given that for the common dictionary or duration, the value does not need to be calculated since we know the difference between the characters for the other subset). Interestingly, despite the mathematical equivalence between the problems, participants massively use the first solving procedure for the weight problems, and used the second solving procedure for the duration problems. We interpreted this difference between the two procedures in terms of the nature of the quantities, cardinal in the first case, in the sense of a combination of subsets, and ordinal, in the second case, in the sense of a continuous axis. Most interestingly, when we introduced problems with a missing data which made the problem unsolvable using the first solving procedure but remained solvable with the second procedure, participants made more errors for the weight problems than for the duration problems. This is because, they spontaneously solved the weight problems with the first solving procedure. The duration problems led to no difficulty because they were not spontaneously solved with the first procedure. Most astonishingly, even math experts rejected the correct solution (using the second, ordinal, solving procedure) more often when it was proposed for the weight problems than for the duration problems. Again, mathematically, the fact that weight or durations were used was mathematically irrelevant.

Table 1. *weight and duration arithmetic problems*

Weight Problem	Duration
John takes a Russian dictionary weighing 5 kg He also takes a Spanish dictionary In total, he is carrying 14 kg of books Claudia takes John's Spanish dictionary and a German dictionary The German dictionary weighs 2 kg less than the Russian dictionary How many kilograms of books is Claudia carrying?	John took painting classes for 5 years He started taking painting classes at a specific age He stopped taking the classes at the age of 14 years Claudia started taking painting classes at the same age as John She took classes for 2 years less than him How old was Claudia when she stopped taking painting classes?

World knowledge in the physical domain: force and energy

Concepts like force and energy are highly formalized and should also be applied in all the conditions in which they are relevant. It is far from being the case as suggested by numerous studies [6], [7]. Megalakaki *et* Thibaut (2016) [8] studied the differentiation of the force and energy concepts for animates and inanimate, in children aged 10-17, in situations such as in Figure 1. Results showed that the younger students made no distinction between the two concepts for inanimate objects. They regarded force and energy as the objects' intrinsic properties, related to their height and weight, and tended to attribute both concepts to animates rather than to inanimate. With age, force continued to impinge on energy, the reverse being less frequent. Conceptions remained unchanged for the animate agents, insofar as younger and older students showed undifferentiated force/energy conceptions, relating both force and energy to the agents' effort or the results of their action. Overall, students tended to regard them as intrinsic properties, relying on the visible parameters and physical characteristics of the objects and agents. This interpretation is in line with a view of knowledge arising from sensory experiences. In fact, participants had difficulties ascribing force and energy to inanimate.

Language use of the corresponding words also interferes with the proper treatment of these concepts.

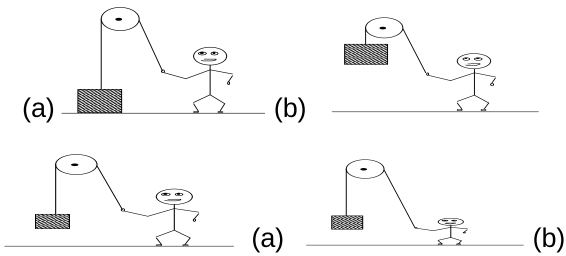


Fig. 1. *two situations involving characters interacting with objects. Participants had to describe them in terms of forces and energy.*

Students' difficulties might also originate from the dynamic nature of these concepts and the necessity to simultaneously consider all the relations between the components of the system(s) into account. This difficulty can be ascribed to relational complexity. This notion accounts for difficulty solving problems or understanding sentences with the idea that the processing complexity of a task depends on the number of interacting variables that must be represented in parallel to perform the most complex process involved in the task. We believe that relational complexity provides an interesting explanation for the difficulty of acquiring the concepts of force and energy, insofar as the students initially regarded them as intrinsic properties, and their subsequent progress stemmed from the discovery of the relations between the different elements.

In sum, our world knowledge [9] dramatically interacts with formal knowledge and interferes both with its learning and its use in problems featuring objects and situations that are not congruent with the relevant technical notions.

REFERENCES

[1] Thibaut, J., Rondal, J., & Kaens, A.M. (1995). Actionality and mental imagery in children's comprehension of declaratives. *Journal of Child Language, 22*(1), pp. 189-209.

[2] Rondal, J. A., Thibaut, J. P., & Cession, A. (1990). Transitivity effects on children's sentence comprehension. *European Bulletin of Cognitive Psychology*, *10*(4), pp. 385-400.

[3] Bassok, M., & Olseth, K. L. (1995). Judging a book by its cover: Interpretative effects of content on problem-solving transfer. *Memory & Cognition*, *23*(3), pp. 354-367.

[4] Bassok, M., Chase, V. M., & Martin, S. A. (1998). Adding apples and oranges: Alignment of semantic and formal knowledge. *Cognitive Psychology*, *35*(2), pp. 99-134.

[5] Gros, H., Sander, E., & Thibaut, J. P. (2019). When Masters of abstraction run into a concrete wall: Experts failing arithmetic word problems. *Psychonomic bulletin & review*, *26*(5), pp. 1738-1746.

[6] Vosniadou, S., & Skopeliti, I. (2014). Conceptual change from the framework theory side of the fence. *Science & Education*, *23*(7), pp. 1427-1445.

[7] Bayraktar, S. (2009). Misconceptions of Turkish pre-service teachers about force and motion. International, Journal of Science and Mathematics Education, 7, pp. 273-291.

[8] Megalakaki, O., & Thibaut, J. P. (2016). Development and Differentiation of Force and Energy Concepts for Animate and Inanimate Objects in Children and Adolescents. *Research in Science Education*, *46*(4), pp. 457-480.

[9] Thibaut, J. P. (1999). Développement conceptuel. In J.A. Rondal & E. Esperet (Eds.) *Manuel de psychologie de l'enfant*, Bruxelles, Mardaga, pp. 343-384.

Enhancing Student's Motivation

Can Web 2.0 Technologies Increase Students' Motivation?

Rdouan Faizi[1], Maria Rudneva[2]
ENSIAS, Mohammed V University in Rabat, Morocco[1]
RUDN University, Russian Federation[2]

Abstract

With the excessive number of students in higher education, educators across the world are increasingly getting frustrated by the ever-growing number of students who are psychologically, socially, and academically unprepared for the demands of university life. Such students often exhibit maladaptive behaviour such as distraction, frustration, boredom and a lack of interest in learning. However, since students' motivation has long been regarded as a key factor for meaningful engagement and positive academic performance, innovative ways that can motivate students on a consistent basis should be sought. Therefore, our objective in this paper is to explore the potentials of Web 2.0 technologies in enhancing students' motivation. In this respect, the findings of the present study have revealed that as opposed to a formal educational setting which is limited in both time and space, Web 2.0 platforms create more opportunities for increasing students' motivation. In fact, these online communities can be used to maintain a positive relationship between teachers and students beyond classroom walls. Via these virtual communities, students can also have access to a wide choice of learning materials that can pique their interest and help them completely different tasks at different rates. Moreover, the communicative and collaborative features of these technologies allow students to interact with each other, learn from one another and jointly work together towards common objectives. Taking these opportunities into consideration, we strongly believe that despite being recognized as a source of distraction, Web 2.0 technologies can serve as a valuable source of encouragement, support and motivation for students.

Keywords: Web 2.0, education, students, motivation

1. Introduction

Given the growing proliferation of social media amongst students, the way education is currently delivered seems to have greatly been impacted. In fact, despite being mainly used for communication and entertainment purposes, these online platforms have altered the way students learn. In this respect, many studies have reported that students are deeply immersed in these Web 2.0 technologies as they resort to them not only to interact with other people or to entertain themselves, but also to enhance their learning experience and widen their knowledge in various subjects and disciplines [1], [2], [3].

Taking into consideration the students' increasing use of Web 2.0 technologies as informal learning environments, our objective in this paper is to explore the potential role of these online platforms in enhancing students' motivation to learn.

The remainder of this article is organized as follows. Section Two examines students' motivation as a key factor in academic achievement. Section Three explores the use of

Web 2.0 technologies as motivation tools in education settings. Finally, Section Four summarizes the findings of this study.

2. Student Motivation as a Key Predictor of Academic Performance

Motivation has always been a fundamental discussion topic among educators given its important impact on students' engagement with curricula and on their overall academic performance. Nevertheless, motivation is not a simple construct. Rather, it is a multidimensional concept in view of the numerous explanations for the engagement in a given activity, the diverse levels of inclination and the kind of motivational orientation [4], [5], [6]. As such, many definitions have been associated with motivation. However, most researchers agree on the idea that motivation denotes the initiation, intensity, direction as well as the persistence of an individual's behaviour.

In the literature, a distinction is usually drawn between two universally-agreed upon types of motivation, namely intrinsic and extrinsic. Intrinsic motivation is a type of motivation in which a person is motivated to do something because it is inherently enjoyable or interesting [7]. In such cases, the activity is carried out for the sake of personal satisfaction or for an inherent desire rather than for a separable consequence.

An intrinsically motivated student, for instance, learns because of some inherent enjoyment or pleasure in the activity or so as to satisfy his natural curiosity and to discover new knowledge. He does so freely with a sense of volition and does not expect any material rewards or constraints. It has been noted that when self and meta-cognitive systems are positively activated, students work hard and do well for their own satisfaction in learning. Given this fact, intrinsic motivation is very important in education as it results in high quality learning and creativity and plays a key role in student achievement.

Unlike intrinsic motivation that comes from within, extrinsic motivation is driven by external desires. It is the motivation that is brought about because of the promise or hope to receive a tangible reward or result, or to avoid punishment. Extrinsic motivation is a product of behaviourism, which stipulates that behaviour can be manipulated by giving rewards for desired behaviour and punishment for undesired behaviour [8]. Extrinsic motivation is, thus, the engagement in a given activity as a means to an end. Therefore, students who are extrinsically motivated learn so as to get external rewards such as a good grade, recognition or to avoid being punished [9]. Although such incentives play an important part in classroom-based teaching and learning, studies have revealed that extrinsic motivation generates merely short-term effects. In fact, rewards may only serve as weak reinforcers. Psychologists also note that these low-powered incentives may have hidden costs as they can become negative reinforcers in the long run once withdrawn [10]. Consequently, they will result in a slower acquisition of skills and will negatively impact a student's learning.

Taking into account the discussion above, it is quite clear that motivation, and intrinsic motivation in particular, is a key component of the teaching/learning process. Therefore, teachers should develop innovative motivational environments that are capable of improving students' engagement and fostering their learning experience [11], [12], [13].

3. Using Web 2.0 Platforms to Motivate Students

Having shed light on the two major types of motivation and on their impact on enhancing students' academic performance and their overall success, our purpose in the present section is to explore the various ways in which Web 2.0 technologies can boost students' motivation in learning.

Despite the fact that Web 2.0 technologies were originally launched as communication and entertainment outlets, the various social, participative and collaborative features that they are bristling with have turned them into valuable educational learning and/or teaching environments that can boost students' motivation.

The first piece of evidence that backs up the assumption that Web 2.0 technologies can increase students' motivation is their ability to maintain a positive relationship between instructors and students beyond classroom walls [14], [15]. Given the fact that in-class or out-of-class communication is an essential element of an effective learning and teaching experience, the incorporation of social media platforms in education contexts can contribute in enhancing students' motivation and engagement in learning.

As opposed to traditional classroom-based learning settings, which are limited in both time and space, social media provide both instructors and students with an easy and engaging way to communicate with each other regardless of time and place. Therefore, a student who has a question about an assignment can get an answer right away by posting a message to his teacher. Similarly, teachers can, via these online communities, extend in-class discussion, help students who are having learning problems and provide them with the feedback they usually need. The teacher can interact with the whole class, but he can also target those students who are shy, quiet or unmotivated and encourage them to participate in class discussion. These online teacher-student interactions will promote accessibility, immediacy and a feeling of closeness and will enable students to be more motivated and actively involved in learning [16], [17].

Another reason that proves that social media can help foster students' motivation and more interest in learning is that they enable teachers to offer students choices about what they learn and how they learn it. Studies have, actually, proven that students who are given more choices in their learning are likely to get engaged in higher-level learning.

Allowing the students to make their own choices while learning has been found out to be a powerful motivating tool as it gives them an opportunity to make their own decisions, fosters creativity and leads to additional positive student working habits like self-initiated revisions and better organization [18]. In a traditional-based educational environment, given the time constraints and the growing number of students in a classroom, a "one-size-for-all" learning model is usually the norm. Therefore, meeting each student's unique needs and interests is always difficult. Nevertheless, using Web 2.0 platforms such as social networks, media sharing websites and discussion forums together with the huge amounts of valuable learning resources that these spaces host, students can be given more personal opportunities to pursue the learning experiences that reflect their personal interests and skills. By empowering students with autonomy to choose their own learning pathways, they can become active participants in their education, thereby increasing their levels of motivation and engagement in learning.

An additional proof that confirms that Web 2.0 technologies can be used as motivational tools in educational settings is that they can support collaborative learning [19], [20]. Though the latter is generally recognized as a face-to-face or a classroom-based activity, the emergence of social media has given students enough opportunities to participate actively in learning. Indeed, given their collaborative components and participatory nature, Web 2.0 platforms provide students with a single destination where they can explore things together and help each other sort out learning problems and address misunderstandings. Henceforth, instead of working on their own on a specific assignment or project, all students are given an additional possibility to team up and to jointly work together to achieve common objectives. Hence, using Web 2.0 platforms as collaborative tools will certainly boost students' motivation to study and will help them be engaged in constructive discussion around the subjects or topics that they are meant to learn.

It is, thus, clear that despite their earned reputation as a source of distraction for students, Web 2.0 technologies can be used as a positive source of encouragement and support. Moreover, they have the potential to play a very important role in developing students' intrinsic motivation to learn and to boost their academic performance and achievement.

4. Conclusion

The objective of this paper was to explore the potential role of using Web 2.0 technologies to increase students' motivation in learning. The results of the present study revealed that since students are greatly immersed in these online communities, the latter can help maintain a positive relationship between teachers and students beyond classroom walls. In addition, they enable instructors to offer students choices about what they learn and how they learn it and they provide students with an ideal virtual learning destination where they can jointly work together to achieve common objectives. For all these reasons, Web 2.0 technologies can serve as an ideal environment that nurtures educational motivation.

REFERENCES

[1] Faizi, R., El Afia, A., & Chiheb, R. (2013). Exploring the Potential Benefits of Using Social Media in Education. *iJEP*, *3*(4), pp. 50-53.
[2] Faizi, R., Chiheb, R., & El Afia, A. (2015). Students' Perceptions Towards Using Web 2.0 Technologies in Education. *International Journal of Emerging Technologies in Learning* (*iJET)*, *10*(6).
[3] Faizi, R. (2018b). Moroccan higher education students' and teachers' perceptions towards using Web 2.0 technologies in language learning and teaching. *Knowledge Management & E-Learning: An International Journal (KM&EL*), 10(1), pp. 86-96.
[4] Kleinginna, P. R., & Kleinginna, A. M. (1981). A categorized list of motivation definitions, with a suggestion for a consensual definition. *Motivation and emotion*, *5*(3), pp. 263-291.
[5] Kiviniemi, M. T., Bevins, R., & Zelick, P. R. (2007). Issues in the psychology of motivation.
[6] Maehr, M., & Meyer, H. (1997). Understanding motivation and schooling: Where we've been, where we are, and where we need to go. Educational Psychology Review 9, pp. 371-409.
[7] Parikh, M., & Gupta, R. K. (2010). *Organisational behaviour*. Tata McGraw Hill Education Pte. Limited.
[8] Tileston, D. W. (2010). *What every teacher should know about student motivation*. Corwin Press.
[9] Levesque, R. J. (2011). Intrinsic and extrinsic motivation. *Encyclopaedia of Adolescence*, pp. 1478-1479.
[10] Benabou, R., & Tirole, J. (2003). Intrinsic and extrinsic motivation. The review of economic studies, 70(3), pp. 489-520.
[11] Anderman, L. H., & Leake, V. S. (2005). The ABCs of motivation: An alternative framework for teaching preservice teachers about motivation. The Clearing House, 78(5), pp. 192-196.
[12] Brooks, D. W., & Shell, D. F. (2006). Working memory, motivation, and teacher-

initiated learning. Journal of Science Education and Technology, 15(1), p. 17.
[13] Seel, N. M. (Ed.). (2011). Encyclopaedia of the Sciences of Learning. Springer Science & Business Media.
[14] Camus, M., Hurt, N. E., Larson, L. R., & Prevost, L. (2016). Facebook as an online teaching tool: Effects on student participation, learning, and overall course performance. *College Teaching*, *64*(2), pp. 84-94.
[15] Ractham, P., & Firpo, D. (2011). Using social networking technology to enhance learning in higher education: A case study using Facebook. In System Sciences (HICSS), 2011 44th Hawaii International Conference on (pp. 1-10). IEEE).
[16] Hershkovitz, A. and Forkosh-Baruch, A. (2013) 'Student-teacher relationship in the Facebook era: the student perspective', *Int. J. Continuing Engineering Education and Life-Long Learning*, Vol. 23, No. 1, pp. 33-52.
[17] Essays, UK. (2018). Importance of Teacher Student Interaction. Retrieved from https://www.ukessays.com/essays/education/importance-of-teacher-student-interaction-education-essay.php?vref=1
[18] Anderson, M. (2016). *Learning to choose, choosing to learn: The key to student motivation and achievement*. ASCD
[19] Faizi R., El Afia A., Chiheb R. (2018) Examining Students' Attitudes Towards Using Facebook as an Educational Platform, *INTED2018 Proceedings*, pp. 5605-5609.
[20] Alkhathlan, A. A., and Al-Daraiseh, A. A. (2017). An analytical study of the use of social networks for collaborative learning in higher education. *International Journal of Modern Education and Computer Science*, 9(2), p. 1.

Development of an Intervention in the Primary Education Classroom to Improve the Learning of STEM Areas

Milagros Mateos-Núñez[1], Guadalupe Martínez-Borreguero[2], Francisco Luis Naranjo-Correa[3]
University of Extremadura, Department of Didactics of Experimental Sciences, Spain[1,2,3]

Abstract

Science and technology are considered a fundamental cornerstone for citizens, which is why various institutions have highlighted the growing need for human resources with the psychomotor skills and cognitive domains required by these progressive scientific-technological advances [1]. Many students lose interest in these subjects because they consider them irrelevant to their personal goals and they are not aware of the usefulness of this knowledge in everyday life [2]. In this line, the present research aims to develop an intervention in the primary education classroom for the improvement of cognitive and emotional domain in learning STEM areas. The methodology used has been experimental with a pre-test and two post-tests. The sampling process carried out was non-probabilistic, obtaining the participation of 144 students in the 5th and 6th grade of primary education. As a measuring instrument, three questionnaires were designed based on previous research. The first questionnaire was used as a pre-test with the purpose of assessing the level of initial knowledge of the students in relation to the chosen contents. The second questionnaire was used as a post-test after the didactic intervention, in order to assess its effectiveness in the classroom. In addition, a second post-test was used to analyse the persistence over time of the STEM contents learned. The results obtained reveal a significant improvement in learning after the didactic intervention developed. The average grade obtained in the post test is significantly higher (Sig. <0.001) than that obtained by the sample in the pre-test. Likewise, statistically significant differences are observed between the average scores of the pre-test and the second post-test, being significantly favourable the score obtained in the latter. Likewise, with respect to the difference between academic levels, the results seem to reveal that there is a positive cognitive evolution, since statistically significant differences are found in the level of knowledge between academic courses (Sig. <0.05). With regard to the affective-emotional dimension, it should be noted that the participating sample mostly expressed positive emotions such as fun or curiosity during the development of the didactic intervention. In addition, 64% of the sample admitted that they would not have learned the contents had it not been for the workshop implemented and 86% of the sample considered that the experience facilitated the learning of the proposed contents. To help students believe that they can understand STEM areas, schools can offer these STEM projects to students in order to provide them with more information about STEM disciplines, greater confidence in their theoretical and procedural capacity, and greater academic and employment opportunities [2].

Keywords: STEM, Primary education, Meaningful learning

1. Introduction

Negative student attitudes are the main problem that science education and science teaching have to face today [1], as many studies have reported on negative and inadequate student attitudes towards science and technology subjects, and more specifically, on the lack of interest shown, leading to a lack of scientific professionals in the working world [2-4].

The work of [5, 6] indicates that students' attitudes towards science are declining due to factors such as the age of the student and the methodology used by the teacher, which is perceived as boring, not very participatory and with few practical activities. With this last aspect in mind, it is necessary to emphasize that teachers should assume the importance of different types of classroom strategies and include as many as necessary in their classroom activities to promote the development of a conceptual change and ensure lasting learning [7]. According to various studies, traditional teaching methods have not succeeded in changing previous conceptions or negative student attitudes towards scientific subjects [8].

In recent years a new educational model has emerged based on the interdisciplinary teaching of scientific and technological subjects, known as STEM (Science, Technology, Engineering and Mathematics) education. This paradigm has arisen as a possible teaching strategy that could be the solution to current educational problems, offering support to the development of problem-solving skills and interest in STEM areas.

Specifically, STEM education provides multiple benefits in learning Because it uses student-cantered models, improves high-level thinking and problem-solving skills, enhances content retention [(9)], and promotes students to be innovative, inventors, self-sufficient, logical thinkers, and technologically literate [10].

On the other hand, with respect to affective factors in teaching, research in science education recognizes the importance of emotions as a regulatory system of learning and advocates the need to consider jointly the cognitive and affective dimensions in the educational process [11].

Based on this background, it is considered necessary to create and study new resources and methodologies, which facilitate learning and motivate students towards STEM areas in early stages of their training. Therefore, the main objective of this study has been to develop an intervention in the primary education classroom for the improvement of cognitive and emotional domain in learning STEM areas.

2. Methodology

The research design has been of an experimental type with pre-test and post-test.

The sample collected by non-probability sampling was 144 students belonging to 5th and 6th grade of primary school (10 and 12 years old).

Three questionnaires implemented at different times were used as data collection instruments. The first one was defined as a pre-test and was carried out before the STEM workshop on forces and movement that was designed. The purpose of this questionnaire was to know the previous ideas of the students regarding the selected subject and it contained ten test-type questions. The second questionnaire or post-test I was conducted by the students at the end of the intervention and contained a section with 12 theoretical questions to assess the cognitive dimension and a second section that evaluated the emotional dimension of students before the practice made. The third questionnaire or post-test II was passed on to the students 5/6 weeks after the classroom intervention and consisted of 12 multiple choice questions to assess the recollection of the contents explained.

The didactic intervention designed was a STEM workshop on forces and movement and was composed of two one-hour sessions. The first session was based on explaining the theoretical contents. In the second session the students made a model closely related to the theoretical contents that were intended to be taught, thus complementing the previous expository session.

The practical activity that the students carried out consisted of a model of a simple car that worked thanks to the impulse of the air contained in a balloon that came out through a straw. The workshop was especially relevant to work on the movements produced by forces and Newton's laws. Figure 1 shows a picture of the model.

Fig. 1. *Action-Reaction Car*

3. Results

The data extracted from the different questionnaires show the didactic validity of the STEM workshops as a strategy in the primary classroom. Specifically, in table 1 we can see that there is a positive evolution in the level of knowledge of the students after the STEM workshop. Although students started out with a certain initial level of knowledge, the STEM workshop not only produced a notable improvement in learning but also led to the retention of the content explained in the long term.

Type of questionnaire	**Mean**	**Std. Error Mean**	**Std. Deviation**
Pre-test	6.53	0.16	1.74
Post-test I	8.09	0.13	1.61
Post-test II	7.34	0.15	1.83

Table 1. *Descriptive analysis*

To check whether there were statistically significant differences between the scores obtained in the three questionnaires, an inferential analysis was carried out using Tukey's Post Hoc One-Factor ANOVA test. This parametric test was chosen to obtain an adequate significance value in the Levene Test in all the cases analysed (Sig. >0.05).

Table 2 shows that there are statistically significant differences (Sig. <0.001) between the average scores of the questionnaires taken by the students.

	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between groups	152.986	2	76.493	25.437	0.000
Within groups	1163.748	387	3.007		
Total	1316.733	389			

*Sig. <0.05**

Table 2. *One-factor ANOVA test*

Table 3 shows the results obtained by applying Tukey's Post-Hoc test to the data. It can be seen that there are statistically significant differences between all the questionnaires, in favour of Post-test I and Post-test II with respect to the pre-test. This again suggests that theory and practice must complement each other to ensure significant learning in the students.

(I) Type of questionnaire	(J) Type of questionnaire	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
PRE-TEST	POST-TEST I	-1.55730*	0.21844	0.000	-2.0712	-1.0434
	POST-TEST II	-0.80620*	0.21917	0.001	-1.3219	-0.2906
POST-TEST I	POST-TEST II	0.75110*	0.20953	0.001	0.2581	1.2441

*Sig. <0.05**

Table 3. *Tukey's HSD Post-Hoc test*

Finally, the analysis of the affective-emotional variable determined that the participating sample showed mostly positive emotions such as fun, curiosity or satisfaction with the STEM workshop. Likewise, more than 80% of the respondents concluded that it would be convenient to implement a STEM education in the classroom more frequently because it facilitates the learning of scientific-technological contents and their long-term recollection [12].

4. Conclusions

The results suggest that to help students believe they can learn science, schools need to approach the emotional challenge from various angles, not only trying to improve cognitive learning but also helping students develop meta-cognition skills and greater confidence in their ability to learn and do science [13]. In this line, it will be essential to incorporate practical interdisciplinary experiences in the curricula because, in addition to learning STEM content more effectively, students will develop critical thinking and improve their collaboration, communication, creativity and problem-solving skills, thus contributing to improve students' practical and cognitive abilities and, consequently, to improve their scientific literacy [14].

Another positive aspect of the hands-on workshops is their ability to motivate students towards STEM learning. In this line, our emotional results coincide with the contributions of [15] who point out that students expect to obtain more positive results when they participate in a task for which they perceive high levels of control and competence, and this entails the manifestation of positive emotions such as satisfaction.

It is also concluded that it is necessary to develop STEM projects that allow these skills to be worked on at all levels of the education system, including the training of future teachers, since this group will be responsible for promoting the acquisition of scientific and technological skills in the students of future generations and promoting future scientific vocations, which are much needed, as warned in numerous European reports [16].

Acknowledgements

Grant GR18004 and Research Projects IB16068 (Junta de Extremadura/Fondo Europeo de Desarrollo Regional) & EDU2016-77007-R (Agencia Estatal de Investigación/Fondo Europeo de Desarrollo Regional).

REFERENCES

[1] Fensham, P. J. "Beyond knowledge: other scientific qualities as outcomes for school science education" in Science and technology education for a diverse world: dilemmas, needs and partnerships, pp. 23-25, 2004.

[2] National Research Council. "Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics", Washington, D.C: National Academies Press, 2011.

[3] Osborne, J., Simon, S., Collins S. "Attitudes towards science: a review of the literature and its implications", International Journal of Science Education, 2003, pp. 1049-1079.

[4] Vázquez-Alonso, Á., & Manassero-Mas, M. A. "El descenso de las actitudes hacia la ciencia de chicos y chicas en la educación obligatoria", Ciência & Educação, 2011, pp. 249-268.

[5] Dávila, M. A. "Las emociones y sus causas en el aprendizaje de Física y Química, en el alumnado de Educación Secundaria", Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 2017, pp. 570-586.

[6] Pérez, A. P., & de Pro, A. J. "Estudio demoscópico de lo que sienten y piensan los niños y adolescentes sobre la enseñanza formal de las ciencias", in Las Emociones en la Enseñanza y el Aprendizaje de las Ciencias y las Matemáticas, 2013, pp. 495-520.

[7] Wade-Jaimes, K., Demir, K., & Qureshi, A. "Modelling strategies enhanced by metacognitive tools in high school physics to support student conceptual trajectories and understanding of electricity", Science Education, 2018, pp. 711-743.

[8] Mulhall, P., McKittrick, B., & Gunstone, R. "A perspective on the resolution of confusions in the teaching of electricity", Research in Science Education, 2001, pp. 575-587.

[9] King, K. P., & Wiseman, D. L. "Comparing science efficacy beliefs of elementary education majors in integrated and non-integrated teacher education coursework", Journal of Science Teacher Education, 2001, pp. 143-153.

[10] Stohlmann, M., Moore, T. J., & Roehrig, G. H. "Considerations for teaching integrated STEM education", Journal of Pre-College Engineering Education Research 2012, pp. 27-34.

[11] Brígido, M., Bermejo, M. L., Conde, M. C., & Mellado, V. "The Emotions in Teaching and Learning Nature Sciences and Physics/Chemistry in Pre-Service Primary Teachers", Online Submission, 2010, pp. 25-32.

[12] G. Martínez, M. Mateos, & F.L. Naranjo, "Implementation and Didactic Validation of STEM Experiences in Primary Education: Analysis of the Cognitive and Affective Dimension" in Theorizing STEM Education in the 21st Century, 2019.

[13] Aschbacher, P. R., Ing, M., & Tsai, S. M. "Is science me? Exploring middle school students' STE-M career aspirations", Journal of Science Education and Technology, 2014, pp. 735-743.

[14] Choi, E., Lindquist, R., & Song, Y. "Effects of problem-based learning vs. traditional lecture on Korean nursing students' critical thinking, problem-solving,

and self-directed learning", Nurse Education Today, 2014, pp. 52-56.

[15] Vongkulluksn, V. W., Matewos, A. M., Sinatra, G. M., & Marsh, J. A. "Motivational factors in makerspaces: a mixed methods study of elementary school students' situational interest, self-efficacy, and achievement emotions", International journal of STEM education, 2018, p. 43.

[16] National Research Council. "STEM integration in K-12 education: Status, prospects, and an agenda for research", Washington: National Academies Press, 2014.

Experiments on Effects of Behaviours in the Rest Time between Learning

Takashi Ito[1], Kenichi Takahashi[2]
Aoyama Gakuin University, Japan[1]
Hiroshima City University, Japan[2]

Abstract

In e-learning, students can learn at their own pace without being relatively restricted by the learning place and the time. On the other hand, there is a tendency that the students gradually get tired during learning. It is important to have break times during study to refresh students and maintain the learning performance. This research investigates how the behaviours during rest times affect the performance through experiment. In the experiment, 30 university students are asked to solve the problems of mathematical calculation for 15 minutes as many as possible. The experiment consists of three learning sessions and two rest times between the learning sessions. The rest time to refresh their feeling is 3 minutes long. Five actions are employed as resting behaviours: (1) a fly-tapping game that refreshes users with an active game by moving their bodies, (2) a game that takes care of a dog to relax their feelings with a non-active operation, (3) reading a book, (4) listening to music, and (5) doing nothing to be calm. The effect of those resting behaviours on learning is examined through experiment. The experimental results are evaluated with regard to the accuracy of calculation and the answering time, and the effect of these behaviours will be discussed based on the experimental results and the questionnaire.

Keywords: rest time, concentration, e-learning, mathematical calculation

1. Introduction

E-learning is proactive learning that utilizes communication networks and information technology. In recent years, e-learning systems have begun to spread in university lectures and company training. The diversification of devices used for learning, such as smartphones and tablets as well as the fact that students can learn at their pace without the restriction of the location and the time seem to push this spread of e-learning forward.

Additionally, there are various good points such as the functions for students to learn repeatedly and to be able to choose learning programs that suit their levels, the low cost, and the ease of managing learning data such as learning progress and results of study [1]. While these various advantages are accelerating the spread of e-learning, there are also disadvantages. For example, because there are no instructors on the spot, subjects with practical skills are difficult to give lectures, and those who do not have a network environment cannot take the courses in the first place. Furthermore, the biggest disadvantage is that it is difficult for students to maintain the concentration and the learning will, since students don’t gather at the same time and place, the opportunity to communicate with the instructor and other students is lost, and that if they cannot be stimulated by the lecture, their willingness to learn gradually declines. In order to solve the problems and to promote student concentration in e-learning, we constructed a system with a function to praise and scold students during learning, and a system with Kinect to measure the concentration of users and learning states during learning [2], [4].

It is also important to have a break during study. There is research investigating how to spend the rest time affect the performance of office workers using Visual Display Terminals (VDT) [5]. This research introduced that Ministry of Health, Labour and Welfare of Japan makes recommendations as a guideline for occupational health management in office workers' VDT work in April 2002 [6] such as "Make sure that one continuous work time does not exceed one hour" and "Make a 10-15-minute break between consecutive works". It is shown that the work performance is actually improved by taking a break. Therefore, for e-learning using VDT it is necessary and important to take an appropriate break between learning, and it is required to take an effective break within the limited time. In this study, we investigate what kind of actions during break times increases the concentration of learners and affects the learning performance through experiment. The experiment consists of three working sessions and two brake times between the working sessions. Five actions are employed as resting behaviours: (1) a fly-tapping game that refreshes users with an active game by moving their bodies, (2) a game that takes care of a dog to relax their feelings with a non-active operation, (3) reading a book, (4) listening to music, and (5) doing nothing to be calm. The effect of those resting behaviours on learning is examined through experiments. The experimental results are evaluated with regard to the accuracy of calculation and the answering time, and the effect of these behaviours are discussed based on the experimental results and the questionnaire.

2. Experiments

2.1 Mathematical calculation

As shown in Fig. 1, the mathematical experiment consisted of three work sessions and two breaks between sessions. The work sessions lasted 15 minutes, and the breaks lasted 3 minutes. Fig. 2 shows an example mathematical calculation. We asked the participants to continue calculating similar problems for 15 minutes in each work session.

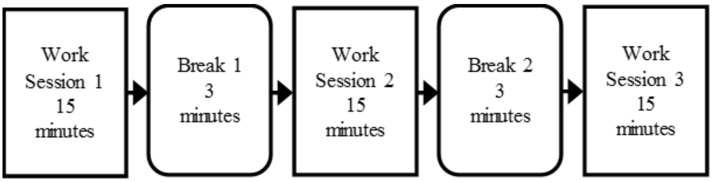


Fig. 1. *The flow of the mathematical calculation experiment*

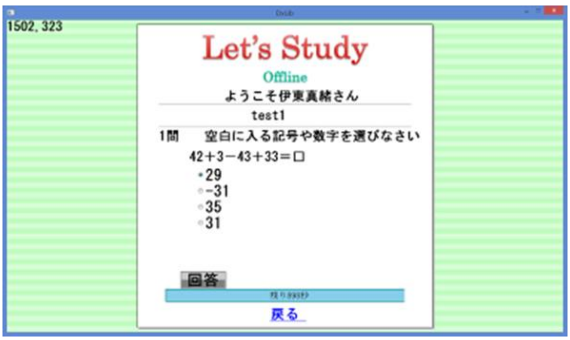


Fig. 2. *A page for mathematical calculation*

2.2 Resting behaviours

We employed five actions during brake times.

(1) "listening to music": a user listens to his favourite music.
(2) "reading a book": a user reads his favourite book.
(3) "doing nothing": a user does nothing to stay calm.
(4) "a fly-tapping game": this game is a kind of shooting game; a user tries to shoot as many flies as possible and the score is determined by the points corresponding to the kinds of flies. This game refreshes users with active actions by moving their bodies. Figure 3(a) shows a screen shot of the game.
(5) "a dog-care game": A user takes care of a dog to relax user's feelings with a non-active operation. The user tries to keep the dog in good mood by giving it foods and tapping it. Figure 3(b) shows a screen shot of the game.

(a) Fly-tapping game (b) Dog-care game

Fig. 3. *Examples of the screen shots of the two games*

2.3 Experimental results

Thirty students from our university served as participants. They were divided into five groups, and each group performed one of the resting behaviours during break times.

The participants were assigned to groups on the basis of the results of preliminary experiments so that each group would be roughly equal in terms of computational ability.

The mathematical calculation experiment consisted of three work sessions.

Figure 4 shows average correct-answer rates and the average answering time of the five groups for the three work sessions. We can see from Fig. 4 that the answering time and the correct answer rate of group 4 that did a fly-tapping game degrade most, and that degradation of those of group 3 that did nothing is least. A fly-tapping game is one that makes the user move his arm frequently, and it makes the user tired. The correct answer rate of group 2 that reads a book did not decrease much, but the answering time increased a lot. The correct answer rate of group 1 listening to music changes much.

The break time is only 3 minutes, and it is too short to finish one song, which did not make the user refresh. The correct answer rate of group 2 with a dog-care game did not degrade, while the answering time from session 2 to 3 increased.

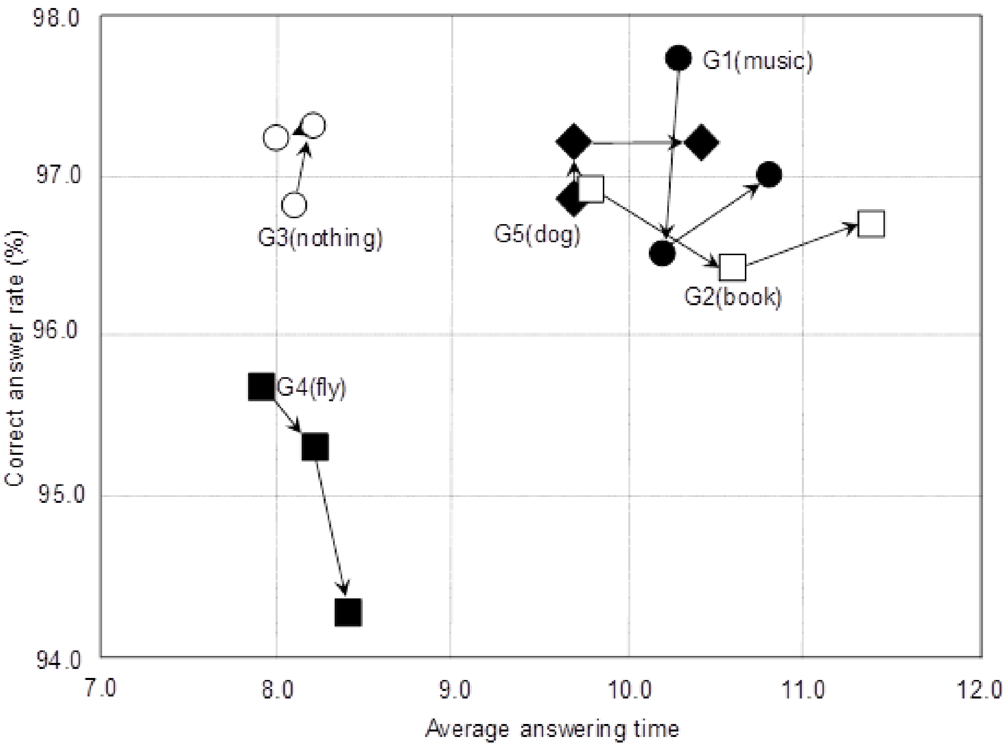


Fig. 4. *Average correct-answer rate vs. average answering time*

2.4 Questionnaire

After the experiment, we asked the participants to complete a descriptive questionnaire and to respond to three statements by selecting responses on a five-point scale (5: strongly agree 1: strongly disagree).

Table 1 lists the evaluation items and the average scores for five groups. We can see from Table 1 that the highest score is 4.5 for items 5, 6 of group 1; "listening to music" users felt that they are refreshed and the concentration improved more than other resting actions, though the performance degraded. They felt that three-minute break time was too short. "Doing nothing" group and "a dog-care game" group answered high scores for items 5 to 8. The scores of "Doing nothing" group for items1-3 increased as the sessions proceed, and three minutes is appropriate for the break time. The scores of "a fly-tapping game" group for items 1-3 decreased; there are comments saying that he was tired and the game didn't refresh him.

Table 1. *Average scores in the questionnaire*

No.	Statement	Group 1 Listen-ing to music	Group 2 Read-Ing a Book	Group 3 Doing nothing	Group 4 Fly tapping game	Group 5 Dog-Care game
1	I concentrated in the 1st session.	3.8	3.3	3.7	4.3	3.8
2	I concentrated in the 2nd session.	3.5	3.3	3.8	3.7	3.7
3	I concentrated in the 3rd session.	3.8	3.0	4.2	3.7	3.7
4	I kept concentration all through the work.	3.8	3.2	4.0	3.0	3.6
5	I felt refreshed well with the resting behaviour.	4.5	3.3	3.5	3.3	3.7
6	I felt that the resting behaviour improved my concentration.	4.5	3.2	3.8	3.2	3.7
7	The resting bahaviour was effective.	3.0	3.2	3.5	2.7	3.2
8	The length of a break is appropriate.	2.5	3.3	3.9	3.7	3.4

3. Conclusion

We conducted experiments in which e-learning students take one of resting behaviours during study breaks to investigate the effect of those behaviours on the will to learn. We found that the “doing nothing” and “listening to music” behaviours refreshed the participants effectively for a simple work task (mathematical calculation based on four arithmetic operators).

Future task includes experiments with more participants and other resting behaviours to improve the accuracy of the effect. In our experiment, the break time was fixed to three minutes. More experiments with various break time will show the appropriate length of the break time.

Acknowledgments

This research was supported by a Grant-in-Aid for Scientific Research JP16K00485.

REFERENCES

[1] Proseeds Inc., “Merits and demerits of introducing e-learning,” http://www.pro-seeds.com/trend/meritdemerit.html, Accessed in Aug. 2019 (in Japanese).

[2] M. Takeue, K. Shimada, K. Takahashi, and M. Inaba, “Experiments of displaying images to keep the motivation in e-learning,” Conf. Rec. IEEE International Conference on Systems, Man, and Cybernetics, Seoul, Korea, pp. 120-125, 2012.

[3] T. Ito, S. Kotake, K. Takahashi, and M. Inaba, “Detecting Concentration of Students Using Kinect in E-learning,” The 5th IIAE International Conference on Intelligent Systems and Image Processing 2017 (ICISIP2017), Hawaii, USA, pp. 450-456, 2017.

[4] T. Ito, K. Kamiya, K. Takahashi, and M. Inaba, “A method for identification of students’ states using Kinect,” The 13th International Conference on Ubiquitous Information Management and Communication (IMCOM2019), P3-3, Phuket, Thailand, pp. 341-350, 2019.

[5] T. Miki, T. Terada, *et al*., "Research of the effects of the break time on work performance," IPSJ SIG Technical Report, 2018-UBI-57(3), pp. 1-8, 2018 (in Japanese).
[6] Ministry of Health, Labour and Welfare, "Guidelines for occupational health management in VDT work, http://www.mhlw.go.jp/file/06-Seisakujouhou-11200000-Roudoukijunkyoku/0000184703.pdf, Accessed in Aug. 2019 (in Japanese).

Intercultural Group Projects as a Pedagogical Technology for Enhancing the Effectiveness of Foreign Language Learning Process. Case Study at the Pushkin State Russian Language Institute

Ekaterina Budnik[1], Arina Zhukova[2], Tatyana Kudoyarova[3], Ivan Leonov[4]
Pushkin State Russian Language Institute, Russian Federation[1,2,3,4]

Abstract

One of the serious challenges in teaching a foreign language in the countries where the language originates is that foreign students often limit the circle of communication to the representatives of their diaspora, using their native language most of the time. The experience of the Pushkin Institute points out that this is the characteristic of large diaspora representatives. Students tend to limit their interaction with the local (in our case, Russian) language and culture to the educational needs. These factors slow down the learning process and prevent the formation of intercultural competence. In addition, we often deal with mono-ethnic study groups.
The organization of extracurricular activities can help overcome this situation. The article discusses pedagogical technology, which we defined as an extracurricular educational intercultural project (EIP). The purpose of the event is to lively introduce a foreign country with the elements of a traditional activity (preparing a national dish, writing hieroglyphs, etc.).
EIP creates a real-life communication in the studied language with its native speakers. Moreover, we point out that the communication is held on the material and by a means of dialogue of cultures. The concept of the project assumes that countries whose historical and cultural ties between them are not obvious (e.g., Cuba and Mongolia) become participants in a particular event, which makes it possible for foreign students to get to know each other better. Thus, within the framework of each project, a trilateral intercultural dialogue is being established, one of the parties of which are the speakers of the "host" linguistic culture.
The authors have been working on this pedagogical technology since 2011, with 26 events taken place, participating representatives from 32 countries (students and trainees of the Pushkin Institute), as well as about 5,000 Moscow schoolchildren and teachers.
The article analyses the content component of the projects created by representatives of different nationalities and cultures. In addition, we summarized the results of a student survey based on the results of their participation in the project, along with a survey of schoolchildren and teachers in Moscow.

Keywords: innovation, pedagogical technology, research projects, enhancing motivation, learning a foreign language, Russian as a foreign language

1. Introduction

In today's multicultural world, a person must adequately perceive cultural differences and interact with other people. Global processes caused by "free information flows, branching and diffusion of intercultural communication, the emergence of new contexts of intercultural interaction (visual virtual and similar), related identities and the propagation of natural boundaries" [2], coexist with a tendency towards ethnocentrism [3]. In this regard, intercultural dialogue, being a community based on mutual understanding and respect between different ethnic groups, faiths, languages and culture, is becoming one of the most important principles underlying the modern education system. The new sociocultural reality "requires the pedagogical community to adequately reflect on scientific and pedagogical knowledge and create relevant educational practices on this basis" [2]. This applies to modern and non-linguistic education – the study of foreign languages, built on the principles of intercultural didactics. The object of this pedagogical theory is teaching aimed at the transfer of cultural values through communication, and the subject is the interaction of students being taught in an intercultural context [1].

The intercultural didactics direction, based on practical needs, meant to help overcome the cultural shock of Americans when adapting to another culture abroad [12; 7]. To raise questions about the ways of forming adaptive skills, qualitative personality traits necessary for comprehensive interaction with other cultural subjects, assessing the level of formation of intercultural skills. Researchers of intercultural communication played representatives of linguodidactics – teachers of foreign languages [8]. The purpose of intercultural didactics is the general intercultural competence of a foreign language person [17]. The intercultural competence has various: both "the ability of a person to exist in a multicultural society, and the achievement of a common understanding of other cultures and representatives of its culture", "the ability to adequately understand and interpret the linguistic and cultural facts inherent in educated values" [4]; as "the totality of background knowledge and the ability to adequately apply it in a comparison based on a comparison of two or more cultural" [10]; as "the ability to cultural identity and cultural identity" [6]. According to M. Bayram, "the study should not be a learned language, but methods of mastering other cultures" [9]. Thus, the study of intercultural communication should be provided with the training of tools for interaction with any other cultural contact with it. For our research, all of these interpretations are crucial.

Today it is already clear that immersion in a foreign cultural environment in itself is not a guarantee of the development of intercultural competence. At the same time, intercultural training, pedagogical support of living in the foreign language environment has a positive impact on these qualities of students. These findings are consistent with our experience. One of the serious problems that we observe when teaching Russian as a foreign language in the language environment is that foreign students often limit the circle of communication to representatives of their diaspora, communicating mainly in their native language, and limiting their interaction with native speakers to the minimum.

First of all, this is typical for representatives of large diasporas (e.g., Chinese, Vietnamese). The result of joint teaching and living of representatives of the same nationality affects the level of mastery of the Russian language, which is noticeably reduced due to insufficient involvement of foreigners in the Russian language environment. There is a paradoxical situation: formally, students' study in a linguistic environment, but in fact they limit interaction with the language and culture being studied (in our case, Russian) to the educational audience.

The disadvantage of mono-ethnic groups is that students lack motivation to communicate with each other in the language they are studying, and thus, intercultural communication in Russian for them is limited to communication with the teacher.

The most effective for learning in these conditions are international, multi-ethnic groups that create a model of a multicultural environment that motivates students to speak Russian, making it easier to them to adapt to a “host” culture. However, in reality, one has to deal with a serious disproportion in the number of representatives of certain countries/ethnic groups. In a situation where it is impossible to avoid mono-ethnic groups, it is necessary to use the opportunities of extracurricular work to develop intercultural competence. In this case, it is necessary to create conditions for 1) the real implementation of intercultural interaction in the process of solving specific communicative problems; 2) the emotional involvement of students in the process of obtaining intercultural skills; 3) their awareness of the practical significance of the acquired knowledge and skills.

2. Methodology

With the formation of “common European thinking”, which is based on the growth of unification processes while maintaining a sense of national uniqueness, the introduction of a number of innovative pedagogical technologies is associated, one of the most effective of which is the project method.

In the context of modern teaching of Russian as a foreign language, the project method is currently considered one of the most effective:

1. Project work allows to increase the motivation of students to communicate in a foreign – Russian – language, namely, motivation is considered by psychologists as a decisive factor in the effectiveness of the educational process. In the process of preparing and implementing the project discussed in this article, students have to search for the necessary information on the Internet in Russian or translate texts from their native language into Russian, exchange information in the language they are studying, discuss the scenario of their presentation and master class with each other and with the teacher- a tutor, communicate with students from other countries and with Russian schoolchildren. Interpersonal and intercultural communication makes students responsible for the overall result. Thus, the participants in the project form cognitive and social learning motives, while the Russian language is transformed from the goal of learning into a means of achieving the project result.

2. The project method allows a student-centered approach to teaching each student, in which not only the result is important, but also the process of acquiring skills – the process of preparing a project, rehearsing performances and conducting master classes.

The teacher-tutor individually with each participant checks his performance, helps to correct mistakes in the language and intonation.

3. Preparation of the project allows to develop the creative abilities of students who themselves come up with and propose elements of a common scenario, the content of the master class. It also contributes to the socialization of the student in a new intercultural team.

4. The versatility of the project contributes to the integration of all types of speech activity not in an artificially created learning situation, but in the course of a real collective creative work. You can use the method in teaching Russian as a foreign project with students of almost any level. It is usually considered that for participation in the project it is desirable to have a base of language and grammatical material of level A2, but, as the authors of the article show, with the right methodological approach, students with level

A1, A0 + can successfully and actively participate in the general project.

The interdisciplinary and practice-oriented nature of the project method correlates with the principles of a communicative approach to teaching foreign languages and, in particular, Russian as a foreign language (hereinafter – RFL) which is started far back in 1970s. The key aspects of communicative competence, the formation of which is fundamental in teaching RFL, are relevant today: "...the essential characteristics of communicative competence described by teachers working in the field of teaching Russian to foreigners: individuality, dynamism, its volume depending on the language acquisition goals chosen by the students, their interests, motivation, accepted and socially determined roles, and types of communicative activity" [20].

In addition to the positive results of the application of the project method, there are a number of difficulties in its application in teaching. Firstly, these are organizational difficulties, since all the preparation of the project is carried out outside regular hours.

These difficulties are overcome by creating a situation of interest of participants, which is one of the main tasks of the teacher-tutor. Secondly, "the question arises of tracking and evaluating the results of using this method in view of the duality of understanding of the final "product" of the project. On the one hand, the result of the project can be considered the knowledge acquired during its implementation, and on the other, the development of independent design skills, research skills, and the development of cognitive and creative activities of students. The effectiveness of using the project methodology in foreign language classes can be determined by the following parameters:

- control over the level of mastery of the language material;
- assessment of the formation of internal motivation of students;
- measuring the degree of development of intra-collective relationships in a student group" [21].

3. Results

The cultural and educational project "Horizons of Friendship" has been implemented at the Pushkin Institute since 2011. During this time, 26 events took place, in which about 5,000 Russian schoolchildren and teachers took part, as well as representatives of 32 countries: Algeria, Bulgaria, Bosnia and Herzegovina, Brazil, Hungary, Vietnam, Gabon, Ghana, Greece, India, Indonesia, Iran, Italy, China, Colombia, Cuba, Latvia, Mali, Mexico, Mongolia, Myanmar, Poland, Turkey, Russia, Romania, Serbia, Slovakia, Slovenia, Ukraine, France, Montenegro, Japan.

The goal and objectives of the project are related to the creation of conditions for the successful development of the process of intercultural communication in educational institutions, the formation of international students' intercultural competence as an important component of the process of mastering the Russian language.

It should be noted that the project is closely related to the educational activities of the Pushkin Institute, aimed at increasing the students' motivation to learn the Russian language and culture, developing their communication skills. To overcome mono-ethnic groups factor, it seems necessary to maximize the ability of students to communicate with a wide range of native speakers (teachers, students, schoolchildren), as well as create for them a variety of communicative situations that contribute to the development of motivation and improve the quality of language training.

The project is implemented in two main formats: cultural and educational event and the festival of cultures. The main differences are related to the number of participating countries, as well as to the more extensive modular structure of the event. If the event supposes the presence of two national teams (in some cases, the “Russian cultural block”, which is prepared by Russian students of the Pushkin Institute) is added to them, then 4 teams will perform at the Festival of Cultures, as a rule, representing not just different countries, but also continents.

3.1 The content of the project

An example is the Festival of Cultures, which was held at the Pushkin Institute in December 2016. Students from Serbia, Romania, Vietnam and Colombia became its participants.

As part of the first presentation block, the guests of the Festival were presented traditional and modern Serbian songs, features of the Serbian modern urban culture, architectural monuments, the unique nature of the Balkan Peninsula. Participants from Romania showed a traditional dance, sang a national song, talked about cultural monuments and traditions of the Romanian people, and also demonstrated a national Romanian costume. After that, the guests of the Festival got the opportunity to get acquainted with the culture of Vietnam: as part of their performance, Vietnamese students presented a number of musical and dance compositions, as well as told the audience about the major cities of their country, Hanoi and Ho Chi Minh City, introduced the national cuisine and traditions of the New Year. In the end of the presentation module, students from Colombia spoke on the culture of their country, its unique flora and fauna, and also introduced the audience to national musical traditions.

If the students’ Russian language proficiency corresponds to level B1 and higher, then they can be recommended to present a classic module that includes a story about their country, its traditions, sights, holidays, national cuisine, etc. In some cases, the structure of the traditional module includes a linguistic warm-up (guests are invited to learn a few simple words in the participants’ native language), small theatrical plays designed to illustrate the difference in the behaviour of representatives of different countries.

In a number of cases, when during the initial diagnosis it turns out that the Russian language proficiency of potential project participants corresponds to A1-A2 levels, it is recommended to abandon the classic module and choose creative one as an alternative.

In this case, the emphasis is shifted from the presentation to such phenomena of national creativity as song, dance, folk games. It should be noted that the creative module does not imply a complete refusal to speak to the guests, otherwise the task associated with the development of the communicative skills of the project participant will not be realized. In this case, a small text is prepared (a kind of verbal “visiting card” of the country), corresponding to the language capabilities of students. In this case, national music, dance, and costume are designed to expand the guests’ ideas about the traditions of the participating country. During the history of the project, the creative module was successfully prepared and presented by students and interns from Ghana, Indonesia, Mexico, Mali, Myanmar, India.

The further preparation is related to the selection of material. Foreign students often note that they are at a loss in choosing it, do not imagine what it would be interesting to know for a Russian school student about their country. In this case, teachers can invite the children to select the material on the basis of which it is possible to trace both general and distinctive features in Russian and native cultures. Such an approach to the selection of material allows us to solve two problems: a) to show the proximity and at the same time differences in cultures, which will contribute to the formation of interest of Russian schoolchildren in the traditions of other countries and foster tolerance towards their citizens; b) to create a number of situations for foreign students that require the maximum mobilization of communication opportunities for the successful delivery of information of interest to the listener.

The next stage of preparation of the project involves editing the text of the speech of foreign students and presentations, conducting rehearsals, the number of which depends on the level of participants' knowledge of the Russian language, the ability to perform on stage, and the coordination of the team. In some cases, teachers have to work out the composition of the speech in detail with the students, shorten the text, removing repetitions, unnecessary details or general information, focusing on the unique phenomena of national culture, sights, aspects of everyday life that are unusual from the point of view of the carriers of the Russian mentality. In this context, work with vocabulary and syntax is very important. It should be recognized that some students in the process of preparing a presentation use the materials from the Internet, in which they find complex and not always completely understandable texts. In this case, the teacher's task is not only to reduce, but also to simplify the text. Editing the text of the speech of foreign students, it is necessary to ensure that all words and expressions are understandable to students, do not allow ambiguity. So, for example, when working with Vietnamese students, we came across such expressions as "feeding pattern" (instead of "eating habits"), "cow pies" (instead of "beef patties" recipe).

3.2 Experiment and survey

In order to identify the attitude of foreign students to this project, as well as to identify its strengths and weaknesses, to outline prospects and ways of improvement, a special questionnaire was developed. The survey was attended by 30 students with experience working with schoolchildren as part of project activities. We are talking about students speaking at the Horizons of Friendship events (including in the format of the Festival of Cultures), teaching practice, and also at other events of the Pushkin Institute.

There is the following distribution of questionnaires by country: 18 students from China, 8 – Vietnam, 1 – South Korea, Indonesia, Romania, Serbia. The respondents were 16 women, 14 men. The age of students ranges from 20 to 27 years. The experience of participating in projects of this kind is different for everyone, from one to five events.

During the survey, foreign students were asked questions related to the peculiarities of their individual perception of Russian schoolchildren, comparing their level of sociability with children and adolescents in their native country. Certain issues were related to difficulties encountered during the preparation and participation in the project, the assessment of their own results of participation in the event and prospects, as well as the identification of the opinion of foreigners about the need to include such projects in the training of modern Philologists-Russian scholars. The answers of foreign students were distributed as follows:

1. Do Russian schoolchildren look like schoolchildren in your country?" "Yes" – 13, "no" – 15. 2 students found it difficult to answer.

2. The qualities of Russian schoolchildren, which mostly surprised foreign students: Activity – 11, Curiosity – 1, No school uniform – 1, Amicability – 7, Good knowledge about my native country – 2, lack of knowledge about my native country – 1, Emotionality and sense of humour – 2, Hard to understand oral speech – 1.

As part of the questionnaire, a question was asked about the difficulties that foreign students encountered during the preparation and implementation of the project. The answers showed that almost half of the respondents experienced difficulties in selecting material and finding ways to submit it. Many of them wrote: "We do not know what a Russian schoolchild would like to know about our country," "It is difficult to understand what might interest a Russian schoolchild," etc. Also, a significant part of foreigners noted the language difficulties they encountered.

3. How foreign students evaluate the result obtained personally for themselves from participation in the project. I started to speak Russian better – 25, Russian students have learnt more about my country – 24, I have learnt more about Russian culture – 23, Now I am not afraid to speak in public – 14, Now it is easier to communicate with Russians – 14, I learnt more about my native country – 13.

4. Would you like to participate in the project next year? 24 – yes, 2 – no. 4 – not sure.

5. Whether it is necessary to include this project in the training program for a Philologist-Russian scholar. 25 – yes, 5 – no. Those who gave negative answers explained that participation in the project was too difficult, and also that they were embarrassed to speak in front of a large audience.

In order to identify the peculiarities of the perception of the project by Russian schoolchildren and the peculiarities of the implementation of tasks related to the development of respectful attitude in the youth environment to people of different cultures, a questionnaire was developed, addressed to the guests of the project. The survey was answered by 100 students from Moscow schools aged 10 to 17 years.

The respondents were asked five questions:

1. How many times have you attended the Horizons of Friendship event? 2. What did you want to receive from this event? 3. What new have you learned about the cultures and traditions of the participating countries of the project? 4. Representatives of which countries would you like to see in the project next time? 5. Do you plan to attend events with foreign students in the future?

Six respondents said that they participated in such meetings 5 times. Nine people – 4 times, twelve people – 3 times, twenty-two schoolchildren – 2 times. The remaining guests (51 people) visited the project for the first time.

The second question raised the following answers: 34 guests noted that they would like to know about the modern life of the participating countries, 25 people are interested in national cuisine, 12 guests are interested in science and technology, 10 are in sights, 10 are in history and culture, 2 are in literature and folklore, one each chose a theatre, national sports, and costume. Four people found it difficult to answer.

When asked about the representatives of which countries the schoolchildren would like to see in the project next time, Japan (42 people) and China (34 people) take the leading place. Further, the answers were distributed as follows: Spain (5 people), Argentina (4 people), Portugal, France, Canada (3 people each), Thailand, Great Britain, Cuba, India (1 person each). Two participants found it difficult to answer. And finally, the question related to further participation in such projects gave the following answers: yes – 96 people, no – 2 people, 2 people found it difficult to answer.

Thus, a significant interest of foreign students and Russian schoolchildren in projects of this kind was revealed. It is obvious that the majority of participants involved in project activities on both sides realize the benefits they receive in the process of intercultural communication.

4. Conclusions

The results of the implementation of the "Horizons of Friendship" EIP as a special pedagogical technology aimed at removing communicative barriers, developing intercultural competence, and deeper integration into the language environment show that this technology is recognized by students as relevant to their interests and needs.

Creating a real situation of communication in the studied language with its speakers on the material and means of dialogue of cultures, EIP promotes the skills of comparing the native culture and other cultures, the presentation of the characteristics of their own culture to speakers of other cultures. Participation in the preparation and implementation of such events, as shown by the results of students' self-reflection, demonstrates the availability of intercultural communication at any level of foreign language proficiency, gives participants the opportunity to feel confident in their abilities, motivates them to further improve their communication skills, and to enter real communication, and therefore, increases the effectiveness of language learning. The combination of the prepared and improvisational parts of the speech (questions from the audience, a situation of misunderstanding and, accordingly, the need to find means and methods of additional explanation at the workshops, the need to interact on stage with partners from another country, etc.).

The format of project activities in which the teacher acts as a tutor-mentor, stimulating and directing the student's independent search, taking into account his capabilities at this stage of training. Overcoming difficulties, the collective search for the optimal solution contribute to the development of managerial and organizational competence of students, as well as their cognitive and emotional involvement in solving real communicative tasks of intercultural dialogue. It also seems important that the pedagogical technology discussed in this work has a pronounced humanistic component that creates the conditions for the formation of tolerance and respect for other languages and cultures of all project participants.

REFERENCES

[1] Petrikova A. "Osnovy mezhkul'turnoj didaktiki" / A. Petrikova, T. Kuprina, Ya. Gallo. – Moscow.: Russkij yazyk. Kursy, 2015. 376 s.
[2] Utekhina A.N. "Modelirovanie didakticheskih osnov mezhkul'turnogo obrazovaniya v informacionnom prostranstve" // Evrazijskij gumanitarnyj zhurnal, № 1, 2019, pp. 138-144.
[3] Ajsman V. "Identichnost', yazyk, naciya i etnos. Etnocentrizm i globalizaciya" // Peresekaya granicy: Mezhkul'turnaya kommunikaciya v global'nom kontekste: Sbornik materialov I Mezhdunarodnoj nauchno-prakticheskoj konferencii. – Moscow.: Gos. IRYa im. A.S. Pushkina, 2018. S.10-13.
[4] Azimov E.G., Shchukin A.N. "Sovremennyj slovar' metodicheskih terminov i ponyatij. Teoriya i praktika obucheniya yazykam". – Moscow.: Russkij yazyk. Kursy, 2018. 496 s.
[5] Ter-Minasova S.G "Yazyk i mezhkul'turnaya kommunikaciya". Moscow.: Slovo, 2000. 261 s.
[6] Elizarova G.V. "Kul'tura i obuchenie inostrannym yazykam". SPb, 2001. 291 s.
[7] Pedersen P.J. "Assesing Intercultural Effectiveness Outcomes in a Year-long Study Abroad Program" // International Journal of Intercultural Relations/2010/ №34. pp. 50-80.
[8] Byram M. "Teaching and Assessing intercultural competence in language teaching". Multiligual Matters. Clevedon, 1997, pp. 34-12.7
[9] Furmanova V.D. "Mezhkul'turnaya kommunikaciya i lingvokul'turovedenie v teorii i praktike obucheniya inostrannym yazykam". Saransk: Izd-vo Mordovskogo un-ta, 1993. 122 s.
[10] Stewart E.C. "The Survival Stage of Intercultural Communication" // International and Intercultural Communication Annual. Vol. IV /N. Jain (ed.). Poenix, Arizona,

1977.pp. 17-31.
[11] Vereshchagin E.M., Kostomarov V.G. “Yazyk i kul’tura. Linvostranovedenie v prepodavanii russkogo yazyka kak inostrannogo”. Moscow.: Rus.yaz., 1990. 245 s.
[12] Zimnyaya I.A, Leontyev A.A. “Psychological features of knowledge of a foreign language” // International Conference of Teachers of Russian Language and Literature “Actual Issues of Teaching Russian Language and Literature”. Abstracts of reports and speeches. Moscow., 1969, pp. 146-148
[13] Kudoyarova T.V, Farisenkova L.V “Thesaurus of competencies for students of philological profile and school students”. Monograph – Palmarium Academic Publishing, 2011.
[14] Kuznetsova S. V., Minakova L.Yu. “On the use of design methods in teaching foreign languages” // Bulletin of Tomsk State University. – Tambov, 2008, pp. 162-165, URL: https://cyberleninka.ru/article/n/k-voprosu-ob-ispolzovanii-proektnoy-metodiki-v-prepodavanii-inostrannyh-yazykov, free access.

The History of Science, Technology and Interdisciplinary: An Engaging and Innovative Teaching Proposal

Cristina Spinicci[1], Marco Santini[2], Juan Peña-Martínez[3], Antonio Moreno González[4]
Complutense University of Madrid, Spain[1,3,4]
I.T.I.S. Firenze, Italy[2]

Abstract

There are many studies that value the use of the history of science for its numerous educational effects and its use is suggested in the school programs of various countries of the world. Through the study of history and the nature of science, students have the opportunity to appreciate not only the final results but also the processes that led to the formulation of scientific ideas, understanding how often the construction of a theory is the result of a long and tortuous process that over the past times clashed with fears, superstition, astrology and religion. In this teaching proposal we want to retrace what led Galileo to abandon a cosmological vision that has lasted for 2000 years and deal with his discoveries, achieved using a simple telescope, in which he believed so much to challenge authorities and prejudices, pursuing what was the goal of his whole life: demonstrating and spreading the heliocentric theory.
It is an important moment in the history of the thought of humanity: understanding the fundamentals of scientific and intellectual change is an essential exercise in order to transfer to our student's what science is, when it was born and what it was born from. But how to teach this to high school students? Many researches have shown how the teaching that involves more sensory aspects can promote motivation and learning, while technology can be a fabulous tool to engage our students. What is proposed here is the use of the Thing-Link platform as a tool that allows access to visual, interactive images, sounds and videos, even in a 360° degree's view. The smartphone becomes a tool to enjoy and build engaging paths even in the form of immersive virtual reality. The path will show the importance of Galileo's astronomical discoveries and their consequences in physics, philosophy, religion and how there is a trace of them in the artworks of museums, churches and palaces in Florence, Madrid, Monaco, Rome, as a demonstration of how art, at that time, received scientific innovations and was an important medium in spreading new ideas. In conclusion, the history of science can be a means to help overcome the traditional separation between science and humanities and technology a powerful tool to stimulate the interest and creativity of our students.

Keywords: History of Science, Galileo, Virtual Reality, Motivation

1. Introduction

A series of studies conducted in recent years have been signalling an alarming decline in the interest of young people in the subjects of science and mathematics. In April 2007, the so-called Rocard Report was published, as a result of the work of a committee of experts on science and research of the European Parliament presided by Michel Rocard.

This report points out how the growing disinterest of young people towards science is a capital danger for the future of Europe and indicates that the origin of this issue can be traced back, among other things, to the way science is taught. It recommends teaching methods not tied to memory learning or abstract concepts and promotes research-centered approaches on how the process of science take place, even historically.

There are many studies that value the use of the history of science for its numerous educational effects and its use is suggested in the school programs of various countries of the world, though it is still not clear what needs to be taught and how to do it.

There have been many methodological proposals in the past: reading of original texts, reconstruction of historical experiments, analysis of disputes, dramatizations, comic book creations, etc.

What we propose here is a multidisciplinary and interactive course, inspired and built starting from one of the recommendations of the EU COUNCIL of May 22, 2018 relating to key competences for lifelong learning, suggesting "*to promote the acquisition of skills in science, technology, engineering and mathematics (STEM), taking into account the links with the arts, creativity and innovation*".

The main objective of the proposal is to convey to the students how the birth and genesis of the concept of today's science was a long and tortuous path; the theme treated as a supporting background is "The astronomical discoveries of Galileo" for their numerous consequences in astronomy, physic, philosophy and religion.

This work involves the use of multiple teaching strategies: reading and discussing the original texts, construction of scientific instruments of interest and the use of art as a starting point for reflection and as a demonstration of how art was an important medium in spreading new ideas.

One of the inspiring ideas is to attract students by means of a new 3D technology with immersive Virtual Reality (VR) as a powerful way to involve them.

The course has been proposed to a class of students aged 15, during the physics' course, who responded with interest and enthusiasm.

2. Materials and Methods

The Thing-Link platform has been chosen as the supporting backbone of the teaching proposal.

Thing-Link is an innovative tool and an important support for learning, which allows to visually and interactively connect texts, images and videos and which allows to build courses and lessons that can also be enjoyed in a flipped classroom model whose potential is highlighted in the literature [4], [5]. The peculiarity of this platform consists in being able to use 360° images that can be viewed on a laptop or in VR mode with a smartphone, by using a simple cardboard. Using a VR platform, the students benefit from rich opportunities in experiential learning, which are inclusive of all learning styles, needs and abilities.

In the present case, a Thing-Link project in VR mode has been created, bringing together multimedia content, significant places and works of art (captured with a 360° camera) related to the theme.

3. Educational Path

The VR educational path begins in the wonderful Palazzo Spada in Rome and guides the student in search of a symbolic painting of the scientific debate of the seventeenth century, between the heliocentric and the geocentric theory: "*The Astronomers*" by Niccoló Tornioli. The analysis of the painting introduces fundamental themes to reconstruct the millennial path that led to abandon the geocentric system. The following step focuses on Galileo's astronomical discoveries and their interpretation, where the students begin to see Galileo as the modern scientist who observes meticulously with an agile mind, curious and completely free from prejudice, eager to reach a single conclusion: the truth. The VR artefacts shows some pictorial and artistic testimonies related to these discoveries in Venice, Florence, Madrid and Monaco.

Galileo's investigative tool was the telescope, a tool that changed the history of astronomy and contributed to cancel 2000 years of Aristotelian philosophy and marked the unequivocal evidence of the need to build a new physics. Students can move virtually in the Galileo room of the History of Science museum in Florence and observe, among other things, the remaining Galilean telescopes. Furthermore, following S. Papert, the father of the constructionism, who suggested that learning is more efficient when it is part of an activity such as building a meaningful artefact, the student was engaged in a laboratory working at the construction of the telescope and helioscope as Galileo did it.

Also, the laboratory was focused in reading parts of Galileo's "Sidereus Nuncius" (book in which Galileo talks about his telescope and his astronomic discoveries), some of them related to the construction of the telescope itself. With scissors, lenses, glue and cardboard, a 10x magnification telescope was built, such as the one that was presented for the first time by Galileo to the Doge of Venice. Today we know the formula of telescope magnification, but how did Galileo determine it? Reading the Sidereus Nuncius students can appreciate the simple practical genius of the eminent scientist.

Using the Galilean telescope is then possible to truly understand the observational difficulties of the past: small field of view, chromatic aberration, difficulty of pointing, how difficult it must have been for Galileo to reconstruct the face of the Moon. Nothing to do with the use of a simple common telescope that can be used by everyone today.

But beyond the enormous observational difficulties, with patience and precision, Galileo gave meaning to small details putting all the pieces together and turning small things into great discoveries. The new image of the surface of the Moon wipes out 2000 years of Aristotelian cosmology: the division between sub lunar and celestial world does not exist, the Moon is of the same matter as the Earth, and the sky is populated by countless objects not visible to the naked eye. All these discoveries definitely highlight how the universe is fundamentally unknown, along with undermining the foundation of astrology.

At that time astronomers were also and above astrologers: in the homocentric vision of the universe, everything was functional to man and everyone, regardless of status and wealth, resorted to astrology. How was then possible to justify horoscopes if there were objects never seen before in the sky?

Moreover, Galileo's ingenious method for observing sunspots and the witty geometric interpretation of their movement allows him, using only reasoning and observation, to dismantle the imaginative and preconceived interpretations originating from the Aristotelian doctrine.

Finally, the discovery of Jupiter's satellites asserts the fundamental truth that not everything revolves around the Earth and a celestial object can safely move in space without losing its satellites: so why Earth can't behave the same way? One of the fundamental objections to the Earth movement was that the Moon could not have maintained its orbit, in case the Earth was moving. So how is that possible? This and other unresolved questions highlight the importance of rebuilding a new physics: no longer an Aristotelian physics based on the centrality of the Earth, but a new physics that can account for terrestrial phenomena assuming earth movement.

The 360° VR tour ends with a visit to the "Il Gioiello", the house now owned by the University of Florence in which Galileo, by then blind, spent his last years in confinement.

In this place he received the visit of the poet John Milton (of which various paintings report the event) who later published the "Areopagitica" – his defense of free speech – where he mentions his journey to Italy and says "*There it was that I found and visited the famous Galileo grown old, a prisoner to the Inquisition, for thinking in Astronomy otherwise then the Franciscan and Dominican licensers thought*".

Here Galileo died January 8th, 1642.

4. Results and Discussion

The students have followed the course with interest and enthusiasm. Beyond the content presented, there were many foods for thought originated by the course itself: science and pseudoscience, science and technology, the role of scientific academies in the past and many more topics.

As a final remark, after knowing and appreciating this part of Galileo's work, the students were offered a reading of Galileo's abjuration. In those words: "*I abjure with a sincere heart and unfeigned faith, I curse and detest the said errors and heresies, and generally all and every error and sect contrary to the Holy Catholic Church*" the students, without any explanation from the teacher, have discovered and recognized how much the genesis of science in the past (and perhaps today) had to struggle with prejudices, personal interests and abuses.

The final test has proved a good understanding of the concepts exposed during the project.

Furthermore, the student's emotions were collected via an anonymous questionnaire and as it can be seen in Figure 1 there is no sign of boredom, tension, sadness or anxiety but only enthusiasm, happiness, fun, satisfaction and surprise. It is reported that positive emotions can successfully influence learning behaviour [6].

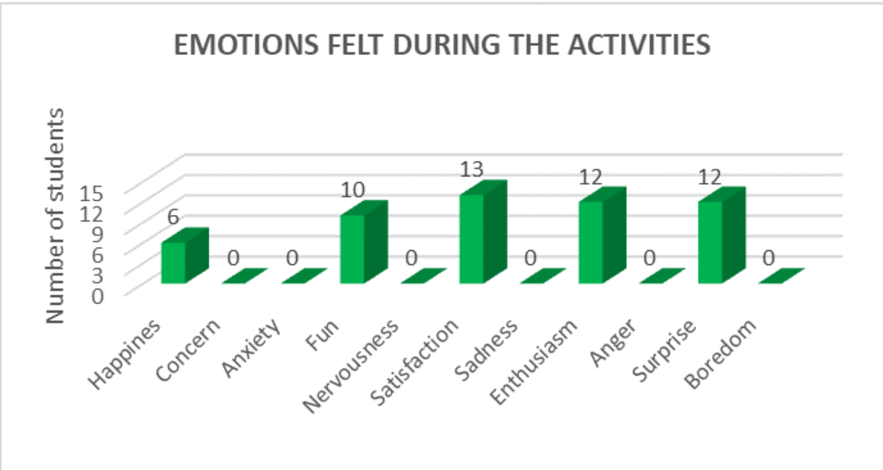


Fig. 1. *Survey's result on the student's emotions*

5. Conclusions

The history of science can be a good means to stimulate the interest of our students and may help to overcome the traditional separation between science and humanities.

Adding the technology as a powerful tool for involvement, all these elements can help to build an interdisciplinary STEAM curriculum [7] and support the students to develop competencies and skills for 21st century [8].

The survey's outcome shows that the students are ready to learn and participate with an active mind-set: the key to the success is to find different or complementary approaches to traditional methods, believing that the proposed work is one of them.

REFERENCES

[1] Camerota F. "Arte e scienza. Da Leonardo a Galileo", Firenze, Giunti, 2009.
[2] Galilei G. "La gaceta sideral", Madrid, Alianza, 2007.
[3] Matthews M. R. "Historia, filosofía y enseñanza de las ciencias: la aproximación actual", Enseñanza de las Ciencias: revista de investigación y experiencias didácticas, 1994, Vol. 12, pp. 255-277.
[4] O'Flaherty J. "The use of flipped classrooms in higher education: A scoping review", 2015, Vol. 25, pp. 85-95.
[5] Karabulut-Ilgu A. "A systematic review of research on the flipped learning method in engineering education", 2017, 49 No 3, pp. 398-411.
[6] Pekrun R. "Emotions and learning", UNESCO International Bureau of Education, 2014.
[7] Madden M.E. "Rethinking STEM Education: An Interdisciplinary STEAM Curriculum", Science Direct., Elsevier, 2013, pp. 541-546.
[8] European Commission "Digital Education Action Plan", Brussels, 2018, pp. 1-12.

Preschool and Primary Education

A School-Made Misconception and its Cause: University Student's Misconceptions on the Formation of River Gravel in Japan

Masaru Taga[1], Toshihiro Onishi[2]
Faculty of Agriculture, Ryukoku University, Japan[1]
Faculty of Science and Technology, Ryukoku University, Japan[2]

Abstract

Children and students acquire misconceptions (naive conceptions) as they grow up. However, in some cases, misconceptions are acquired from science classes of school. As an example, we focused on the formation of river gravel. Japanese rivers are shorter and steeper than continental rivers in Europe and sometimes flow from mountains like waterfalls. Japanese science textbooks in elementary school explain that square stones flow from the upstream of the river and gradually become small round stones as they flow into the middle and downstream. To clarify the misconception of gravel formed in the Japanese river, we surveyed the misconceptions of university students that occur after learning about river gravel in Japanese elementary schools. As a result, understanding of the formation process of gravel in the river is as follows: 1. the stone upstream of river is large, the middle stream is a little small and the downstream is small like pebbles and sand as being scraped or broken. 2. The stone upstream is angular, and as it goes downstream it gradually becomes rounder. This understanding is different from the gravel actually observed. The actual shape of the gravels are as follows: 1. Not only gravels of the same size but also gravels of various sizes are present in the river. 2. The roundness of the river gravel should not be uniform in the same place. 3. The shape of the river gravel (roundness) is not determined by the distance from the upstream to downstream, but by the distance from the point where the gravel is supplied.

Keywords: gravel, misconception, river, shape, formation, science textbook

1. Introduction

As children grow up, they acquire naive concepts, misconceptions that are often scientifically incorrect. Unfortunately, these naive concepts are also not easily modifiable. In science classes, it is important to turn these misconceptions into the right scientific concepts, but new misconceptions can sometimes be created in a science class at school as well, referred to as "school-made misconceptions" [1]. In this paper, one such "school-made" misconception, namely the formation process of river stone (gravel) in Japan, will be studied.

Japanese rivers differ greatly from rivers on continents such as Europe and South America. For example, the Amazon River basin area is 7.05 million km^2, while Japan's largest river, the "Tone River," is 18640 km^2, 420 times smaller. In the central part of Japan, there are many steep mountains on the order of 3,000 meters, and rivers in Japan are shorter and steeper than many in the world [2]. In addition, rainfall levels in Japan are twice the world average, and because its rivers cannot hold excessive water volume, it flows into the sea at once, causing a disaster. There are also common misconceptions among the Japanese public about river stones, or gravel, found in Japanese rivers. Fifth-grade students are introduced to river stone formation through the elementary science curriculum, a part of the Japanese standard curriculum [3], where "the function of flowing water and the change of land" are described. Differences in size and shape of river stones are taught as such: "(1) To examine differences in the speed and volume of water flow, focus on the size and shape of the river stones (gravel)." In particular, the meaning of "capturing the river from upstream to downstream" might be a reflection of cultural conceptions regarding Japanese rivers passed down through the generations.

2. Purpose of Study

The purpose of this study is to clarify that understanding the origin of river stone and sand is Japanese misconception and its cause.

3. Methodology

In order to gain understanding of the shape and size of the stones from upstream to downstream in the river, Japanese university students (128 students aged 20 to 21) were surveyed using a questionnaire (Fig. 1). The questionnaire consisted of 9 questions in total, regarding changes in the shape, size, and speed of river flow from upstream to downstream (No. 1 to 5 in Fig. 1), when and from whom they learned (No. 6, 7, and 9 in Fig. 1), and an understanding of sand formation (No. 8 in Fig. 1).

Survey Questionnaire on River Stone Formation

We are investigating changes in the size and shape of river stones.

1 Circle the number you find closest to the shape of the river stone.

Upstream	squared 1 — 2 — 3 — 4 — 5	round
Midstream	squared 1 — 2 — 3 — 4 — 5	round
Downstream	squared 1 — 2 — 3 — 4 — 5	round

2 Circle the number you find closest to the size of the river stone.

Upstream	large 1 — 2 — 3 — 4 — 5	small
Midstream	large 1 — 2 — 3 — 4 —	small
Downstream	large 1 — 2 — 3 — 4 — 5	small

3 Circle the number you find closest to the speed of the river flow.

Upstream	fast 1 — 2 — 3 — 4 — 5	slow
Midstream	fast 1 — 2 — 3 — 4 — 5	slow
Downstream	fast 1 — 2 — 3 — 4 — 5	slow

4 How do river stones change size and shape as they flow from upstream to downstream?

5 Please write how you came to the reasoning in question 4, above.

6 When did you come to know or learn of the reason provided in question 4?
① before elementary school ② elementary school ③ junior high school
④ high sch0ol ⑤ no reason

7 From whom did you know or learn the above? Please answer by number.
① teacher ② mother ③ father ④ other family ⑤ book ⑥ TV
⑦ experience ⑧ other ( ) ⑨ do not know

8 Please write about how sand is mad.

9 Did what you learn in elementary school affect your thoughts on river stone formation? Please answer by number.
① Yes ② No ③ do not know

Fig. 1. *Survey questionnaire on river stone to students*

The same survey was also conducted for an elementary school teacher (45-year-old male) and the author’s family (32-year-old female, 59-year-old female, 85-year-old female, 88-year-old male).

4. Results

First, Figure 2 shows the survey results for items 1, 2, and 3 (Fig. 1).

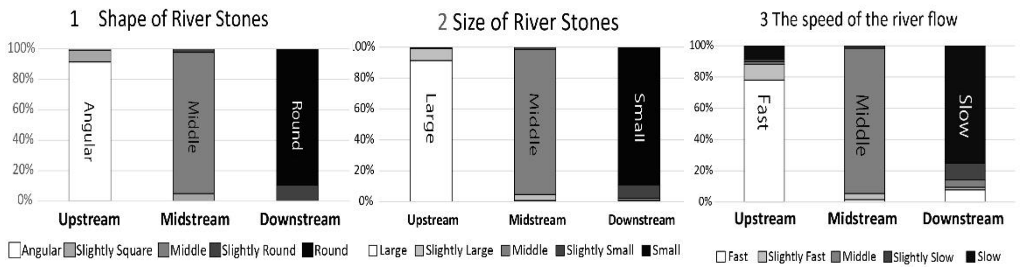


Fig. 2. *Diagrams: Questionnaire results for stone shape & size and speed of river flow*

Figure 2 shows that students perceive river stones as angular and large upstream, middle in shape and size midstream, and round and small downstream. They believe that the speed of river flow is fast upstream, medium in the middle and slow downstream.

They also report that the shape, size, and speed of the river change continuously from upstream to downstream.

Questionnaire item 4 describes how the shape and size of river stones change. As a result, “flows of the river which were large and angular in upstream flowed down, and the stones were cut by the flow of the river or other stones becoming smaller and rounder. And the shape gradually becomes rounder as the water flows downriver.” The participants provided many descriptions where the shape and size of stones change continuously from upstream to middle and downstream, supporting the results of Figure 2. In addition, the results of item 5 support item 4 as indicated by the statement “Stones collide and cut each other”.

Questionnaire items 6 and 7 suggest that fifth graders (69%) in elementary school were taught and understood most of the above-mentioned conceptions, and that they learned from teachers (73%). In item 9, 55% of students thought that elementary school learning was effective regarding the above perceptions, and many indicated the major impact of elementary science classes.

Next, in item 8 regarding the formation of sand, 61.4% of the students thought that “stones would be cut down in the river and become fine and sandy”, and 11.8% of students said that “stone shavings would turn into sand.” Together, 73.2% believed that “sand is formed when stones are washed down from upstream to downstream in rivers.”

Surveys of an elementary school teacher and the author’s family yielded similar results. Although only one elementary school teacher was surveyed, he had almost the same understanding as university students. An elderly 85-year-old female and 88-year-old male in the family also showed the same understanding, suggesting that Japanese people of various ages may have similar perceptions of river stone formation.

5. Discussion

The general perception of Japanese people revealed in this survey is that “upstream, there are many large rugged and lumpy stones, and when descending to the middle stream they gradually become smaller and rounder as they collide with each other in the river." And "going downstream, stones are almost uniformly cut into sand." Next, we consider those results.

5.1 Understanding that large stones gradually become smaller from upstream to downstream

Japanese rivers have various stones of different sizes and shapes. In fact, there are many rocks and large square stones upstream, small round stones and coarse sand in the middle fan and smaller grains and sand approaching downstream. What is the cause? The formation of strata (called sedimentary facies) occurs by the change of flow velocity, resulting in the accumulation of various stones [4]. In sedimentology, the range of such velocity changes is described by the concept of "hydraulic energy" [5]. Hydraulic energy is how large the running water can carry debris particles. In fact, hydraulic energy is exerted on the river by the flow, and the speed of the flowing water can explain the erosion, transport, and accumulation of stone and sand. This force increases as flow velocity increases, while larger stones at the bottom of the river become more difficult to move. In the upstream of the river, small and light stones and sand are washed away because of the high velocity, leaving large and heavy stones. Small stones and sand roll down or float and are transported while remaining in a location that is balanced by flow velocity [6]. Thus, the differences in stone size at the upstream, midstream and downstream is not caused by "cutting corners while colliding" but by "the difference in flow velocity." Hiroki (2019) points out that the understanding that "the size decreases as if being polished when going from upstream to downstream" is wrong. In fact, stones flow into rivers through landslides and debris flows and are subsequently transported by the speed of the stream: that is, hydraulic energy. This energy rapidly decreases and changes from upstream to downstream in Japanese rivers. Therefore, stone transported by running water becomes smaller as it goes downstream. Further, it can be explained that the upstream gravel is large, and the downstream gravel is small. However, current Japanese elementary school science textbooks explain that gravel is reduced by grinding while being transported [7].

5.2 Understanding that angular stones gradually become rounder from upstream to downstream

Next, we will examine the understanding that "from the upstream to the downstream, the angular stones are cut and polished and gradually rounded." According to Furuta (2018), in Japanese rivers (1) the shape (degree of roundness) of the stones of on the river bed is not uniform, even in the same river. (2) Gravel flows only 3 to 4 km without turning over a long distance such as 10 km and becoming rounded. (3) The shape of gravel on the river bed (degree of roundness) is not determined by the distance from the upstream, but by the distance from the point where the gravel was supplied [8]. Certainly, it seems correct that it is washed away by flowing water and polished round. However, in rivers in Japan, stones are actually polished for only a few kilometres rather than over a long distance.

5.3 Understanding of sand formation

Next, we examine the formation of sand in rivers in Japan. Hiroki *et al.*, (2011) suggest that more than half of elementary and junior high school students in Japan consider that sand is formed by riverbed erosion from flowing water in rivers or collision during transport of stone [9]. In this survey, 73.2% of students believed that sand is formed when rocks are washed away from upstream and downstream in rivers, with

61.4% stating that “stones were cut down in the river from upstream to downstream and became fine,” and 11.8% stating that “stone shavings became sand.” However, in fact, the sand downstream of the river cannot be reduced as stones flow down the river from upstream to downstream. Sand is originally formed by the weathering of rocks and is contained in weathered soil [9], which flows into rivers through debris flows and landslides. Thereafter, sand transported from upstream and midstream, where the flow is fast, accumulates in the downstream where the flow is slow, resulting in more sand accumulation downstream. This demonstrates that the understanding that “stone is cut from upstream to downstream and becomes sand” is a misconception.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number 16K04725.

REFERENCES

[1] Barke, H. D., Hazari, A., & Yitbarek, S. “Misconceptions in Chemistry Addressing Perceptions in Chemical Education”, Springer-Verlag Berlin Heidelberg, 2009, p.294.
[2] CTI Engineering Co., Ltd. “Nazenazeomosirodokuhon-bousai kara sinnsui made-なぜなぜおもしろ読本-防災から親水まで-”, Kindaikagakusha, 2012, p. 218. (in Japanese)
[3] The Ministry of Education, Culture, Sports, Science, and Technology (MEXT). “COURSE OF STUDY for Elementary Schools-Science”, Tokyo, Dainippon Tosho, 2017, p. 167. (in Japanese).
[4] Walker, R. G., & James, N. P. “Facies Models: Response to Sea Level Change”, Geological Association of Canada, Newfoundland, 1992, p. 409.
[5] Tucker, M. E. “Sedimentary Rocks in the Field, 2nd Edition”, John Wiley & Sons, Chichester, 1996, p. 153.
[6] Aqua Restoration Research Center, Public Works Research Institute, National Research and Develop Agency, Saai J., (in Japanese) https://www.pwri.go.jp/team/kyousei/jpn/research/m3_04_1.htm
[7] Hiroki, Y. “Hjulström’s Diagram: Understanding the Formation of Detritus Sediment Strata Associated with Stream Water”, Education of Earth Science, 2019, 71(3), pp. 97-107. (in Japanese)
[8] Furuta, Y. “Utsukusii Nagara-kawa no kawarade reki no shinnjitu ni semaru”, Education of Earth Science, 2018, 71(2), pp. 45-46 (in Japanese)
[9] Hiroki, Y., Yamasaki, S. and Hirata, T. “Understandings on the Origin of Sands by Elementary School, Lower Secondary School, and University Students, and Problems on the Lesson of Rock Weathering”, Journal of Research in Science Education, 2011, 52(1), pp. 47-56.

Can a Snail Be a Pet? An Activity Proposal Based on Research Activities

Tânia Mata[1], Ana A. Cruz[2], Ana Paramés[3], Ricardo Machado[4]
ISEC Lisboa – Instituto Superior de Educação e Ciências, Portugal[1,2,3,4]

Abstract

Inquiry Based Learning is a pedagogical approach that engages students in new discoveries [1]. *This work emerged from an activity in the class regarding the reading of two tales from two Portuguese writers: "A nuvem e o caracol" (The snail and the cloud)* [2] *and "A Sofia e o caracol" (Sofia and her snail friend pet) [3]. After these readings, the group discussed their conceptions about the animal and the research question emerged: Can a snail be a pet? The aims of this work were: (1) to design and implement an interdisciplinary activity proposal (Portuguese, Mathematics, Science and Expressions); and (2) to promote scientific literacy throughout the practical science activities. We assumed an interpretative paradigm [4] and developed an action-research project [5]. The participants were nine students from a class that included graders from 1st and 4th, the teacher/researcher and the supervisor teacher. Data were collected through observation, students' protocols and informal conversations. The procedures were developed in three phases: (1) outside of the classroom, the investigation performed by the teacher/researcher related to this animal, his living conditions and possibilities of study in the classroom; (2) in the classroom, students' conceptions about the snail were discussed and the research question was answered for the first time; living specimen were observed and the snail terrarium previously constructed after testing different conditions was analysed; the work and conclusions achieved during phase 2 lead to a different answer to the initial research question and promoted new investigations; (3) in the classroom, students suggested the making of their own classroom terrarium and formulated new research questions, namely regarding nutritional conditions and the life cycle of these animals. During all the procedures, technical and scientific rigor was taken into account. The results shaped that these investigative activities promote scientific reasoning, critical sense, curiosity and introduce students to the scientific method, therefore, developing scientific literacy. All the activities promote interdisciplinarity and stimulate student participation, exploration, and development of abilities and competencies.*

Keywords: Science Education, IBL, Experimental Activities, Scientific Literacy

1. Introduction

Inquiry Based Learning is a valuable strategy for introducing young students into small research activities, promoting the acquisition of scientific knowledge and scientific method [6]. Although undeniably stimulating for children, this approach is also very challenging for educators and teachers who have mostly to cope with rigid schedules and, consequently, do not use it as a common practice in Pre-school and Primary Education in Portugal [7].

IBL is one of the science teaching approaches we develop in ISEC Lisboa in our classes in the Master Degree in Pre-School and Primary Education, and the basis of the work performed by students in *Didactics of Science* and *Experimental Science Teaching* curricular units during their degree. One of the authors of this work, (T. Mata) a student at the time, had the possibility of implementing this proposal in a primary school, in a class of nine students, including graders from 1st and 4th.

2. Method

In this study, we assumed an interpretive paradigm [4] and developed an action-research project [5]. The participants were the nine students from a class including 1st and 4th grade, the teacher/researcher and the teacher supervisor. Data was collected through observation, documents, students' protocols, and the teacher/researcher's diary.

3. Can a snail be a pet? – Proposal of an activity based on research

Using an IBL strategy, we intended to design and implement interdisciplinary science experimental activities in a class including students from the 1st and 4th grade of Primary Education, in order to develop scientific literacy and to introduce scientific method.

Based on the curricular guidelines for the 1st grade ("Discovering the natural environment") and the 4th grade ("Discovering different materials and objects") [8] we decided to choose the snail as our subject of research. This is an example of a not so common animal – the snail (instead of a dog or a cat or a bird) – to be studied in classes, although easily available, harmless and easy to grow and maintain.

The activity was developed in three phases that we summarize in Table 1.

Table 1. *Summary of Activity Phases*

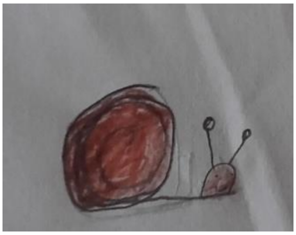
Phases	Aims to achieve and some results
Phase 1 – ***Preparing and planning the activity*** (teacher/researcher)	***To construct a snail terrarium for the class***
Document's analysis:	To adequate activity to the syllabus of the class To select methodology to the study
- curriculum, bibliography	To choose the animal for the study and learn about its characteristics
- bibliography	To establish growth and maintenance conditions
Contact expertise	To test different growth conditions (type of box for the terrarium, soil, humidity, type of food)
Construction of a snail terrarium	 ***Fig. 1.*** *Snail terrarium*

Table 1. *Summary of Activity Phases (cont.)*

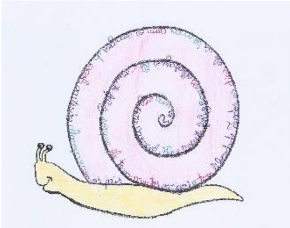
Phases	**Aims to achieve and some results**
Phase 2 ***In class: Introduction of IBL*** (teacher/researcher; students; teacher supervisor) - Reading of the tale *the snail and the cloud* + Drawing a snail - Reading of the tale *Sofia and her snail friend pet* - Investigation and record (books, internet, interviews and observation of live specimen) + - Observing the snail terrarium constructed by the teacher/researcher - Drawing a snail and comparing the first drawing	***Can a snail be a pet?*** To get access to students' knowledge about this animal. To introduce the concept of an *animal pet*. To arise the research question: Can a snail be a pet? All students answered NO! To know the characteristics of this animal and its life cycle To understand its life conditions To manipulate a magnifying glass Students' knowledge increased and changed Students answered the same initial research question (comparison of the "before" and "after" answer) All students answered YES! Students suggested new investigations (type of foods and what happens when the snail dies) and the **construction of a new class snail terrarium**
Phase 3 ***In class: the students' snail terrarium*** (teacher/researcher; students; teacher supervisor) - Designing a protocol - Identification of study variables – students' suggestions (type of food – e.g., "soup", "yoghurt", "rice pudding", "watermelon", among others) - Observation of the snail shell (interior and morphology)	***Evaluate if the students were able to put in action the IBL approach in a new scenario*** To construct the new terrarium and identification of: What will I have held constant? (controlled) What will I change? (independent) What will I observe? (dependent) To understand what happens when a snail die

During all phases of IBL, there was always a concern about relating different curricular areas (science, language, mathematics and expressions), adapting activities and language to the two different graders, in order to promote a meaningful learning. For instance, in phase 2, students were asked to read, interpret and enact the two tales.

Moreover, drawing the snail in two different moments of phase 2, enabled the student to work syllabus of expressions' curricular area, and also to observe and reproduce details of the animal structure and characteristics. The comparison of the snail drawings done in the two different moments (phase 2 and phase 3) showed us that there was an evolution of the concept of the animal that went from a "tale animal" to a "real animal" (position of the eyes (Fig. 2), orientation of the shell spiral). The observation of the snail's shell allowed the teacher/researcher to introduce the concept of spiral (geometry content).



A



B

Fig. 2. *Example of students' drawings before (A) and after (B) the activities*

One of the aspects we would like to highlight is that the students were able to propose new research questions (e.g., "do snails eat soup?"; "do snails eat rice pudding?"), based on the previous work, and their daily life experiences, which is one of the goals of a science teacher. Moreover, the students' suggestion for the construction of a class snail terrarium for the study of other variables showed us not only the motivation and interest of the students, but also the engagement in a way of thinking, characteristic of the scientific method.

4. Conclusion

Our proposal does not require any special material or equipment and can be easily performed in class. The snails are animals with simple growth conditions and a life cycle relatively short (1 to 2 months) which allows the study of the different stages of the life cycle and reproduction, observed during phases 1 and 3.

This interdisciplinary approach highlights that it is possible to work all the curricular areas from a central science theme, overcoming the limits of time and rigid schedules of some institutions.

Investigative activities were performed with teacher guidance and orientation, promoting the development of students' abilities and competencies, namely, responsibility, autonomy, critical sense, reasoning and decision-making. Besides that, this kind of approach enabled students' appropriation of new scientific knowledge, leading to an increase of scientific literacy. Students are stimulated to experiment, manipulate, predict, hypothesize, register, interpret results and conclude, characteristics of the IBL approach and scientific method.

REFERENCES

[1] Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., ...Tsourlidaki, E. “Phases of inquiry-based learning: Definitions and the inquiry cycle”, Educational Research Review, 2015, 14, pp. 47-61.

[2] Torrado, A. “A nuvem e o caracol”, Lisboa, Ed. Asa, 2002.

[3] Colaço, M. R. “A Sofia e o caracol”, Lisboa, Ed. Veja, 2004.

[4] Denzin, N.K. “The interpretive process”, In A. Haberman, & M. Milles (Eds.), The qualitative researcher’s companion, California, Sage Publications, 2002, pp. 349-366.

[5] Mason, J. “Researching your own practice: The discipline of noticing”. London, Rand Falmer, 2002.

[6] Levy, P. “Inquiry-based Learning Planner”. Sheffield: Centre for Inquiry-based Learning in the Arts and Social Sciences, University of Sheffield, 2010.

[7] Santos, M., Gaspar, M., & Santos, S. “A Ciência na Educação Pré-escolar”. Lisboa, Fundação Francisco Manuel dos Santos, 2014.

[8] Ministério da Educação. “Organização Curricular e Programas: 1º Ciclo do Ensino Básico”, Lisboa, ME, 1998.

Pre-Service Teacher's Professional Development

Narrative Inquiry of Chinese Science Teacher Candidates' Cross-Culture Learning Experience in Canada

Chunlei Liu[1], George Zhou[2], Clayton Smith[3], Judy Xu[4]
University of Windsor, Canada[1,2,3,4]

Abstract

This study conducted a narrative inquiry of the experiences of Chinese pre-service teachers who participated in an exchange program. Data were collected through participant observations, reflective journals, and interviews. Results suggest that key challenges participants experienced included culture shock, isolation, language barriers, and undeveloped time-management skills. Based on these findings, the study recommends that to maximize the benefits of cultural exchanges, it is critical to ensure students understand the nuances of time management and the transformative learning process so as to maximize their time and critical engagement while being abroad. Prior to departure students should learn about Western pedagogical models and the possible challenges related to culture shock.

Keywords: science teacher candidates, reciprocal learning, cross-culture, narrative inquiry

Introduction

International exchange and training programs play an integral role in developing international cooperation among educators in different countries (Altbach & Knight, 2007). An increasing number of teachers and school administrators are involved in exchange programs and implement new courses and teaching practices in their institutions. According to Trice (2003), these international exchange programs offer two key benefits: they provide insights into different pedagogies while providing supplemental education, and they provide students who may not be able to afford international education with an opportunity to gain the benefits of an international experience. In addition, participation in international courses can significantly affect educators' teaching practices, expand the scope of teaching methods, make curriculum alumni more culturally sensitive and insightful, and influence their interpersonal relationships, career development, and social status in school. The Reciprocal Learning Program (RLP) is an exchange program that involves two universities, one from China and the other from Canada. Each year, the Chinese university sends teacher candidates to the Canadian university where they spend three months auditing education courses at the Faculty of Education and observed Canadian elementary and secondary schools.

RLP was designed as a transformative learning experience. Marx *et al.*, (2004) defined transformative learning as learning through which individuals critically challenge their beliefs, knowledge, and environment to understand a range of events and phenomena from perspectives outside of their own experience. This new information will then influence their subsequent decisions and reshape or transform their worldview and behaviours. According to Taylor (2007), transformative learning is a process of development that stems from experience. A critical component of transformative learning is that it challenges individuals to change their frame of reference by critically rethinking their assumptions and beliefs. As a result, they consciously develop and implement plans that lead to new ways of defining and engaging with their world. This study conducted a narrative discussion of Chinese science teacher candidates' cross-cultural learning experiences. Two research questions guided the study: What cross-cultural experiences and challenges do Chinese exchange students encounter in the RLP? How does participation in this program influence their perceptions about science teaching?

Literature Review

International teaching experience has been found to increase tolerance and respect for others while contributing to personal development (Byram, Gribkova, & Starkey, 2002). These experiences provide opportunities for teachers to deepen their understanding and reflection of the world and to share global ideas among teacher candidates, which is critical as teacher candidates need to be aware of what they are doing in different contexts. Due to the different cultural backgrounds, teaching internships in China are different from those in Western countries such as Canada.

According to Hynie, Jensen, Johnny, Wedlock, and Phipps (2011), teaching internships in Canada encourage students to recognize the entire world community and foster a desire for diversity in personal relationships. The teaching internship in China is intended to provide students with the opportunity to engage in practice teaching, test their professional knowledge and teaching skills, and identify their own problems. In contrast, China's teaching practice lacks a sense of world identity, and in order to correct this, China is now actively promoting the international teaching internship program.

According to Maynes, Allison, and Julien-Schultz (2012), many international teaching programs have consistently set the same goal: transforming teacher candidates' understanding and pedagogical approaches by increasing exposure to other cultures.

After gaining international teaching experience, teacher candidates should be better able to work in multicultural classrooms (Sleeter, 2001). Cross-cultural experiences allow teacher candidates to learn deeply about a culture through immersion in an international practicum that includes significant, direct, and personal interaction within the culture (Maynes, Allison, & Julien-Schultz, 2012). Goals such as intensifying the world's horizons, enhancing the world's perceptions, and better classroom teaching after returning home are the common outcomes of such programs.

Methodology

This study employed narrative inquiry to investigate Chinese science teacher candidates' cross-cultural experiences in Canada. Narrative inquiry allows study participants to define what is central and crucial in their experience by using their own terms (Connelly & Clandinin, 1990). It can help researchers gain a deeper understanding of the participants' attitudes, viewpoints, and behaviour patterns (Kothari, 2004). Four Chinese science teacher candidates who enrolled in the RLP participated in the study: Pauline, Jennie, Holly, and Zelda. They were in their third year of university study and approximately 20 years old. Data were collected through participation observation, reflective journals, and interviews.

As a research assistant (RA) for the RLP, I had the opportunity to engage with teacher candidates including my study participants. As a result of my involvement in the program, I developed close work relationships with these participants and therefore had the opportunity to observe them on a regular basis throughout the program. My participant observation focused on participants' daily action and involvement in various contexts in Canada including auditing in education course, placement in Canadian school classrooms, and participation in cultural activities prepared by the Canadian university.

One-on-one in-depth interviews were employed as another method to collect data.

Participants were interviewed three times at the beginning, the middle, and the end of the exchange program respectively. The purpose of individual interviews was to understand the participants' narratives, thoughts, and reflections on their exchange experiences, as well as reflections on their cross-cultural learning experience in Canada and how it influenced their personal and professional cross-cultural development.

Interviews were guided by a set of open-ended questions. Interviews lasted approximately 30-40 minutes each and were conducted in Chinese, participant's mother tongue language. All interviewed were recorded and later transcribed for analysis.

Participants were also asked to write reflective journals, which were read and analysed weekly. These journals recorded their description and reflection on what they experienced every day during the three months stay in Canada. Through journal writing, participants reflected on many aspects of their learning processes including language development, cultural understanding, class dynamics, and science teaching practices.

Journal writing provided participants the freedom to describe details about their experiences or challenges, which participant interviews may not cover. It also provided the researcher insights into participants' internal thought processes, which could not be recorded through observation.

Content analysis approach was used to analyse the data. The researcher first read all texts for a couple of times to develop a general understanding of the scope of the data. After the initial review, data were coded and re-coded. Themes were generated through categorizing the codes. In the process of data analysis, three courses of data were cross-read, compared, triangulated, and synthesized.

Findings

Experience and Challenges

Homesickness. Although study participants had lived on their own in China, they had always been in close proximity to their parents. Coming to Canada was the first time they had lived on their own without having access to support from their parents. As a result, participants suffered from homesickness during the first few weeks. For example, Pauline noted that she lived with her mother for 20 years and had never been so far away from her. As a result, she called her mother numerous times throughout the first two weeks. Zelda began to feel excessively homesick by the second or third week and even "cried on the phone while talking to her mother." Holly reported that she missed her parents when she "was unhappy or had difficulty." She went on to state that her parents "always did everything for" her and believed she could not handle living on her own.

Language barrier. Participants had difficulty in Canadian education classes due to their inability to understand the instructor and class interaction. At schools, they did not have confidence speaking with the Canadian teachers and students. The researcher observed that at the lunch hours in schools, Canadian teachers gathered in the staff room, but the participants only socialized with other teacher candidates from the RLP, with whom they spoke Chinese. They rarely spoke with the Canadian teachers.

Time management. Because the school day in Canada is significantly shorter than in China, participants were not sure how to effectively utilize their spare time. Holly's feeling of unhappiness was typical: "I didn't have lots of things to do and I felt empty. I am that type of person who, if I don't have enough things to do, will focus on some unrelated activities." Zelda was unsure how to use her time, which limited her overall engagement and learning outcomes.

Isolation. At the Canadian university, the Chinese exchange students also took some courses with the domestic students. In this context, the feeling of isolation was strong throughout the three-month exchange. Although participants reported that they learned a lot from auditing education classes, they did not feel to be the part of the class community. There was lack of a mechanism to ease their integration into the Canadian classes and address some of the difficulties they encountered.

Changing Perspective about Science Education

Stimulate students' curiosity. Pauline noticed Canadian teachers did not lecture as much as Chinese teachers; instead, they constantly motivate students to ask and answer questions. She was impressed by Canadian teachers' creative and innovative presentations. Pauline majored in geography. In one of Pauline's reflections from the first week, she observed that the pre-service program in Canada emphasized teacher candidates' motivation to teach and described her experience in geography class. With the purpose of learning "the different approaches to teaching," Pauline paid particular attention to teaching strategies. In the second week of auditing the pre-service program, she wrote on some of the differences between Chinese and Canadian pedagogies. For instance, in China, professors often put an emphasis on academic grades rather than students' curiosity, whereas Canadian professors emphasize stimulating students' curiosity.

Jennie recalled the scene when she first entered a Canadian high school: it was a lesson about friction. When conducting physics experiments in Chinese classrooms, students always follow teacher's instructions. Jennie recalled that when she did the friction experiment in China, she just repeated what the teacher did, which she found to be boring. However, in Canada, when the teacher explained friction, she applied the lesson to a practical example the student would be familiar with: the sole of sports shoes.

The teacher first commended that each company had a large amount of money invested in the soles every year, and the fundamental thing was to study the friction of the sole. Then the teacher grouped the students in the class, and let the student select one shoe from each group. The teacher joked that this might be a smelly experiment.

Then the students tested the friction of that shoe. Because the teacher related the lesson to a practical problem, student curiosity and engagement were stimulated.

When observing a lesson on seed germination, Zelda saw the benefits of encouraging students' curiosity rather than simply lecturing them. In the lower grades, the students were required to do "seed germination experiments." By conducting experiments in person, they were able to observe the whole process of germination of a seed and understand the conditions required for seed germination. At the same time, through the teacher's proper guidance, the students also became curious about what substance was causing seed germination and seed maturity. Zelda reported that in the upper grades, students learned relevant knowledge. Through learning, they came to understand the control variable method in the seed germination experiment, the relationship between biology and the environment, and the necessary conditions for seed germination. After having seen this, Zelda expressed that she wished she had had the opportunity to do such an experiment so as to develop an understanding of the science behind this phenomenon.

Knowledge application. One of the similarities that the participants identified between the teaching models used in China and Ontario is the focus on the practical application of lesson content. Jennie said that "Education should originate from and be applied to life" and found that "Canadian Physics textbooks do not focus on difficult and systematic concepts since students may not use the specific knowledge learned in high school in their daily lives in the future." This, she found, was consistent with "the new curriculum reform in China". This was consistent with the lesson on friction, which involved the shoes the students wore. Jennie concluded that this approach was beneficial because "Life is education, which implies that education should originate from and be applied to life."

Zelda noted that the teachers use some practical, everyday objects when teaching students numeracy, such as coins, labels, and stickers. She outlined her process: "When tutoring a student "8+9" in the after-school program, I have the student count different objects several times. When teaching theory and concepts, teachers in Canada are always connecting it with students' experiences and give many real-life examples."

Based on these observations, Zelda expressed a desire to utilize this approach when teaching in China by linking theoretical concepts to practical, real-world examples that students are familiar with.

Pauline asserted that environmental education is a critical component of the study of geography and of students' daily lives. Pauline reported that the geography teacher asked the students to imitate the water cycle, and then the teacher dropped "contaminants (ink)" into the "marine system (sink)" to allow the students observe the results. The students concluded that the pollutants will eventually penetrate into every part of the water cycle, and the students came to understand that the damage caused by water pollution is serious. The teacher then asked everyone to go back and collect the reports of water pollution, and let the students share the information they found in next class. Pauline wrote in her journal: "Canadian society has devoted itself to the cause of environmental protection and formed a social concept of honour and disgrace, and reinforces the belief that it is very shameful to harm the environment and be wasteful."

Although Pauline believed that China's geography education also attaches importance to the environment, she suggested that the degree of emphasis is significantly lower than what she saw in Canadian classrooms.

Pedagogy of science teaching. When asked about how science education differs in primary and secondary schools in China and Canada, Jenny reported that the use of experiments differed significantly. In China, students attend a theoretical class in a conventional classroom that does not have lab equipment and may sometimes have an experimental class afterwards in an actual lab. In this context, student may simply watch the teacher do an experiment as there are limited resource and thus do not always have an opportunity to do an experiment themselves. Alternately, science classrooms in Canada are conducted in a lab and they combine theory with experiments. In this context, there is no clear distinction between theory and practice, especially in high schools. Through the 6-week high school physics class observation, she found that each class combined theory with practice and made the physics class vivid. Therefore, she concluded that after she became a physics teacher, she would follow the Canadian physics teaching pedagogy and teach in the laboratory.

Holly was impressed that Canadian teachers did not confined teaching within the classroom. She recorded in his journal a science lesson about the growth of trees.

Instead of simply telling students about the growth of trees the professor suggested pre-service teachers to go outside to observe what happens to the trees. Holly concluded that the professor's approach was more immersive than just telling students about the topic.

Pauline stated that Chinese geography lessons relied heavily on the textbook and that students consequently may not have a proper understanding of topics. As Holly, she observed that the Canadian teachers took their classes outside to create concrete connections between the textbook and the real-world context. She liked the field trip taking place in Canadian schools. Teachers always reviewed student learning experiences from the field trips to make connections between what they experienced and what they learned in class. Pauline decided that she would employ this pedagogical method in her future science teaching.

In a science class, Zelda noted that the teacher asked the students to design and create a device that uses air pressure to push a propeller so as to move a ping pong ball, but the teacher did not tell the student theoretical knowledge and the concrete operation process; he just gave the materials to the students and then separated the students into different groups. When the students finished the work, the teacher explained the working principle of the device, which left a deep impression among the students. Zelda indicated that this was contrary to the approach used in China, where teachers would introduce the theoretical knowledge first. The Chinese teacher would also provide the students with step-by-step instructions and offer a template for the students to imitate.

Student assessment. Holly noticed that Canadian teachers gave students greater autonomy in terms of test time and group-member selection. For instance, the chemistry teacher she observed allowed students to vote as to whether they would have their chemistry test on either the Friday or following Tuesday when she realized that some students had a biology test on Monday. The teacher also assigned students into study groups using a diplomatic and democratic approach: each student wrote the names of the four students who they most want to study with in order of preference. By calculating the preferences, the teacher then created the groups. However, to encourage students to learn from different students and get different perspectives, these groups were changed after each unit. Based on this experience, Holly decided that "Giving students more autonomy" with respect to testing and participation was something she wanted to employ in her future classrooms.

In the physics class Jenny observed, she noted that the preparation approaches the teacher used were different than those used in China. In Chinese classroom, teachers employ test-sea tactics. Teachers request students to learn through repetition of problem solving. Jenny observed that group discussions were used in Canada. For example, in advance of a comprehensive test on force, the teacher handed out a test discussion page to his Grade-11 students. The test discussion page provided a description of the applications that would be featured in and covered by the upcoming test. The discussion page encouraged peer-to-peer learning through specific instructions: "With your group: 1) Decide on the key events for the problems; 2) Explain to each other the physics that takes place with a focus on forces." Jenny thought the test discussion page provided a novel and inspiring approach for test preparation. Students learned from each other in the exchanges.

Discussion and Conclusions

The participants experienced a number of challenges in this exchange program, including homesickness, language barriers, time management, and isolation. Zhang and Zhou (2010) reported that international students often do not have close friends to associate with in their spare time, and as a result, homesickness and loneliness are common challenges for them. Consistent with their findings, most of the study participants reported feelings of loneliness and homesickness in relation to a lack of social relations and their struggles with living independently. Zhang and Zhou (2010) also reported that one of the major challenges for the international students is their weak English language proficiency, which affects their acclimatization to the new learning environment. Participants in this study also identified language barriers, especially oral communication in English, as the central reason they were not able to socialize with Canadians and integrate into the Canadian university. Study participants experienced the feeling of isolation due to language barriers and culture shock, as well as the different instructional context and requirements as Zhou and Zhang (2014) discussed. Lack of self-management skill was another challenge participant experienced. The test-oriented and competition-driven education system in China does not leave students with much time to do things outside of their studies. They were looked after well by teachers and parents. As a result, students lost opportunities to exercise independent study and living.

When placed in a Canadian learning context, their previous experience posed a number of problems, both with respect to their understanding of Canada's pedagogical model and their own ability to navigate their study and life.

Despite of the challenges they experienced study participants agreed that the exchange program was valuable and influenced their perspectives of science teaching.

Coming from a Confucian pedagogical model, the participants attached significant value to rote learning and teacher-centered approaches; therefore, they were shocked to see a pedagogical model that seemed to devalue rote learning and focused instead on student-centered approaches. In Canada, they saw that teachers used reciprocal auditory learning approaches that involves student speaking out or questioning teachers, as well as visual and tactile/kinaesthetic learning approaches. Moreover, instead of exam-orientated assessment, the teacher relies on multi-assessment tools. Outwardly, these approaches did not seem to promote learning in the way that they had conceptualized learning; however, after being exposed to these styles for a longer duration, they came to value them. They saw that Canadian students who struggled to answer questions or excel on tests performed better when being evaluated with different tools. Moreover, they saw that students who excelled on test struggled with other areas of assessment. This allowed them to recognize that the visual and kinaesthetic learnings in China may be neglected and that the Chinese model, though efficient in many respects was limited. For example, rather than maintaining a rigid commitment to China's Confucian model, Jenny stated that "it is essential for science teachers to be able to find ways to improve students' engagement in relatively boring science class" by incorporating more activities and hands-on learning. This goes for teacher attitude as well. For example, Pauline noted that her own teachers in China were stern compared to their Canadian counterparts. The teacher she observed "had so much energy and passion that every student was smiling all day," which is an approach she hopes to bring back to China.

In order for the participants to see a genuine change in their teaching philosophy, the learning experience they have in the exchange program must be transformative in nature. Firstly, the participants should challenge their own context. According to Wu, Garza, and Guzman (2015), exchange students may not agree with Western teaching philosophies, which may not make sense to their own cultural context. Despite this, exchange student much tries to understand the pedagogies by examining them form a different perspective, which requires asking critical and reflective questions and reserving judgment. At the early stage of this exchange program, study participants noticed that Canadian students had short school days and less homework and they were very critical for this without sound understanding of Canadian education. However, the three-month exchange program offered them opportunities to critically revalue their initial education value and realized many great aspects of Canadian education (Messelink, Van Maele, & Spencer-Oatey, 2015). They learned about the importance of creating an inclusive and accommodating classroom that supports all students with respective to abilities and cultures. In China's teacher-centered culture, when students perform poorly, this performance is often attributed to a lack of effort from the student; however, a more global view would typically frame these struggles as the result of a learning barrier or exceptionality. Although the study participants seemed to be critical of Canadian students who did not dedicated to their studies as much as Chinese students and expressed disapproval of some Canadian students' behaviours in class, they came to realize that Canadian education approaches did have value and helped address the varying needs of diverse learners. In this process of transformation, participants were engaged in self-reflection by writing reflective journals and having critical discussions with peers and mentors.

In conclusion, it is clear that the Chinese exchange students had encountered many cross-cultural experiences and challenges in Canada. However, the data suggests that the RLP has profoundly influenced their views on science teaching. The cross-cultural exchange experience should be recommended for teacher education programs who aim to prepare for innovative and inclusive teachers for schools.

REFERENCES

[1] Altbach, P. G., & Knight, J. (2007). The internationalization of higher education: Motivations and realities. *Journal of studies in international education*, *11*(3-4), pp. 290-305.

[2] Byram, M., Gribkova, B., & Starkey, H. (2002). Developing the intercultural dimension in language teaching. *A practical introduction for teachers. Strasbourg: Council of Europe*.

[3] Connelly, F. M., & Clandinin, D. J. (1990). Stories of experience and narrative inquiry. *Educational researcher*, *19*(5), pp. 2-14.

[4] Hynie, M., Jensen, K., Johnny, M., Wedlock, J., & Phipps, D. (2011). Student internships bridge research to real world problems. *Education + Training*, *53*(2/3), pp. 237-248.

[5] Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

[6] Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., & Tal, R. T. (2004). Inquiry-based science in the middle grades: Assessment of learning in urban systemic reform. *Journal of research in Science Teaching*, *41*(10), pp. 1063-1080.

[7] Maynes, N., Allison, J., & Julien-Schultz, L. (2012). International practice experiences as events of influence in a teacher candidates' development. S. McGill Journal of Education (Online), *47*, pp. 69-91.

[8] Messelink, H. E., Van Maele, J., & Spencer-Oatey, H. (2015). Intercultural competencies: what students in study and placement mobility should be learning. *Intercultural Education*, *26*(1), pp. 62-72.

[9] Sleeter, C. E. (2001). Preparing teachers for culturally diverse schools: Research and the overwhelming presence of whiteness. *Journal of teacher education*, *52*(2), pp. 94-106.

[10] Taylor, E. W. (2007). An update of transformative learning theory: A critical review of the empirical research (1999-2005). *International journal of lifelong education*, *26*(2), pp. 173-191.

[11] Trice, A. G. (2003). Faculty perceptions of graduate international students: The benefits and challenges. *Journal of Studies in International Education*, *7*(4), pp. 379-403.
[12] Wu, H. P., Garza, E., & Guzman, N. (2015). International student's challenge and adjustment to college. *Education Research International*, *2015*.
[13] Zhang, Z., & Zhou, G. (2010). Understanding Chinese international students at a Canadian university: Perspectives, expectations, and experiences. *Comparative and International Education/Éducation Comparée et Internationale*, *39*(3), pp. 43-58.
[14] Zhou, G., & Zhang, Z. (2014). A study of the first-year international students at a Canadian university: Challenges and experiences with social integration. *Comparative and International Education/Éducation Comparée et Internationale*, *43*(2), article 7.

Biology Teaching Has to Be Founded on the Theory of Evolution

Jan-Eric Mattsson[1], Ann Mutvei[2]
Södertörn University, Sweden[1,2]

Abstract

Scientific revolutions may be characterized by the replacement of some fundamental theories by others, changes of scientific practices, transforming the world, and reaching popular consciousness. The theory of evolution by natural selection by Darwin is a good example. The expressions of the theory may change over time; Darwin's hypotheses were in an ordinary language, today often presented as mathematical models. Thus, the theory is explanatory only if the context is well-known and the concepts used are clear. Artificial and natural selection differ, as the (artificial) action based on the choices of acting individuals to reach specific long-term goals, are completely different from the (natural) act (active or passive) by organisms to achieve something within the next minute. Thus, for humans it may be hard to identify the natural selective forces leading to changes, although it is possible to use the perspective of Darwin on cultural activities. The theory of organic evolution was developed more than 150 years ago, and explains almost all of the phenomena in biology. Anyhow, the use of the theory in biology teaching is astonishingly low. Almost all teaching from primary schools to universities, is based on facts or simple mechanisms between individuals. Biological communities on different levels from biotopes to biomes may be included in the curricula but only a small number of students seem to understand the evolutionary background and its processes. In order to increase the understanding of evolutionary theory, some ideas how to reform teaching in general and how to create a better understanding, through fieldwork, observations in nature, discussions etc., are presented.

Keywords: Biology teaching, Darwinism, evolution, natural selection

1. Introduction

Scientific revolutions may be characterized by the replacement of one fundamental theory by another, thus changing the scientific practice, and further transforming the world it partly describes, and finally reaching popular consciousness. The theory of evolution by natural selection as originally described by Darwin is an example of a scientific revolution [1]. This theory, as many others, also may change over time.

Darwin's hypotheses were expressed in a rather ordinary language but today these often are presented as mathematical models [2].

2. Contextual Reality of the Theory

Thus, today the theory may be explanatory only if the context is well-known and the concepts used are understandable. *Natural selection* differs from *artificial selection* not only because of the differences between the meanings of the concepts *natural* and *artificial* but also because of the actual differences between the two types of selections.

The (*artificial)* action based on the choice of an acting individual to reach a specific long-term goal, is completely different from the (*natural*) act (active or passive) by an organism to achieve something within the next minute [3]. Thus, within the human cultural world it may be hard to identify the *natural* selective forces leading to changes in nature, although it may be possible to use the perspective of Darwin on, e.g., cultural activities as literature [4].

3. The Theory of Evolution in the School Context

Although the theory of organic evolution is more than 150 years old, and may explain almost all phenomena in biology, the use of the evolutionary theory in the teaching of this subject is astonishingly low. From our experience, as educators of biology teachers, almost all teaching in biology from primary schools to universities, is based on facts or simple mechanisms including the interaction of, maybe, a couple of species. Although biological communities on different levels from biotopes to biomes may be included in the curricula only a small number of students seem to understand the evolutionary background and the ongoing processes within and between these [5].

Further, usually only minor parts of the content of different biological courses are presented as results of evolutionary processes. Variation and its maintenance are almost always possible to explain out of evolutionary processes. Likewise, similarities within or between taxa also may be explained by the theory out of environmental conditions often regardless the relationship in terms of genetic distance or evolutionary history.

4. Goals…

Based on our experiences of biology teacher training, some ideas about the reformation of the teaching in general may be suggested. We present these as they may increase the understanding and the teaching of the evolutionary theory. Primarily, we here focus on achieving a deeper knowledge of the dynamic processes of organic evolution among students. Simultaneously we try to show how it may be possible to stimulate a better understanding of what is going on in nature, by using a variety of pedagogic methods, like diverse types of fieldwork and observations, discussions, games.

The main challenge for the biology teacher is usually to design the teaching, in order to create the understanding of the dialectic dynamics of all the processes of life, from the regulation of the chemical processes in the cells up to the complex relations between organism constituting (and developing) their biomes on a global scale. The networks of relations between organisms create relatively stable societies but the large individual variation of characteristics almost always result in a number of different responses to the same stimulus. Thus, general principles may be regarded as general, but rarely in more than 70% of the cases.

This perspective is already common in different fields. For example, "biotechnology may have future applications for a concept called "personalized medicine". The explanation is precisely what it sounds like – the move away from a "one size fits all" mentality to healthcare tailored to the unique needs of the patient considering lifestyle and genetics, using targeted therapies, treatments and care [6]. Also, in architecture, "technologies need to be thoroughly integrated into the building fabric; they will also be influenced by the physical and climatic conditions of the site. The nature of the problem is therefore site specific. There will never be a standard "one size fits all" solution [7].

Similarly, the evolutionary results are products of the interactions between the present state of the organic world and the, mainly genetic, variation between actors, from cells to communities, on different levels in the ecosystems.

5. … and How to Achieve them

In order to, among the students, create a general understanding of the evolutionary development the teacher has to acknowledge the variation of biological processes and the fairly common absence of mechanistic relations. This is true, not only within the subject that is being taught, but also among the students in the classroom. The teacher has to accept that even an excellent pedagogic method, selected for teaching a specific subject, only will result in high quality learning among about one half of the students. In order to reach everybody, the teacher has to use a variation of methods palatable for different students and take into account their different learning strategies.

The usefulness of the knowledge content of the students depend on their possibilities to understand the theories and how to make practical use of them. With this in mind the teacher may promote learning of high quality for all.

Primarily, and basic, is the understanding of the processes described by the theory, not the exact facts of previous evolutionary events. Many teachers are aware of the necessity to meet or teach students differently depending on the students' learning strategies. Nevertheless, most of them don't acknowledge the similarities between teaching and evolutionary processes: The variation of characteristics within a group generally result in a variation of the responses to a specific stimulus. In the organic world there will almost always be more than one reaction to one specific action. Here, not only the genetic background and the previous experiences of the organisms are important for the results, but also the organic and inorganic environment may be influential.

In order to create an understanding for the possible variations of the outcome of an evolutionary event, the teacher has to focus on the processes creating new situations rather than descriptions of previous events. From our experience, the different reactions of the students in the classroom on an event or incident, may be used as examples or parables of evolutionary development. If students may react differently also other organisms may show different responses to specific stimuli. By using examples of this type, based on events in the classroom, the teacher may create an understanding of evolutionary processes, based on individual responses but further developed by different kind of communications in the group. In the long run this may change the learning in the class from the individual to the group. When students realise the differences in their learning outcomes and how these differences are beneficial for everybody's learning and also changes the learning culture, they also realise the possibility of the diversity in and between different evolutionary developments.

6. Conclusions

In order to develop an evolutionary based teaching of biology the teacher needs two main competences in this teaching strategy: 1) Personal understanding of the evolutionary processes and how they may work on all levels from single cell organisms to the complete organic world (including all organisms on the Earth); and 2) skills to create situations stimulating learning of all students independent of their different learning strategies.

The first competence may be obtained not primarily by detailed studies of the history of organic evolution but also by own reflections and discussions with others about the processes and the impact of (natural) variation. This may be based on specific cases, but should preferably be made with an open mind, avoiding mechanistic explanations only including a low number of participants. It is always important to have in mind the dynamics of the relations between the performers (on different levels) in the organic world and remember how (genetic) variation always produces different outcomes.

The teachers' own learning experiences are important to share with the students. "But I think I learned much just because of you, we were reflecting but you were thinking, because you had achieved something or learnt something and gave ideas how we could transform specific areas within biology" [7].

The skills of creating active learners in the classroom may be developed by thinking evolutionary. How do we create opportunities for a group of students in order to enhance their learning and understanding of the subject? The answer may be easy but anyhow hard to realise. Use the same evolutionary processes you are supposed to teach. The class is a group of organisms developing together under the supervision of the teacher, who also is a part of this community and its processes.

Thus, the content of the teaching and its organisation has to be closely related and may be used in order to enhance the learning and understanding of the on-going evolution on the Earth.

REFERENCES

[1] Hoyningen-Huene, Paul (1993) Reconstructing Scientific Revolutions: Thomas S. Kuhn's Philosophy of Science. The University of Chicago Press, Chicago and London.

[2] Godfrey-Smith, Peter (2003) Theory and Reality. The University of Chicago Press, Chicago and London.

[3] Golinski, Jan (2005) Making natural knowledge: constructivism and the history of science. The University of Chicago Press, Chicago and London.

[4] Carroll, Joseph (2004) Literary Darwinism: evolution, human nature, and literature. Routledge, New York and London.

[5] Alters, Brian J. & Nelson Craig E. 2002. Teaching evolution in higher education. Evolution 56: pp. 1891-1901.

[6] Mason, Matthew (2020) Biotechnology: Combining Engineering with the Biological Sciences. EnvironmentalSciences.org. https://www.environmentalscience.org/biotechnology

[7] Couzens, Vanessa (2020) Ken Yeang and Bioclimatic Architecture. Australian Architecture Association https://www.architecture.org.au/news/enews/354-ken-yeang-and-bioclimatic-architecture

[8] Mattsson, Jan-Eric, Mutvei, Ann and Lönn, Mikael (2015) Students' Different Strategies in their Development of Knowledge, Understanding, and Skills in Science Education – *Conference proceedings. New perspectives in science education*, 4th ed. pp. 450-454, ISBN 978-88-6292-600-3, Libreriauniversitaria.it

Science and Engineering

"Don't Throw Away your Mobile!": Pupils' Perception of Raw Materials in Electronics

Mariaconcetta Canino[1], Armida Torreggiani[2], Alessandra Degli Esposti[3], Mirko Seri[4], Alberto Zanelli[5]

National Research Council of Italy (CNR) – Institute for Microelectronics and Microsystems (IMM), Italy[1]

National Research Council of Italy (CNR), Institute for Synthesis and Photo-reactivity (ISOF), Italy[2,3,4,5]

Abstract

In this paper we make a re-examination of the messages resulting from the communication products created by pupils of secondary school after participating to a learning paths focused on raw materials and their key role in new electronic technologies. The path is inserted in the "Raw Matter Ambassadors at Schools" project (RM@Schools). The project proposes to 10-17-year old pupils an active learning pathway where students, after attending RM-related classes, are asked to become science communicators and to create dissemination products focused on issues related to RMs. The starting lesson called "Don't throw away your mobile" deals with chemical elements applied in emerging technologies, e.g., Gallium in light emitting diode (LED) illumination, Rare Earth Elements in high efficiency permanent magnets, Indium in flat panel displays and solar cells, etc. All these elements can be found in a mobile phone, from here the name of the lesson. More than 20 dissemination products collected along 4 years of activity are examined. Due to the general character of the lesson, the related dissemination products deal with several topics including ethical and geopolitical issues consequent to the exploitation of natural resources, the analysis of the materials composing mobile and recycling strategies, and the researches on the substitution of critical materials with environmentally friendly alternatives. In addition to the most used communication tools like didactic videos and power point presentations, the pupils' creativity elaborated also stories in the form of comics and cartoons. A detailed analysis allows to understand which are the most important RM-related issues for pupils and identify the most promising strategies for an unbiased communication of the topic.

Keywords: secondary school, critical raw materials, electronics, research, communication

1. Introduction and Methodology

The supply of raw materials is crucial for Europe economy. Since the supply of a certain group of raw materials is a major concern for European industry growth [1], it is important to create a strategy to face this problem with a holistic approach: better exploitation of local resources, substitution of critical raw materials, transition to circular economy. Education of highly skilled professional is a mandatory element in such strategy. For this reason, the European Commission has funded a pool of educational projects, finalized to explain the value of raw materials to society. The project Raw Matters Ambassadors at Schools (RM@Schools) [2] has received funding by the European Institute of Technology (EIT) in the sector of Raw Materials [3] since 2016. It is aimed to raise awareness of the importance of some materials in everyday life in schools and promote the image of science & technology for students aged 10 to 19 years in order to make new professional careers in this sector attractive to youngsters.

The learning pathways proposed in RM@Schools are addressed to a whole class and are featured by a modular structure. The core activities consist in attending a lesson on RM-related issues lead by a researcher and in the creation of a dissemination product inspired by the lesson [4]. Further activities can include either attending a second lesson to learn more or to deepen the previous knowledge, or running an experiment, or visiting a research center, or a company.

In this paper we focus on learning pathways related to raw materials in electronic devices. The core lesson is named "Don't throw away your mobile!". The choice of the title is due to the fact that mobile phones are widely accessible devices which exploit many innovative technologies. The topic is introduced by a google search of "raw materials in electronic devices" which shows the most relevant criticalities in the RM supply chain: scarcity in the Earth crust, provenience, pollution, prices, and ethical issues. Then, we speak about the properties of materials used in various sectors of the semiconductor industry: electronics, photovoltaics, lighting, signal transmission through fiber optics. The main scientific topic of the lesson is the substitution of indium tin oxide (ITO) in transparent conductive electrodes. Since participation in the project is meant to deepen the curricular knowledge, a "context-based" educational approach is chosen in order to raise interest in the audience [5].

The lesson "don't throw away your mobile!" can be combined with other lessons: i) "Organic materials for photovoltaics", which deals with the use of alternative photoactive materials, instead of (conventional) Silicon, for the fabrication of photovoltaic devices; ii) a lesson about the lifecycle of RMs integrated in electronics, with a focus on circular economy.

The learned contents are re-elaborated by the pupils in autonomy with the class split into groups of 4-5 people. In this paper we make a re-examination of the topics treated in the communication products created by pupils of 13 classes.

2. Results and Discussion

2.1 State of the art before taking part in the project

In order to have a better evaluation of the background knowledge among high school students, it is useful to report on the results of a survey prepared by the pupils of two pilot classes, who attended the lesson a couple of weeks in advance with respect to their peers [6]. The survey was made up of 27 questions covering several topics concerning RMs. 433 pupils aged between 13 and 18 years took part in the survey. We can comment some of the answers, see Figure 1. The correct answer to the question "what is the percentage of raw materials imported by Europe?", i.e., ">80%", was given by 14% of the audience. This indicates that pupils' awareness about criticalities in RM supply was limited before taking part in the project. Pupils favourite solution to RM issues, represented by the question "Which is the best option to invest in?", is Recycling, chosen by 47% of the audience. The focus on recycling is probably related to the feeling of empowerment towards the topic: indeed, recycling is something that most people are used to in everyday life and is perceived as something possible. Other solutions are perceived as a prerogative of scientists and engineers. However, though good recycling practices are widespread for materials like glass, paper and plastics, in most cases electronic devices are bound to lie in a drawer at the end of their lives [18].

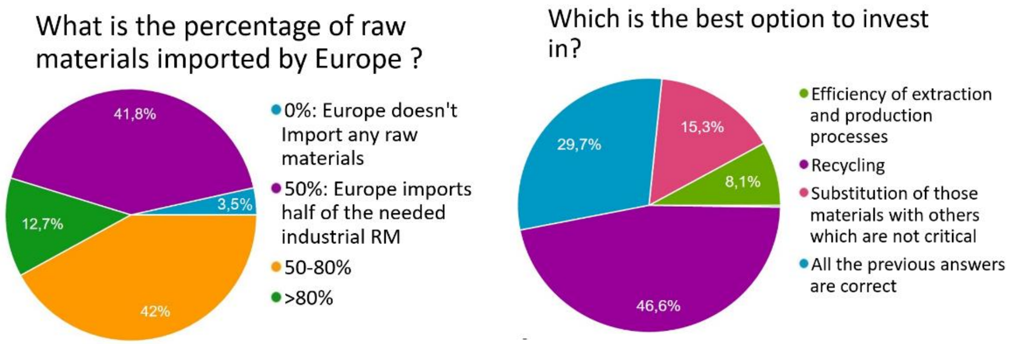


Fig. 1. *Answers to the survey*

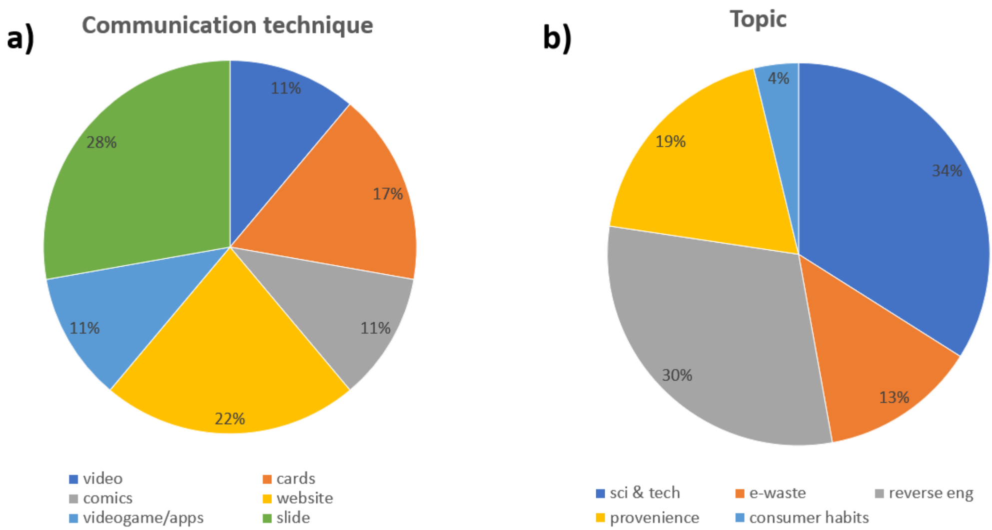
2.2 Dissemination products

Table 1 summarizes the main features of the collected products. The products are grouped by class and each class has been given a progressive number.

Table 1. *Title, class number, type of communication technique, age, main topics (including mobile), number of lessons attended by the class, reference number for each product*

title	class nr.	type	age	topic 1	topic 2	mobile Y/N	nr. lessons	ref.
don't throw your mobile… recycle it!	1	poster	11	elements	e-waste	mobile	1	[7]
elements in a mobile	1	poster	11	elements	reverse eng	mobile	1	[8]
waste of materials	1	poster	11	elements	provenience	mobile	1	[9]
don't throw away your mobile	2	slide	11	reverse eng	provenience	mobile	1	[10]
supercell	3	comics	11	e-waste	consumer habits	mobile	1	[11]
do not throw your cellphone (correct disposal)	4	slide	14	e-waste	provenience	mobile	1	[12]
don't thrpw away your phone (pollution, depletion)	4	slide	14	e-waste	sci & tech	mobile	1	[13]
Smartphones	5	slide	15	reverse eng	elements	mobile	1	[14]
padlet	6	website	14	sci & tech	reverse eng	mobile	1	[15]
a tresure in my pocket	7	video	16	provenience	reverse eng	mobile	1	[16]
substitution and miniaturization	7	video	16	sci & tech	substitution		1	[17]
interviews about consumerism	7	video	16	e waste	consumers habits	mobile	1	[18]
galaxy	7	video	16	reverse eng	sci & tech	mobile	1	[19]
light in blue bulbs	8	cards	16	reverse eng	substitution	mobile	2	[20]
PS4	8	cards	16	reverse eng	sci & tech		2	[21]
li battery in mobile	8	cards	16	reverse eng	recycling	mobile	2	[22]
hybrid cars	8	cards/website	16	reverse eng	elements		2	[23]
polaroid	8	cards/website	16	reverse eng			2	[24]
public event san lazzaro	9	event	16	sci & tech	consumer habits		1	[25]
"Have you seen it ?" Looking out for Europium.	10	video	16	sci & tech			3	[26]
magnetic levitation trains	11	cards	16	reverse eng	provenience		2	[27]
lithium battery	11	cards	16	sci & tech	e-waste		2	[28]
lithium battery	11	slide	16	reverse eng	recycling		2	[29]
drugs	11	cards	16	reverse eng			2	[30]
formula 1	11	cards	16	reverse eng	provenience		2	[31]
digital camera	11	cards/website	16	reverse eng	provenience		2	[32]
videogame	12	slide + videogame	16	e-waste	provenience	mobile	1	[33]
element id cards	12	slide/cards	16	reverse eng	provenience	mobile	1	[34]
apps "power electronics"	13	apps	17	sci & tech	provenience		1	[35]

Almost every class made homogeneous works with respect to the communication technique (e.g., video, slide presentation…), owing to two possible reasons: first, the type of output is established in advance by the teacher and the researcher; for example, cards are frequently proposed in order to focus on chemical elements and on working principles of electronic devices. In other cases, the of the means of communication is chosen by the class in order to create homogeneous products which can be grouped: this is the case of the videos produced by class nr. 7 and of the pallet produced by class nr. 6. Thus, the output by elaboration techniques, is presented in Figure 3a by grouping the class as a whole. We identified 7 categories of communication techniques. The preferred means of communication are slide presentations, for their ease of realization and versatility, also used as a supporting material for other types of product. Pupils produced also a good number of websites, which are used also to make the presentation of the content (for example of a card) more attractive. The interest for computer-based products is also witnessed by the presence of apps and a videogame. The occurrence of cards appears connected with agreement made by teachers and researchers, and for this reason is to be interpreted as a top-down assignment.



In Table I two columns summarise the main two themes touched by each product

Figure 3b summarizes the occurrence of each theme. For this analysis each product is counted as a single one. The most recurring topic is “science and technology” referring to products in which physical or chemical properties of one critical RM are described in order to explain the working principle of a device or to explore the feasibility of their recycling or substitution. In this kind of product, students often talk about graphene which is introduced in the lesson “don’t throw away your mobile”. Beside graphene, Europium for magnets, and Lithium recycling are treated. The second choice is reverse engineering, i.e., the analysis of the materials constituting an electronic device. Objects such as lithium batteries, hybrid cars, and digital cameras, are ideally dismantled to gather information on the materials they are made up of. Dismantling of mobile phones is mainly chosen by younger students (<16-year-old) who attended only the class “Don’t throw away your mobile”. The focus on provenance issues is coherent with the poor awareness of Europe dependence on RM import evidenced by the peoples who answered the survey. Many products recognize e-waste recycling and virtuous consumer habits as possible solutions to critical RM issues. Most of these products have a pedagogic intention: people are urged to pay attention to the correct disposal of their technological devices and consumerism is criticized. Though the lesson “don’t throw away your mobile” is centered on substitution of critical RMs in emerging technologies, the title induces to consider the end of life of electronic devices. This bias sums to the initial situation depicted by the survey: indeed, before attending the learning pathway, the interviewed pupils showed interest in recycling as a solution that they can afford.

Thus, the way pupils speak about recycling in a dissemination product addressed to their peers is coherent with the spirit of the project.

3. Conclusions

We analysed the messages resulting from the communication products created by pupils of secondary schools after participating to learning pathways focused on raw materials and their key role in new technologies and electronic devices. The goal of the lessons was to make pupils aware of the importance of the research in the field of critical raw materials. The fact that most products focus on the properties of elements which make them unique in the production of important electronic devices indicated that the goal has been reached. Moreover, these products indicate that the choice of the context-based approach is effective in involving the students in the search for solutions. The high occurrence of products which deal with mobile phones indicates that probably a combination of the lesson "don't throw away your mobile!" with lessons centered on other topics fosters students' abstraction capability; coupling the lesson with an experiment on ITO substitution can help in fixing the concept of substitution of critical RMs.

REFERENCES

[1] https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en
[2] http://rmschools.eu
[3] https://eitrawmaterials.eu/eit-rm-academy/
[4] http://rmschools.eu section "Events"
[5] King, D. "New perspectives on context-based chemistry education: using a
[6] dialectical sociocultural approach to view teaching and learning", Studies in Science Education, Taylor and Francis, 2012, Vol. 48, No. 1, pp. 51-87.
[7] Survey on perception of raw materials among youngsters.
[8] Don't throw away your mobile, recycle it!
[9] Elements in a mobile
[10] Waste of materials
[11] Don't throw away your mobile
[12] Supercell
[13] Don't throw your cellphone (correct disposal)
[14] Don't throw away your phone (pollution, depletion)
[15] Smartphones
[16] Padlet
[17] A treasure in my pocket
[18] Substitution and miniaturization
[19] Interviews about consumerism
[20] Galaxy
[21] Light in blue bulbs
[22] PS4
[23] Li battery in mobile
[24] Hybrid cars
[25] Polaroid
[26] Public event in San Lazzaro
[27] "Have you seen it?" Looking for Europium
[28] Magnetic levitation trains
[29] Lithium battery
[30] Lithium battery

[31] Drugs
[32] Formula 1
[33] Digital camera
[34] Videogame
[35] Element ID cards
[36] Apps “power electronics”

Parameterization of Whirling Inner Circles

Tanja Van Hecke[1]
Ghent University, Faculty of Engineering Sciences, Department of Information Technology, Belgium[1]

Abstract

Optical illusions attract young people because they are surprising and mysterious. They can also be used as a starting point for a mathematical topic such as parametrization of planar curves. From a mathematical point of view, this paper describes the path of fixed points on a circle while whirling inside a larger circle. A surprising linear path is evoked under specific conditions and is analysed by mathematical parameterization, which can be used to start discussing parameterizations of planar curves in a calculus course at university first degree level. Moreover, we provide Maple-code to foster student exploration of paths on whirling inner circles. A description of the implementation and students' reactions in our own calculus classes is added.

Keywords: parameter, modelling, geometry

Introduction

Popular internet movies (www.youtube.com/watch?v=pNe6fsaCVtI) show the surprising optical result of dots moving on a straight line when a circle through the origin rotates with fixed point (0, 0) inside the outer circle with center (0,0) and radius *R*. The American University in Washington DC (Rose-Henig & Shapiro, 2013) developed an applet, which visualizes this movement. The amazement awakened by this applet is an exquisite opportunity for mathematics teachers of calculus courses to let students understand this phenomenon by means of geometry and parameterizations (Adams & Essex, 2013) (Harrison & Afima, 1993) of planar curves. A simulating tool can serve as a confirmation of the constructed mathematical model. Controlling the movements of the circles by means of this simulation tool (made with Maple-code (www.maplesoft.com)), will strengthen their deeper understanding of the parameterization.

1. Parameterization

We want to define a fixed point on an inner circle with radius $\frac{R}{2}$, which is rotating around its center. Its center is moving on a circle with center (0, 0) and radius $\frac{R}{2}$. With names defined in Figure 1, we can write down a vectorial identity

$$\overrightarrow{OP} = \overrightarrow{OM} + \overrightarrow{MP} = \left\{\frac{R}{2}\cos\varphi, \frac{R}{2}\sin\varphi\right\} + \left\{\frac{R}{2}\cos\alpha, \frac{R}{2}\sin\alpha\right\},$$

so an arbitrary point *P* on the inner circle through the origin can be described as

$$PARA: \begin{cases} x = \frac{R}{2}\cos\varphi + \frac{R}{2}\cos\alpha \\ y = \frac{R}{2}\sin\varphi + \frac{R}{2}\sin\alpha \end{cases} \qquad 0 \leq \alpha, \varphi \leq 2\pi.$$

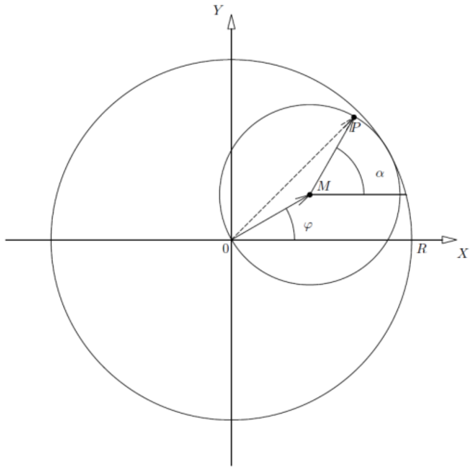


Fig. 1. *Notations in the parameterization of the whirling inner circle*

2. Varying Parameters

Changing the angle φ makes the inner circle move along the outer circle, while changing the angle α moves *P* along the inner circle while the center and radius of the latter are fixed. Figure 2 (left) shows the movement caused by varying φ. We start from an initial circle with center (R_2, 0) and radius R_2, which contains a chosen point *P*.

Consecutive circles ($\varphi = i\,\frac{\pi}{3}, 0 \leq i \leq 5$) with center M_φ arise where only the center M_φ is making a circular movement, but where no movement along the inner circle is present as α is fixed. The dashed line shows the circular path of point *P* for this variation.

When α is the only angle that is varying, a circular movement as in Figure 2 (right) is created along the initial circle with center (R_2, 0) and radius R_2.

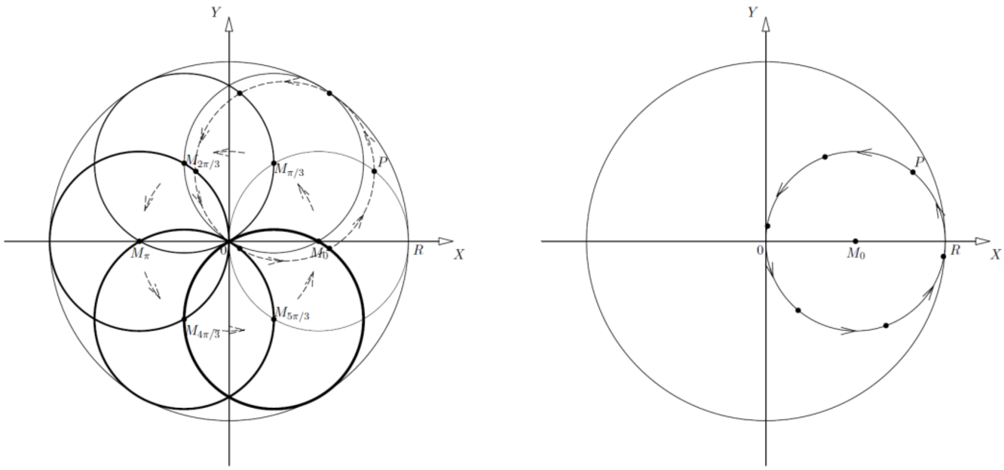


Fig. 2. *Circular path described by a point P with varying i (left) and with varying α (right)*

When the variations of φ and α are combined, the inner circle is whirling counter clockwise, while meanwhile we move along the inner circle. The movement from point

$A_1(x_1, y_1)$ to point $A_2(x_2, y_2)$ parameterized as in *PARA*, will follow a straight path through the origin as in Figure 3 if $\Delta\varphi = -\Delta\alpha$ with $\Delta\varphi = \varphi_2 - \varphi_1$ and $\Delta\alpha = \alpha_2 - \alpha_1$. This can be verified by calculating the slope of the tangent of the curve

$$\begin{cases} x = \frac{R}{2}\cos(\varphi_0 + \Delta\varphi) + \frac{R}{2}\cos(\alpha_0 - \Delta\varphi) \\ y = \frac{R}{2}\sin(\varphi_0 + \Delta\varphi) + \frac{R}{2}\sin(\alpha_0 - \Delta\varphi) \end{cases} \qquad 0 \le \Delta\varphi \le 2\pi$$

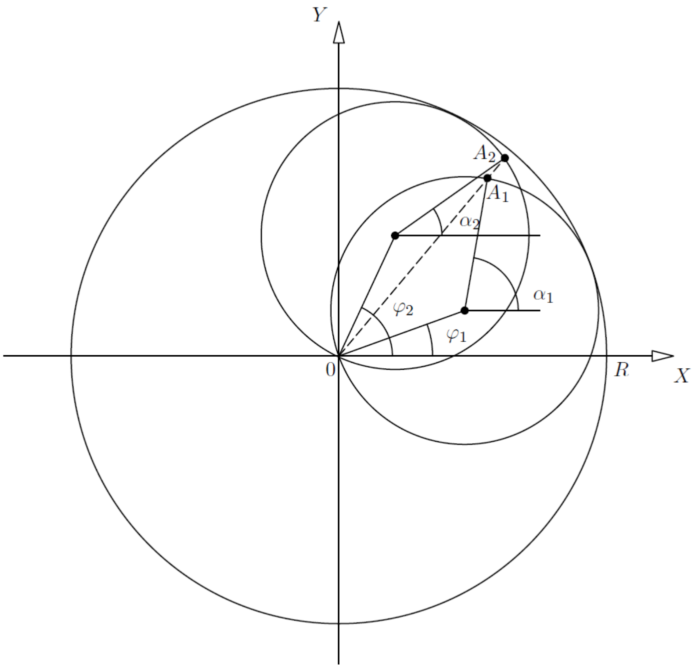


Fig. 3. *Linear path of circle points*

described by the single parameter $\Delta\varphi$:

$$\frac{dy}{dx} = \frac{dy/d\Delta\varphi}{dx/d\Delta\varphi} = \frac{\cos(\varphi_0 + \Delta\varphi) - \cos(\alpha_0 - \Delta\varphi)}{-\sin(\varphi_0 + \Delta\varphi) + \sin(\alpha_0 - \Delta\varphi)}.$$

Due to the sum-to-product formulas in trigonometry, this expression is equal to *y*/*x* (as they are both equal to $\tan\frac{\varphi_0+\alpha_0}{2}$), the slope of the line through *P*(*x*, *y*) and *O*(0, 0).

This confirms the linear path through the origin.

For the choice $\varphi_0 = 0, \alpha_0 = \frac{5\pi}{18}, \Delta\varphi = \frac{\pi}{6}$, consecutive points

$$P_i\left(\frac{R}{2}(\cos\varphi_i + \cos\alpha_i), \frac{R}{2}(\sin\varphi_i + \sin\alpha_i)\right)$$

with

$$\varphi_i = \varphi_0 + i\,\Delta\varphi$$
$$\alpha_i = \alpha_0 - i\,\Delta\varphi$$

are created for $i \in \{0, 1, 2, 3, 4, 5\}$, which are collinear as φ is increasing at the same speed as α is decreasing. This linear movement of the point *P* along a line through the origin, is shown in Figure 4.

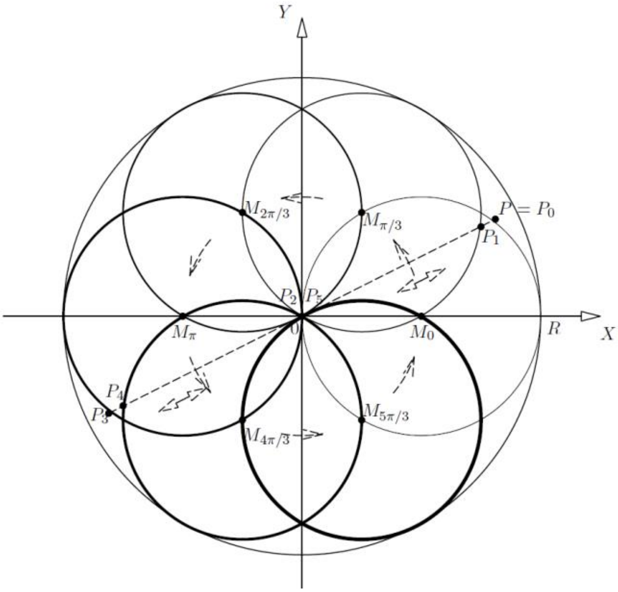


Fig. 4. *Circular path described by a point P while φ is increasing with $\Delta\varphi$ and α is decreasing with $\Delta\varphi$*

3. Simulation Tool

For students with some experience in mathematics and coding, an added value can be reached with an additional simulation instruction using Maple-coding. When this approach is beyond the scope of the student group, it can still be used as demonstrative material.

3.1 Creating a linear path when $\Delta\boldsymbol{\varphi} = -\Delta\boldsymbol{\alpha}$

Students can create the path that a point *P* on the inner circle is describing, by writing the following Maple-code. The graph will convince them of the linear character of the path while the inner circle is rolling inside the outer circle.

```
R: =2:
phi0: =0:
alpha0: =Pi/4:
x: = R/2*(cos(phi0+n) + cos(alpha0-n)):
y: = R/2*(sin(phi0+n) + sin(alpha0-n)):
verz: = {seq ([x, y], n = 0 ... 10)}:
with(plots):
pointplot (verz);
```

3.2 Varying one parameter at a time

To experience the influence of each of the determining parameters, the following Maple-code will create an animation which visualizes the variation of $\varphi,\ \alpha_0$ and $\Delta\varphi$ each at a time.

```
phi0: = 0:
alpha0: = Pi/4:
```

```
x: = cos(phi0+n) + cos(alpha0-n);
y: = sin(phi0+n) + sin(alpha0-n);
condition: = [[phi0=Pi/4, n=0], [alpha0=Pi/8, n=0],
[alpha0=Pi/8, phi0=Pi/4]];
for j to 3 do
co[j,1]: = subs(condition[j], x);
co[j,2]: = subs(condition[j], y)
end do;
with(plots);
animate curve ({[co [1,1], co [1,2], alpha0=0…2*Pi],
[co [2,1], co [2,2], phi0=0...2*Pi],
[co [3,1], co [3,2], n=0...2*Pi]}, view = [-3…3, -3...3])
```

4. Incorporation in Math Classes

We evaluated this developed application with our first-year engineering students. In their calculus course in the first bachelor year a chapter is dedicated to curves described by parametric equations, for which this application is appropriate. Because a course on programming is only given after the calculus course, the coding in Maple was not feasible. However, the animation tool based on the Maple-code was successful as demonstration material. This was preceded by a collective view of the YouTube video, which evoked students' attention that was far more than on average. The explanation of the mathematical formulas was tackled after the students got a deeper understanding of the problem and notations. This was reached by ten minutes during exercise to find the parametrization *PARA*. They were asked to work independently and to make use of Figure 1. Two students addressed the lecturer after the lesson. They expressed that they would appreciate if the Maple-code was uploaded in the electronic learning environment, so they could experiment on their own at home. A request that can only be welcomed. A general survey among the students on their opinion about the content of the lesson, revealed that they were pleased to have classes where mathematics is more than proving formulas.

5. Conclusions

For students with moderate interest in mathematics the topic of a circle whirling inside an outer circle can be an attractive subject to discuss parameterizations of planar curves in a calculus course at university first degree level. The subject can be offered to students with limited mathematical background as demonstrative material, while the creation of a simulation tool is a far more challenging instruction, appropriate for students with more developed mathematical and ICT skills.

REFERENCES

[1] Adams, R. and Essex, C. (2013). Calculus. Canada: Pearson.
[2] Harrison, M.C. and Afima "Parametric curves: an introduction to curve design", Teaching Mathematics and its Applications 4 (1), 1993, pp. 167-173.
[3] Rose-Henig, A. and Shapiro, A. "A comparison of hypocycloid perception produced by two different elemental constructions", Journal of Vison 13 (9), 2013, pp. 819-819.

Science and Environment

Educational Approach for a Sustainable Energy Future

Mona-Christin Maaß[1], Alexander Tasch[2], Niklas Weber[3], Cynthia A. Volkert[4], Thomas Waitz[5]
Institute of Materials Physics, Georg-August-University Göttingen, Germany[1,3,4]
Department of Chemistry Didactics, Georg-August-University Göttingen, Germany[2,5]

Abstract

Climate change increasingly threatens our everyday life and demands important changes in how we use energy. The EU targets a 40% decrease in greenhouse gas emissions compared to 1990, an increase in shares of renewable energies to 27% and an improvement in energy efficiency of 27% until 2030. The research of the Collaborative Research Centre (CRC) 1073 "Atomic scale control of energy conversion" at the University of Göttingen contributes to these goals by acquiring the fundamental knowledge needed for the development of clean and more efficient ways to convert and store energy. But a clean energy supply can only be reached when everyone and especially the next generation is willing to contribute. Therefore, the CRC educational approach is to develop accessible and exciting hands-on experiments to arouse interest and initiate social discussions about renewable energy. These experiments are regularly exhibited at numerous local public events like "IdeenExpo" in Hanover and "Girls' Day". All primarily target school students. Apart from that, they are essential parts of camps at the XLAB – Göttingen laboratory for young people and of "Hands-On Energy Science Workshops" at the University of Göttingen offered for and adapted to the individual knowledge and interest of local school classes. The triboelectric generator which uses friction losses to generate power is presented here as an example of one of the hands-on experiments. It is based on CRC projects about understanding and controlling friction and energy dissipation in order to improve energy efficiency. The triboelectric generator can be included in an interactive display when shown at public events, or can be explained with the help of everyday phenomena and entertaining experiments when presented directly to school students.

Keywords: Experiments, energy science, research

1. Introduction

The Collaborative Research Center 1073 (CRC 1073) is a research institution in which physicists and chemists from the Georg-August-University Göttingen, the Clausthal University of Technology, the Max Planck Institute (MPI) for Biophysical Chemistry and the German Electron Synchrotron (DESY) have the overarching research goal to understand and control energy conversion in materials at the atomic scale. They are divided in three working groups (A-C) which deal with energy losses (A), energy conversion of optical excitations (B) and energy storage (C) [1]. Their work is highly valuable for the society, as it aims to provide the fundamental knowledge needed to improve the renewable energy technologies to such an extent that the EU climate targets to drastically decrease the greenhouse gas emissions and increase shares of renewable energies can be fulfilled.

2. Educational Approach of the CRC

In order to implement the research results, politicians and the society need to appreciate and rely on research and to actively live and use energy in a responsible and conscious way. For this reason, the educational approach of the CRC is to get in touch with the general public and especially school students via experiments. School students are the main target group, since they are the next generation and will shape the future.

Experiments are appropriate tools to arouse curiosity in energy science, gain an insight into the CRC research projects and thereby pass an understanding of research and the generation of research results on to school students. Furthermore, they can stimulate rethinking about our current use of resources without blaming or convicting.

The CRC presents them at fairs like the “IdeenExpo” in Hanover which is Europe’s largest science fair for school students. Besides that, they are the central elements of courses and camps at the XLAB – Göttingen laboratory for young people and of “Hands-On Energy Science Workshops” for school students. The educational concept of the workshop about the hydrogen economy was already published [2].

The recent “Fridays for Future” demonstrations of school students all over the world reveal that educational approaches like the one of the CRC actually work.

3. The Triboelectric Generator

The triboelectric generator generates power from friction losses. This opens the opportunity to increase the efficiency of energy generation using wind or water power. In addition, friction is present everywhere in daily life and could be used to incidentally generate energy. Therefore, Zhu *et al*., developed already a prototype of a generator included in a commercial shoe [3].

The triboelectric generator builds a bridge between the CRC scientists and school students or the general public, because:

- it triggers discussions between them about the energy future.
- it is closely related to the CRC research project A01.
- the triboelectric effect is an everyday phenomenon.

The educational objectives of the interconnecting triboelectric generator are: Students

- think about their current use of energy or resources and the energy future.
- discuss based on scientific knowledge using the right scientific terms.
- have a better understanding of research and its impact on their life.
- trust in research results.
- are interested in energy science.

3.1 Related CRC research project

Project A01 in the CRC aims to fundamentally understand and control friction and the related energy losses or dissipation in the material at the atomic scale by performing measurements with an Atomic Force Microscope (AFM) (s. Figure 1). The motivation behind it are applications e.g., for bearings or climbing shoes. Friction losses in ball bearings need to be minimized, whereas friction is required for climbing.

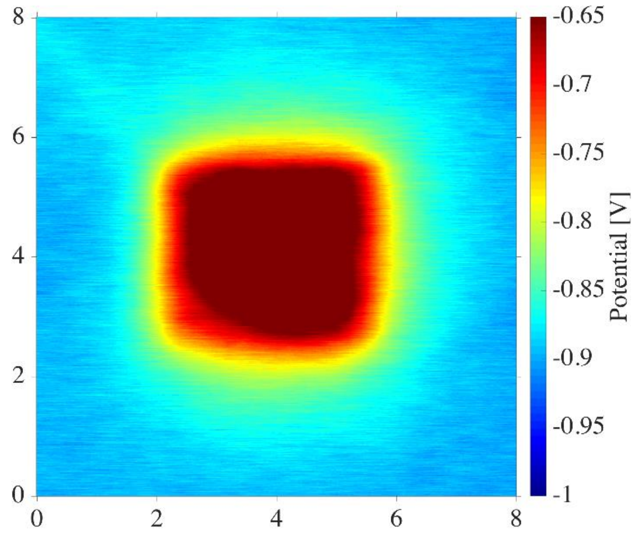


Fig. 1. *AFM image of a polymer surface (8 µm x 8 µm) showing local charges. It can be observed that the area which was scanned before is charged*

The triboelectric effect is one of many energy dissipating channels in the material caused by friction and can be studied with an AFM. To get an AFM image of the surface topography of a sample at the nano-meter scale, a tip with a tip radius of a few tens of nano-meters scans the samples surface. Thereby, the triboelectric effect between the tip and the sample causes the sample surface to become charged. In Figure 1 the surface area which was scanned before has a different colour than the surrounding area which reveals that it is charged.

3.2 The student experiments

Students know the triboelectric effect from their everyday life. They probably have all occasionally received an electric shock for example when they have touched a door knob. This happens, because they got charged by the triboelectric effect acting between them and the floor during walking. The lightning during thunderstorms is another everyday phenomenon caused by this effect.

German school books contain several very simple student experiments which demonstrate the triboelectric effect [4].

The CRC experiments are a professionally built triboelectric generator replicated from Zhu *et al*., [5] for exhibition purposes and a triboelectric generator made of everyday materials.

Professionally build triboelectric generator

The replication of the triboelectric generator basically consisting of an aluminium rotator and Teflon is shown in Figure 2 a., and b. When the crank is turned, an alternating current is generated between the underlying electrodes A and B (s. Figure 2 c and d).

This can be explained as follows. The triboelectric effect causes a charge transfer between the aluminium rotator arms and Teflon. These charges induce charges in the electrodes A and B. If the arms move from the position shown in Figure 2 c to the one illustrated in Figure 2 d, the electrons move from electrode A to B due to the electrostatic induction. Further rotation results in the first position again (s. Figure 2 c), so that the electrons move back to electrode A. The whole process repeats again and again during the rotation which results in an alternating current between the electrodes A and B.

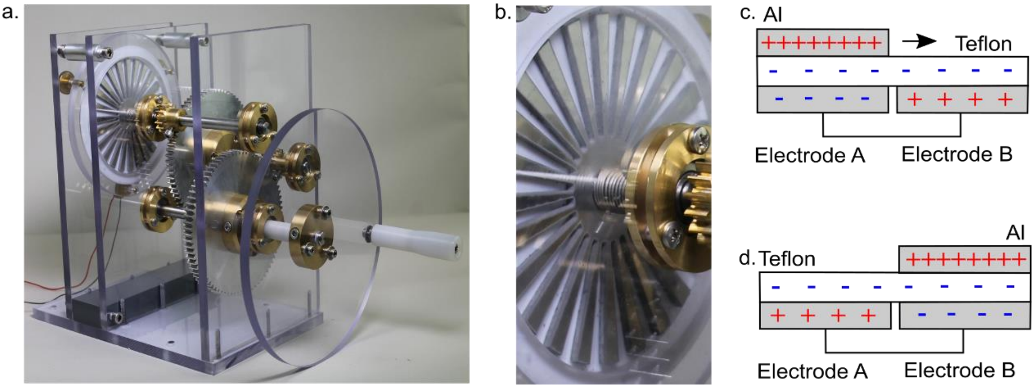


Fig. 2. *Professionally built triboelectric generator: picture of the whole setup (a) and the aluminium rotator in contact with Teflon (b), schematic pictures of one rotator arm on Teflon and the underlying electrode A and B (c, d) [5].*

Triboelectric generator made of everyday materials

The CRC developed a triboelectric generator out of everyday materials (s. Figure 3). This has the huge advantage that the materials are easy to obtain and affordable for schools. In addition, the generator can be built even by young school students.

Setup: It consists of two electrodes connected to an LED (s. Figure 3 a). The electrodes are made of kitchen-grade aluminium foil and are glued on acrylic glass as a substrate. One electrode is additionally covered with Teflon sealing tape.

Generation of an alternating current using the:

- Rubbing mode [6]:

Electrodes are rubbed against each other (Figure 3 b).

- Tapping mode [7]:

Electrodes are alternatingly contacted and isolated (Figure 3 c).

Rubbing mode: In the first position in Figure 3 b in which the electrodes are in contact, the triboelectric effect charges them on their surfaces. If electrode A is then rubbed against electrode B until the second position in Figure 3 b is reached, the negative charge of the Teflon induces a positive charge in the electrode B leading to an electron flow from electrode B to A. If electrode A is then moved backwards to the first position again, the electrostatic induction let the electrons flow from electrode A back to B.

Tapping mode: Just like in the other mode, the electrodes are charged by the triboelectric effect when they are contacted (Figure 3 c). As soon as the electrodes are separated from each other the negative charge of the Teflon induces positive charge in the underlying aluminium electrode B by electron flow from electrode B to A. If they are contacted again, electrons move back to electrode B because of electrostatic induction.

For both modes, the LED lights up when the electrons flow in its forward direction.

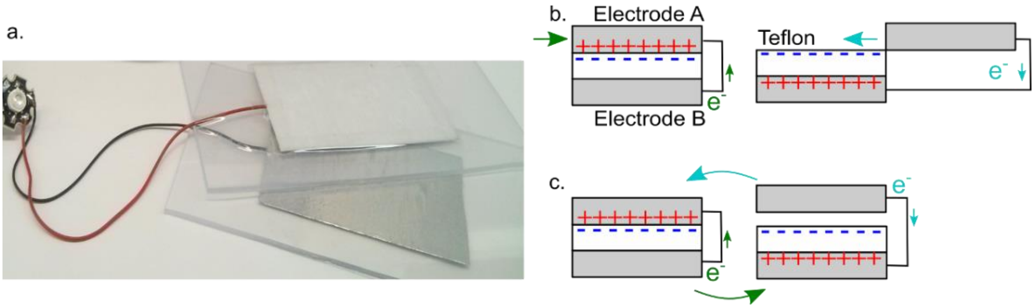


Fig. 3. *Triboelectric generator made of everyday materials: picture of the electrodes consisting of aluminium foil and of aluminium foil covered with Teflon sealing tape (a), schematic pictures of the rubbing mode (b) and the tapping mode (c) [6, 7].*

Extension of the main experiment: If the main learning objective is triggering thinking about the energy future, students can become the task to attach triboelectric generators to moving objects such as flags or the wheels of their bikes where friction is present.

Experience-based misconceptions of students regarding electrostatic charging are:

- Charge transfer between materials is only possible when they are both conductive.
- The triboelectric effect requires the mechanical rubbing of materials.

The triboelectric generator is excellent to create a *cognitive conflict* which can change students' misconceptions of electrostatic charging, because the Teflon is not conductive, and the generator works in the tapping mode without any mechanical rubbing.

4. Conclusion

The CRC aims to contribute to the energy revolution not only by its research, but also by an educational approach in which experiments take a center stage. The presented triboelectric generator is an adequate experiment to understand research and its impact on technical development for everybody's life and, moreover, to stimulate thinking and discussions about the recent and future use of energy.

REFERENCES

[1] CRC 1073 Homepage: https://www.uni-goettingen.de/de/437142.html.
[2] Maaß, M.-C., Tasch, A., Winkler, S. A., Volkert, C. A., Jooß, C. Waitz, T. "Educational Concept for Hands-On Energy Science Workshops", New perspectives in science education - Conference proceedings, Florence, PIXEL, 2019.
[3] Bai, P., Zhu, G., Lin, Z.-H., Jing, Q., Chen, J. Zhang, G., Ma, J., Wang, Z. L. "Integrated Multilayered Triboelectric Nanogenerator for Harvesting Biomechanical Energy from Human Motions", ACS Nano, 2013, 7, pp. 3713-3719.
[4] Spektrum Physik – Ausgabe 2013 für Niedersachsen: Schülerband 7/8, Schroedel Verlag GmbH, Braunschweig, 2013.
[5] Zhu, G., Chen, J., Zhang, T., Jing, Q., Wang, Z. L. "Radial-arrayed rotary

electrification for high performance triboelectric generator", Nat. Commun., 2014, 5, pp. 1-9.

[6] Zhu, G., Chen, J., Liu, Y., Bai, P., Zhou, Y. S., Jing, Q., Pan, C., Wang, Z. L. "Linear-Grating Triboelectric Generator Based on Sliding Electrification", Nano Lett., 2013, 13, pp. 2282-2289.

[7] Zhu, G., Pan, C., Guo, W., Chen, C.-Y., Zhou, Y., Yu, R., Wang, Z. L. "Triboelectric-Generator-Driven Pulse Electrodeposition for Micropatterning", Nano Lett., 2012, 12, pp. 4960-4965.

Riparian Vegetation, a Decisive Factor for the Conservation of the Biodiversity of Flowing Waters Case Study – Some's, a Medium-Sized River in South-Eastern Europe

Alexandru Laposi[1], Monica Marian[2], Oana Mare Roșca[3]
Technical University of Cluj-Napoca, Romania[1,2,3]

Abstract

The present study aimed to analyse the current situation of the riparian vegetation belt along the banks of Someșului (NV of Romania), under the conditions of high anthropic pressure, in order to evaluate the degree of anthropic affectation of the riparian vegetation and the extent to which the current structure allows to perform the functions from an ecological perspective. In order to obtain the data from the field, during the period 2015-2017, 63 transects were crossed on the banks of the Some's river. The riparian vegetation of Some's, is an essential element for the conservation of the river ecosystem. Despite the anthropic pressures, which have significantly changed the ecosystems, the banks of the river have a structure with natural characters on significant portions. The riparian vegetation, even though it is currently strongly affected by anthropogenic factors, has sufficient resources to restore and ensure the specific functions, provided that the legislation of a protective nature is in force.

Keywords: Riparian vegetation, ecological function, biodiversity conservation

1. Introduction

River banks by: the shape and structure of the river, the slope of the banks, the mineral composition, the riparian vegetation, influence the stability, shape, spatial and temporal dynamics of the river [7, 2]. The riparian area, as a buffer between the riverbed and the lands exposed to anthropization outside the riverbed, is defined as the adjacent land, directly influenced by the river, whose water regime allows the development of vegetal communities distinct from those of the neighbouring lands [5, 2, 13], the ecotone area between the aquatic and terrestrial ecosystems [16].

Riparian vegetation is essential for both the aquatic ecosystem and the riparian areas, due to the specific functions: permanent source of organic matter, influences the temperature and the quality of the water, role in the antierosional stabilization of the riverbank, of the shores, offers shelter for a large number of organisms, including bird species and functions as a corridor connecting the river to other ecosystems [10, 11, 9, 16, 17, 21, 4]. Reported on the restricted surface, riparian vegetation harbours a very large number of organisms, compared to neighbouring lands [1, 17]. The efficiency with which riparian vegetation can perform these functions depends on its characteristics: specific composition, structure and width of vegetation belt [15, 8]. The recommended width of riparian vegetation differs depending on several factors: river width, riverbed slope, shore structure, soil structure, and riparian vegetation type [11].

The rivers withstand enormous anthropic pressures, all over the world, dramatically changing the entire aquatic system, from the water quality, the flow regime, the physical structure of the riverbed and the banks, the quality of the habitats, which in turn affect the structure of the biological communities and the normal functioning. of aquatic ecosystems [20]. Riparian vegetation is one of the most strongly affected components.

The study analyses the current situation of the riparian vegetation belt that accompanies the banks of Some's, under the conditions of the high anthropic pressure, to evaluate the degree of anthropic affectation of the riparian vegetation and if the current structure allows the fulfilment of the specific ecological functions.

2. Material and Methods

In an extended study were analysed the two banks of Someșului (NV of Romania) on a length of 240 km (97.32%), between Dej and Satu Mare, in 2015-2017, through 63 transects made on foot, by car and boat. The physical characteristics of the banks and the banks of the some river such as: the structure and characteristics of the shore (natural or artificial, the slope of the shore, the elevation), the riparian vegetation (types, width), the use of the land (on a 50 m strip along the river), the accumulations of alluviums (islands, islands, beaches or bars), point threats (works in the minor riverbed, landfills, disruption of connectivity) mainly determine the distribution of birds (as a bioindicator group) and define the river ecosystem. In the present study, particular aspects of riparian vegetation were selected.

Equipment used were: Garmin Etrex GPS, Nikon D 7000 camera, mobile applications: Google Maps, Mobile topographer, satellite maps (Google Earth). The measurements were made on the ground, with the roulette wheel, and for the calculation of the lengths and surfaces we used the planimetry in Google Earth Pro.

3. Results

The qualitative and quantitative analyses of riparian vegetation are summarized in table 1.

Table 1. *Centralizing table of the values obtained for the categories of parameters analysed*

Parameter	Category	Explanations	Total km	%
Width of riparian vegetation (km)	5-10 m		289,158	60,24
	0-5 m		74,319	15,48
	10-20 m		51,449	10,72
	0		44,945	9,36
	>20 m		20,129	4,19
Type of riparian vegetation (km)	Za	Willow forest	292,447	60,93
	Zt	Bushwood	142,539	29,70
	0	0	44,857	9,35
	Za/St	Willow forest with reed	0,157	0,03

4. Discussions

4.1 Riparian vegetation

The banks of Someș are predominantly (60.93%) accompanied by willow formations, from habitat type R4407 – Danube forests of white willow (*Salix alba*) with *Rubus caesius*

[3]. Riparian forests (Fig. 1), with numerous trees over 50 years old, even secular, are extremely valuable for the river's biodiversity, ensuring ideal conditions for various communities of organisms.

a. b.

Fig. 1. *Old tree trusses on the bank of Someș in Cicârlău (a) and Pomi (b) (original photo)*

The large crowns shade the water, lower the water temperature in the hot summer days, provide protection for river predators from aerial predators, and the roots secure the shores, and fallen trunks in the riverbed provide shelter for fish. For birds it represents the habitat with the highest specific richness of the entire river ecosystem. The rich crowning and especially the massive, scrubby logs represent an extremely valuable nesting habitat and increasingly difficult to find in other deciduous forests.

The riparian shrubs, regenerated, successively after grubbing up the trees (R4416 – Willow shrubs (*Salix triandra*) (Fig. 2.a), or the consequence of anthropization (*Amorpha fruticosa* shrubs – R4423) (Fig. 2.b) accompanying 142,539 km from the total of the banks (29.70%) [3].

a. b.

Fig. 2. *Seashore covered areas with shrubs made of shrubs of Salix, at Apa's Lunca (a) and Amorpha at Mireșu Mare (b) (original photo) 44,857 km (9.35%) of the banks are devoid of riparian vegetation, and the other types of riparian vegetation are negligible, below 1% (fig. 3).*

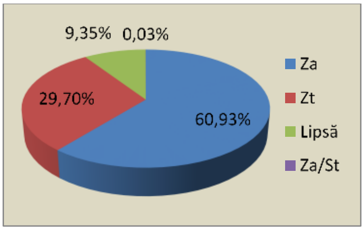


Fig. 3. *The main types of riparian vegetation Za-willows; ZT-bushes; Lipsă-No riparian vegetation; Za/St-stand mixed with the reed.*

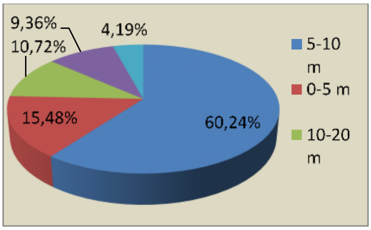


Fig. 4. *Distribution of segments with different widths of riparian vegetation*

4.2 Width of riparian vegetation (m)

The width of the riparian vegetation belt varies on different sectors (tab. 1, fig. 5).

According to bibliography [11], tree-riparian vegetation provides: necessary input of organic matter if the tree is between 3 and 10 m wide, protects the water quality at values between 5 and 10 m, stabilizes the riverbed and the banks at values between 10 and 20 m and provides quality riparian habitats, between 30 and 500 m. A minimum width of 40-50 m, is recommended to ensure habitat suitable for most bird species [12, 5, 6, 18]. The ecological reconstruction of the riparian areas, provides vegetation widths between 10 and 30 m for successfully providing buffer function and over 100 m for the ecological corridor [6].

The riparian vegetation of Someș, except for short segments, is too restricted to ensure the optimal functions of the healthy lotic ecosystems for the ornithofa of the river, but also for the fauna in general. In a landscape dominated by agricultural land, the riparian area of Someș is the only natural refuge for the resident, characteristic bird species and those that use the occasional river habitats. Riparian vegetation and the surface it occupies, play a much more important conservative role than other natural elements of the landscape, being a key element in nature conservation [14, 1].

4.3 The spatial dynamics of the riparian vegetation structure of Someș

For the analysis of the spatial distribution of riparian vegetation along the Someş river and its impact on the ornithofauna of the river, the length of the river was divided into 8 sectors equal to 30 km each, noted from upstream to downstream, as follows: S1 (km 0-30), S2 (km 30-60), S3 (km 60-90), S4 (km 90-120), S5 (km 120-150), S6 (km 150-180), S7 (km 180-210), S8 (210-240) (Fig. 5) In this way, one can analyse sequentially parameters of interest and the dynamics of the quality of riparian habitats along the river and the identification of the problem areas. The width values of the riparian vegetation in the 8 sectors are included in table 2

Fig. 5. *Location of the 8 river sectors analysed (Google Earth Pro, downloaded on 7/18/2017)*

Table 2. *Distribution of riparian vegetation in 8 river sectors. Za-willows; ZT-bushes; Lipsă-No riparian vegetation; Za/St-stand mixed with the reed*

Parameter	Width/the type of vegetation	S1	S2	S3	S4	S5	S6	S7	S8
%	5-10 m	88.30	80.97	57.01	54.41	58.58	58.75	24.76	59.16
	<5 m	2.27	2.34	15.02	21.21	18.79	14.93	33.16	16.14
	10-20 m	6.47	8.91	17.29	6.28	10.39	16.29	8.58	11.54
	0	0.24	5.31	7.69	13.14	12.23	5.75	22.46	8.09
	>20 m	2.72	2.47	3.00	4.96	0.00	4.29	11.05	5.07
%	Za	97.20	89.42	89.05	63.75	32.14	48.28	14.74	52.84
	Zt	2.56	5.27	3.26	23.11	55.63	46.50	62.80	38.44
	0	0.24	5.31	7.69	13.14	12.23	4.96	22.46	8.73
	Za/St	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00

The width of the riparian vegetation, implicitly and the occupied surface, shows a tendency of decreasing from upstream to downstream (tab. 2). The portions with riparian vegetation below 5 m, those without riparian vegetation, but also those with more than 20 m (with a maximum at S7 for the 3 categories) (Fig. 6) grow at the expense of the segments in which the vegetation belt registers 5-10 m Also, the trellises with trees (with a minimum at S7) decrease and the shoreline segments covered with bushes, but also those without riparian vegetation (with a maximum at S7), from upstream to downstream (Fig. 7).

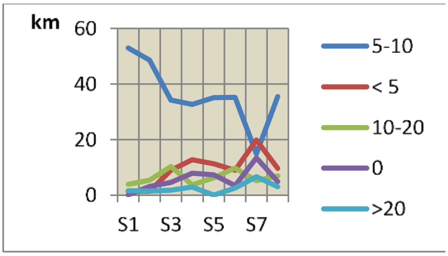


Fig. 6. *Variation in the width of riparian vegetation*

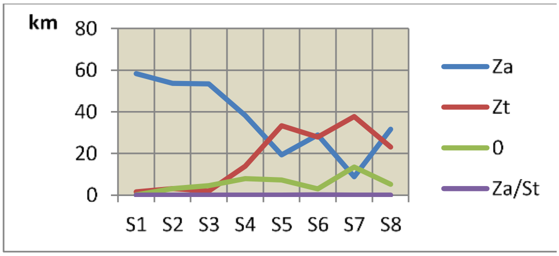


Fig. 7. *Share of riparian vegetation types Za-willows; ZT-bushes; 0-No riparian vegetation; Za/St-stand mixed with the reed*

5. Conclusions

The anthropic pressures on the river Someș severely damage the riparian vegetation and the attached ecosystems. The trees, though heavily weighted, have small widths and are only remnants of the former locks. The shrubs are largely built by an invasive alien species *Amorpha fruticosa*, which does not provide superior ecological parameters for the habitat. The riparian vegetation is discontinuous on the banks of Someș, being interrupted by longer segments of banks without vegetation. The riparian vegetation of Someș, even if it is strongly affected by anthropogenic factors, has sufficient resources to restore and ensure the specific functions, provided that the legislation in force, which should protect the banks of the river, is respected.

REFERENCES

[1] Bennett, A. F., Nimmo, D.G., Radford, J. Q. "Riparian vegetation has disproportionate benefits for landscape-scale conservation of woodland birds in highly modified environments", Journal of Applied Ecology 2014, 51, pp. 514-523. doi: 10.1111/1365-2664.12200
[2] Cristescu, C. C. "Morfologia albiilor şi conceptul de restaurare a râurilor" (thesis chapter). Facultatea de Silvicultură şi Exploatări Forestiere, 2015, Brașov.
[3] Doniţã, N., Popescu, A., Paucã-Comãnescu, Mihaela, Mihãilescu, Simona, Biriş I. A. "Habitatele din România", Ed. Tehnică Silvică, București, 2005.
[4] Dountchev, A., Dimova, D., Dimitrov, M., "Riparian forests: benefits, present condition, conservation", WWF report, 2017, Sofia.
[5] Fischer, R. A., Martin, C. O., Fischenich, J. C., "Improving Riparian Buffer Strips and Corridors for Water Quality and Wildlife", International Conference on Riparian Ecology and Management in Multi-Land Use Watersheds, 2000, American Water Resources Association.
[6] Fischer, R.A., "Widht of riparian zones for birds", EMRRP Techical Notes Collection (TN EMRRP-SI-09), U.S. Army Engineer Research and Development Center, 2000, Vicksburg MS. www.wes.army.mil/el/emrrp
[7] Frissell, C. A., Liss, W. J., Warren, C. E., Hurley, M. D. A., "Hierarchical Framework for Stream Habitat Classification: Viewing Streams in a Watershed Context", Environmental Management, Vol. 10, No. 2, 1986, pp. 199-214.
[8] González Del Tánago, Marta, García De Jalón, D. "Attributes for assessing the environmental quality of riparian zones", Limnetica, 25(1-2): 389-402, 2006, The ecology of the Iberian inland waters: Homage to Ramon Margalef © Asociación Española de limnología, Madrid. Spain. ISSN: 0213-8409.
[9] Green D, "Biological Processes in Riparian Areas – Habitat", https://cals.arizona.edu/extension/riparian/pub/UARA_07-17-07_chapter5.pdf 2005.
[10] Gregory, S.V., Swanson, F.J., Mckee, W.A., Cummins, K.W., "An ecosystem perspective of riparian zones", BioScience 41,1991, pp. 540-551.
[11] Hawes, Ellen, Smith, Markelle., "Riparian Buffer Zones: Functions and Recommended Widths", Eightmile River Wild and Scenic Study Committee, 2005.
[12] Kinley T. A., Newhouse Nancy J., "Relationship of Riparian Reserve Zone Width to Bird Density and Diversity in South-eastern British Columbia". Northwest Science, Vol. 71, No. 2, 1997.
[13] Mainstone, C., Hall, Ruth, Diack, I., "A narrative for conserving freshwater and wetland habitats in England", Natural England Research Reports, Number 064, 2016.
[14] Miller, J.R., Wiens, J. A., Hobbs, N. T., Theobald, D. M., "Effects of Human Settlement on Bird Communities in Lowland Riparian Areas of Colorado (USA)", Ecological Applications, 13(4), 2003, pp. 1041-1059, The Ecological Society of America.
[15] Munne, A., Prat, N., Sola, C., Bonada, N., Rieradevall, M., "A simple field method for assessing the ecological quality of riparian habitat in rivers and streams QBR index", Aquatic Conservation: Marine and Freshwater Ecosystems, 13, 2003, pp. 147-163, (www.interscience.wiley.com). DOI: 10.1002/aqc.529.
[16] Naura, M., Sear, M., Alvarez, M., Penas, F., Fernandez, D., Barquin, J., "Integrating monitoring, expert knowledge and habitat management within

conservation organisations for the delivery of the water framework directive: A proposed approach", Limnetica, 30 (2) 2011, pp. 427-446.
[17] Padmalal, D., Maya, K., "Sand Mining. Environmental impacts and Selected Case Studies", 2014, http:/www.springer.com/978-94-017-9143-4.
[18] Pearson., S. F., Manuwal, D. A., "Breeding Bird Response to Riparian Buffer Width in Managed Pacific Northwest Douglas-Fir Forests", Ecological Applications, 11(3), 2001, pp. 840-853 q 2001, The Ecological Society of America.
[19] Richardson, J.S., Moore, R. D., "Stream and riparian ecology". Compendium of forest hydrology and geomorphology in British Columbia. RG Pike, TE Redding, RD Moore, RD Winker, and KD Bladon (editors). BC Ministry of Forests and Range, Forest Science Program, Victoria, BC, and FORREX Forum for Research and Extension in Natural Resources, Kamloops, BC Land Management Handbook. No. 66, 2001, https://www.for.gov.bc.ca/hfd/pubs/docs/lmh/Lmh66/Lmh66_ch13.pdf
[20] Thomson, J.R., Taylor, M.P., Fryirs, K.A., Brierley, G.J. 2001, "A geomorphological framework for river characterization and habitat assessment", Aquatic Conser: Mar. Freshw. Ecosyst, 11, 2001, pp. 373-389. DOI: 10.1002/aqc.467.
[21] *** "Strategia naţională şi Planul de acţiune pentru conservarea biodiversităţii" 2014-2020. (SNPACB), Bucuresti.

Science and Society

An Interdisciplinary Scientific Education, from Relevant Social Problems such as Sexist Hate Speech

M.ª Teresa Sánchez-Compaña[1], Cristina Sánchez-Cruzado[2], Carmen Rosa García-Ruiz[3]
University of Málaga, Spain[1,2,3]

Abstract

The intention of this communication is to share an experience in initial training of Secondary Education teachers, in which teachers from different areas of university knowledge participate. The training programme is organized around the design of an Integrated Project based on Mathematics, Social Sciences and Philosophy curricula. The theme of the project focuses on a social problem which involves the dissemination of current of sexist opinion in social networks, the media and popular culture; in the form of hate speeches.
Integrated Projects are designed based on the identification of hate speeches of a sexist nature, with the aim of making the educational proposal contemplate its analysis. They also seek to develop counter-narratives which allow us to educate scientifically as an exercise towards achieving a critical and sensible environment.
The commemoration of the International Day for the Elimination of Violence against Women will allow us to implement, in real educational contexts, the designed projects, as well as developing skills for educational action-research.
The subject "Teaching Innovation and Initiation to Educational Research", is structured to train future teachers as critical curricular agents, committed to teaching science to everyone in a responsible way.

Keywords: teacher training, integrated curriculum, hate speech, sexism

1. Introduction

The educational proposal laid out is organized around the design of an integrated project, based on the Mathematics, Social Sciences and Philosophy curricula. Namely, it is developed in the subject of "Educational Innovation and Initiation to Educational Research", within the training plan of future teachers of Secondary Education as critical curricular agents, committed to educating towards a citizen's science.

The integrated projects have been designed based on the identification of hate speech of a sexist nature, in order that the educational proposal contemplates its analysis, and therefore can develop counter-narratives supported by mathematical contents, which would allow the possibility for scientific education to create critical and thoughtful citizens. We will also observe that this kind of practice may help students to become aware of the need to adopt a social and interdisciplinary perspective in the classroom, and in doing so, develop the instrumental, functional and above all formative character that a quality mathematical education entail [1]. This will influence the potential of the teaching of the humanities, sciences and mathematics in order to achieve a scientific and technological literacy of the citizenship from a social and humanistic approach.

2. Curricular integration. The Integration of Mathematical and Social Thinking

There are various ways of understanding curricular integration, the traditional interpretation sees education as a democratic social process [2]. Consequently, we must also assume that a scientific-mathematical education contains a social process at its core. This statement seems trivial, but the social, human and largely interpersonal nature of education is often ignored due to the rush of acquiring mathematical techniques and the desire to achieve an “efficient” scientific-mathematical education [3].

There are two models for curricular integration which discuss the following: Key concepts that structure disciplinary knowledge; Problems, topics or centers of interest that respond to social concerns. In the second case, a methodological position to work projects is established.

Mathematics is instrumental, formative, and functional. It is a subject found in virtually all fields of study not only in Science and Technology, but also in other seemingly unrelated disciplines such as Social Sciences, Music, Video Games, Poetry or Politics.

However, this formative character of mathematics is usually neglected in the teaching process, but it is still highly necessary to be able to offer a comprehensive training to the general population of the 21st century. [1]

Although it is also usually true that – from an educational perspective – certain forms of mathematical and scientific activity have been considered which favour the development and acquisition of general cognitive abilities (hence, the educational interest of its teaching). Almost all math and science curricula value this teaching for its formative nature. However, the formative values associated with mathematics and science are not exhausted in cognitive aspects since, as a global human activity, they are connected with norms and values and are also linked to the emotional sphere [4].

3. Experience in the Training of Teachers

The participating university teaching staff has experience in training for the integration of disciplinary knowledge in the areas of Social and Mathematical Sciences in the Master’s Degree in Secondary Education Teachers [5]. The projects were presented as a practical job-related problem, linked to the design and development of the integrated curriculum.

3.1 Contextualization of the Developed Experience

In the experience carried out, a total of 80 female and male students participated from the University Master’s Degree in Elementary and Secondary Education, Technical College, and Foreign Language Teaching. The formative plan is organized around the design of an integrated project, based on the curricula of Mathematics, Social Sciences and Philosophy. The theme of the project takes on the social problem of the dissemination of different opinions streamed in the media, including social networks and conventional media, in the form of hate speech. It consisted of carrying out integrated projects with the students of Secondary Education in a public center of Malaga, for the celebration of the “International Day for the Elimination of Violence Against Women”.

The work groups put disciplinary ideas and concepts into practice for five sessions which acted as connection operators for the critical understanding of the issue at hand.

The distinctive feature of the experience is that the integration did not occur by resorting to disciplinary methodological structures, nor among areas of similar epistemological conceptions such as Math and Science. It was brought together by converging mathematical and social thinking skills which were then used to address the spread of sexist hate speech in the media and on social networks. [6]

3.2 Results

The students were organized into 12 interdisciplinary groups. This may suggest that future teachers will have developed some autonomy and creativity in these areas. It also should be noted that they were able to identify their strengths and how to take advantage of them in order to achieve a good layout and implementation of the activity. By the very nature of the activity, they were able to clearly observe how it is possible to develop the functional – and of course formative – nature of mathematical education.

Tablet 1 shows the hate speeches chosen by these 12 groups and highlights the mathematical content they used to build counter-narratives. It also briefly describes some of the activities carried out.

Tablet 1. *Hate speeches and activities*

Groups	Identified Hate Speech. Mathematical Content Used. Brief Description of the Proposed Activities for the Development of a Counter-Narrative
Applicad@s	Social Invisibility of Women. Graph Theory. Multiple questions are raised to generate debate around what is the invisibility of a collective group, specifically that of women. The responses are gathered with Post-it notes and a graph is made using the ONODO application. Link: https://onodo.org/visualizations/53877
REMIX	Women in Sports. Percentages and Bar Graphs. The students analysed different sport activities using percentages and bar graphs. They addressed the different kinds of sports in which they and their peers participate, clearly indicating certain patterns among girls and boys in this field.
Caminantes	Women Mathematicians Hidden from History. Irrational Numbers. The activity was carried out by 12-year-old students who had yet to learn irrational numbers. They were given an analogy between women hidden in the history of mathematics and the existence of irrational numbers. This awoke a sense of surprise and curiosity from the students (in both a mathematical and historical sense) and encouraged them to continue research on the life and work of these women.
MIH	Microaggressions in Everyday Life. Mathematical Modelling. The students were faced with a “modelling” problem regarding the economic benefits – which may be subtle and difficult to notice at first – of a bar or club that uses the strategy of free admission for women.
GLOBE	Women in Professional Sports. Statistics. A statistical survey was carried out which revealed, through numerical evidence, the hate speech that is generated day after day in the press and social networks, regarding the role of women in professional sports.
DES-tereotípos normalizados	Stereotypes. Normal Distribution. The students classified the lyrics of several songs as “sexist content”, “romantic myth” and “healthy”. This classification was then analysed and observed according to Gauss’ normal distribution or bell distribution. This in turn generated a debate which revealed that many of us “normalize” negative gender stereotypes in our daily lives and in our emotional-personal relationships.
Powers-Rangers	Toxic Relationships. Whole Numbers. The activity is carried out with students who are working on whole numbers. Its aim is to draw an analogy between the positive and negative numbers with toxic or positive behaviour in a relationship.

Perestroika	Music and Dance. Statistics. The presence of women in major music and dance festivals is statistically analysed. It shows that the role of women is almost non-existent, and mostly presented in a degrading way that generates further hate speech.
Inclusiv@s	Gender Violence. Percentages. Press clippings are analysed which show the percentages dealing with women who have been murdered by their male partners.
Diversitarias	Comments on Press Headlines and Social Networks. Whole Numbers. The words that appear in press clippings or found online in social networks are classified as positive or negative. An analogy is then made using whole numbers.
Random	Career and Job Stereotypes in Advertising. Percentages. Advertising clippings are shown which detail various job stereotypes as well as the percentage which corresponds to professions that are seen as either masculine or feminine.
Cambio docente	Housework. Monetary Value. A graph with the monetary value of different household tasks is shown. Students are asked to fill out another graph by gathering specific information of the tasks that are performed in their households. Lastly, a debate is generated after sharing the results.

4. Conclusions

In general, the results were satisfactory, as they promptly and smoothly reached the interconnection of different conceptual structures which can be converted into teaching knowledge.

Ultimately, it proved to be a relevant practice not only for curricular integration, but also for enhancing culture by mathematical means. It can be used as a tool by the teachers in training for understanding hate speech and gaining a personal and critical awareness of the issues at hand [3]. Mathematical reasoning has been successfully determined as a fundamental cultural value as it provides a more complete understanding of relevant social problems.

Acknowledgments

This work is part of the Reference Research Project PGC2018-094114-A-I00, “Didactic Analysis of Teaching and Learning Units in Math and Science Textbooks from a Gender Perspective”, funded by the MINECO/MICIU, Ministry of Science. Innovation and Universities.

REFERENCES

[1] Duarte, I., Sánchez, M. T., Arnal, M. & Sánchez, C. (2018). A curricular approach to develop autonomies from the mathematics and scientific education. En Pixel (Ed.), *Conference proceedings. New perspectives in science education 7th edition.* (pp. 236-239). Italy: Libreriauniversitaria.it Edizioni.
[2] Beane, J. (1997). *Curriculum integration. Designing the core of democratic education*. New York: Teachers College Press.
[3] Bishop, A. J. (1999). *Enculturación matemática. La educación matemática desde una perspectiva cultural*. Barcelona: Paidós.
[4] Rico, L. (1990). Diseño curricular en Educación Matemática: Una perspectiva actual. En S. Linares y V. Sánchez (eds.). *Teoría y práctica en Educación Matemática Didáctica*. Sevilla: Alfar.
[5] Sánchez-Compaña, M. T., García-Ruíz, C. R., y Sánchez-Cruzado, C. (2019).

La integración de pensamiento matemático y social. Una práctica en formación inicial del profesorado de educación secundaria. A. Codina y M. F. Moreno (Eds.), *Investigaciones en Pensamiento Numérico y Algebraico* (pp. 179-195). Almería: Universidad de Almería.

[6] García Ruiz, C. R. y Zorrilla Luque, J. L (2019). Educar para la ciudadanía frente a discursos de odio desde la prensa digital. Una experiencia en formación inicial del profesorado de Educación Secundaria. En M. J. Hortas y A. Dias (eds.). *Enseñar y aprender Didáctica de las Ciencias Sociales: La formación del profesorado desde una perspectiva socio-crítica*. Lisboa: Escola Superior de Educaçao de Lisboa y AUPDCS.

Appliance of Botanical Garden Space and Plant Expositions to Introduce Topic of Bioluminescence and Biofluorescence to Society

Asta Malakauskiene[1], Nerijus Jurkonis[2], Vesta Aleknaviciute[3]
Vytautas Magnus University Botanical Garden, Lithuania[1,2,3]

Abstract

Botanical gardens have an obvious and vital role to play in conserving plants, but conservation cannot succeed without education. Usually having specimens of old mature trees colonized with diverse fungi species and a wide range of introduced plant species attracting numerous insects, they provide convenient spaces for education and demonstration of bioluminescent and biofluorescent features of living organisms to visitors of various age. Society in Lithuania is usually aware of local glowing firefly and sometimes fungi species but has little acquaintance of full diversity of bioluminescent creatures [1]. After an introductory lecture about local and global diversity of glowing species, the causes and functions of such phenomenon, it is time for attractive part – night expedition in search of real samples (explaining how to find glowing mycelium of Armillaria mellea, tracing females of Lampyris noctiluca or representatives of Geophilus easoni and etc.) and under ultraviolet flashlights (resins of Pinus sylvestris, sap of Chelidonium majus, wood of Rhus typhina, young shoots or flowers of Fraxinus excelsior, fruiting bodies of Pholiota squarrosa, grubs of Calliteara pudibunda and etc.). Biofluorescence and bioluminescence is a fun and exciting way to teach basic science concepts [2], as chemical, physical and biological knowledge are combined for explanation of glowing phenomenon. Due to the visual appeal of these phenomena, it is possible to discuss basic photophysical principles in undergraduate level [3]. To strengthen the final impression on the received information – a workshop of creating own bioluminescent/biofluorescent (depends on the pigments and paints used) prototypes is offered. Educational activities at Vytautas Magnus University Botanical Garden (VMUBG) fulfil the idea of experimental learning: participants are involved into activities, critically reflecting and analysing them, and by received results gaining new providence for the perception change. Participants get meaningful and interesting for themselves learning as they try practical activities. As a feedback we attain requests to organize more seminars on the topic with following night expeditions and workshops for teachers and students from all around the country.

Keywords: botanical garden, bioluminescence, biofluorescence, night expedition, workshop of prototypes

1. Introduction

Botanical gardens possess a wide variety of introduced and local flora plant species, endangered, sometimes extinct in natural habitats, young cultivars and old, having important historical value plants, but conservation of them cannot succeed without education. Old mature trees colonized with diverse fungi species and a wide range of introduced plant species attract numerous insects, which provide convenient spaces for education and demonstration of bioluminescent and biofluorescent features of living organisms. Usually botanical gardens have rooms or classes for educational activities.

Lectures or seminars inside buildings and expeditions, excursions outside in plant collections and surrounding parks or arboretums, provides a particularly comfortable space for teaching and learning of natural sciences.

Some botanical gardens around the world have already experience in education and attractive activities on bioluminescence or biofluorescence. For example, Singapore botanic gardens publish magazine “Gardenwise”, which includes topics about bioluminescent species, Denver botanic gardens exhibit Sam Mitchel Herbarium of Fungi, which includes specimens of bioluminescent species, South Africa’s Kirstenbosch National Botanical Garden is worldwide known due to summertime numerous firefly glowing observation excursions, the Hunter Region Botanic Gardens in Australia are distinguished organizing walks of bioluminescent fungi sightseeing, Queen Sirikit Botanic Garden in Thailand has a large program of firefly conservation and education (one of their goals is to save endangered species of the world’s largest fireflies – *Lamprigera tenebrosus*). Biofluorescence is also a noticed phenomenon by botanical gardens. For example, Royal Botanic Garden Victoria, Cranbourne Gardens in Australia exhibited photographs of floral fluorescence of their plants, botanical garden of Pavol Jozef Šafárik University (UPJŠ) in Slovakia created exhibition of fluorescent plants (plants were treated with a special substance and illuminated with ultraviolet light), the Royal Botanic Garden in Sydney had educative activities on fluorescent moss *Schistostega pennata*, Jawaharlal Nehru Tropical Botanic Garden studies fluorescent prey traps in carnivorous plants.

Society in Lithuania is usually aware of local glowing firefly and sometimes fungi but has little acquaintance of full diversity of bioluminescent species [1]. Bioluminescence and biofluorescence get little attention in **basic school**, pre-gymnasium and gymnasium teaching programs of natural sciences. The topic is a very convenient tool for STEAM teaching, because it combines themes from different subjects (physics, chemistry, biology, geography, ecology, and etc.) which traditionally are taught separately.

Biofluorescence and bioluminescence is a fun and exciting way to teach basic science concepts [2]. Even though basic school teachers know about the meaning and aims of the STEAM education in detail, they often take a neutral attitude toward the actual teaching method [3]. Bioluminescence and biofluorescence can help in explaining spectrum of visual light in attractive way as organisms’ glow in various colours, presenting fluorescent proteins, pigments or explaining luciferin oxidation could be additional interesting topics in teaching chemistry, distribution and biodiversity of glowing organisms may intrigue in teaching biology or geography, and etc. Participation in experimental learning educational activities in botanical gardens could be useful not only for students in understanding natural science themes, but also for teachers in comprehending how STEAM activities should be organized.

Bioluminescence and biofluorescence can be presented for listeners of various age, choosing different level of scientific explanation of the origin and functions of these phenomenon. Due to the visual appeal of these phenomena, it is possible to discuss basic photophysical principles in pre-school level [4]. Our aim was for the first time in Lithuania to apply the space of Vytautas Magnus University Botanical Garden (VMUBG) to introduce topic of bioluminescence and biofluorescence to society – from pre-school children till seniors.

2. Methods

Theoretical background is always a must in introducing a new topic. Therefore, an introductory lecture on bioluminescence and/or biofluorescence is presented in the beginning of the educational activities. An introductory lecture involves explanation of basic knowledge on light production of living organisms, local and global diversity of glowing species, the causes and functions of such phenomenon, time and conditions for glowing, new applications of phenomenon's in science and technology. Some specimens of glowing species might be demonstrated during the lecture in the room, which should have a possibility to control lighting (best if windows can be covered by dark fabric and lights may be switched off whenever needed). For example, a very effective demonstration attaining much attention is showing fluorescent aeculin release from conker or ash twigs in water in transparent vase or bowl (Fig. 1a), also showing fluorescent curcumin from dried tumeric powder sinking in alcohol in transparent container (Fig. 1b) under UV light.

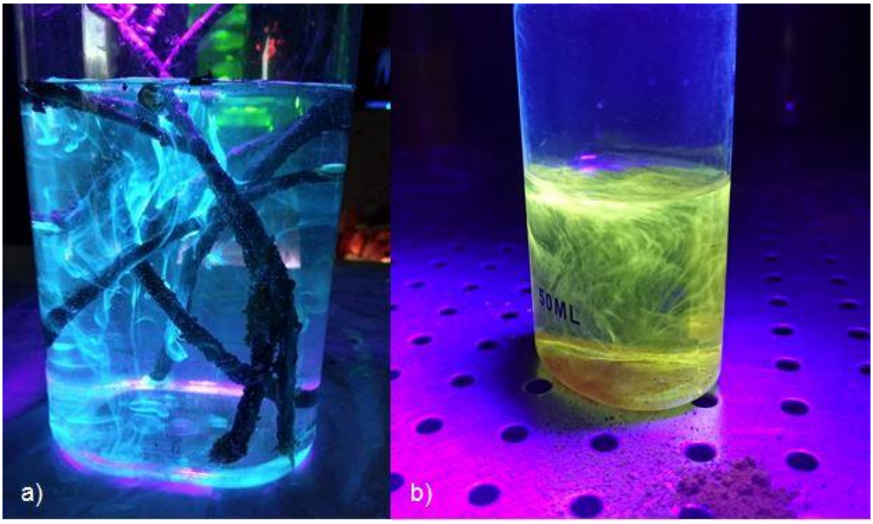


Fig. 1. *Demonstration of fluorescent plant compounds in liquid a) aesculin b) curcumin*

Second step – attractive part – night expedition in search of real samples. Participants are given UV flashlights and they go together with the leading educator to botanical garden collections and arboretum at night. Biofluorescent specimens are well visible in dusk or shadow, but for bioluminescent species observation full darkness is better (bright summer nights are not convenient for such activity). Educator might show some glowing species examples for participants, but it is much more fun, when they find glowing objects themselves and call everybody to see their finding.

To strengthen the final impression on the received information – a workshop of creating own bioluminescent/biofluorescent (depends on the pigments and paints used) prototypes is offered as a third step of teaching about bioluminescence or biofluorescence. Prototypes are kneaded from clay, which hardens in contact with oxygen. Photoluminescent pigments and paints are used for "bioluminescent" (because such materials are charged by extra light source and keep glowing until 2 hours) prototype creation, and fluorescent pigments and paints (they glow only under UV) are used for fluorescent prototype creation. Participants choose themselves what representative of glowing species to knead and how to decorate it. At the end of this activity, everyone presents his/her glowing prototype and its features, explains why and when it glows.

3. Results and Discussion

Experiential learning is a process that creates knowledge as the outcome of an experience combined with abstract understanding [5]. Educational activities at VMUBG fulfil the idea of experimental learning: participants are involved into activities, critically reflecting and analysing them, and by received results gaining new providence for the perception change. Participants get meaningful and interesting for themselves learning as they try practical activities: night expeditions (Fig. 2a) searching for real glowing samples (examples are presented in Table 1) and creating their own "bioluminescent" or biofluorescent prototypes (Fig. 2b, 2c). If time and strength of the participants of educational activities about glowing organisms let, in the end it is fun to play imitative behaviour of biofluorescent organisms by using glowing body painting (Fig. 2d) and discussing what they are meant for: attracting pollinators, repel predators, finding love partners and etc.

Table 1. *Examples of real bioluminescent or biofluorescent samples, found during night expeditions in Vytautas Magnus University Botanical Garden*

Name of species in latin	Type of organism	Type of glowing	Glowing part	Season of finding
Armillaria mellea	Fungus	Bioluminescent	Mycelium	Autumn (October, November)
Geophilus easoni or *G. carpophagus*	Centipede	Bioluminescent	Disturbed mature individuals produce bioluminescent slime (defensive secretions)	Autumn
Lampyris noctiluca	Firefly	Bioluminescent	Female underside of their last three abdominal segments	Summer (June, July)
Pholiota squarrosa, Hypholoma fasciculare, Russula delica	Fungi	Biofluorescent	Fruiting bodies	Summer, autumn
Calliteara pudibunda	Insect	Biofluorescent	Grubs	Summer, early autumn
Chelidonium majus	Herbal plant	Biofluorescent	Sap, when plant tissues are torn	Spring-Autumn (during vegetation period)
Rhus typhina, Robinia neomexicana, Gleditsia triacanthos,	Woody plants	Biofluorescent	Wood (cuttings of branches)	Always
Berberis thunbergii	Woody plants	Biofluorescent	Wood	Always

Fraxinus excelsior (and other ash species)	Woody plant	Biofluorescent	Young shoots, flowers and wood cuttings (tissues containing aesculin)	Flowers in spring, shoots during vegetation period, wood – always
Aesculus hippocastanum (and other conker species)	Woody plant	Biofluorescent	Wood cuttings (tissues containing aesculin)	Always
Pinus sylvestris	Woody plant	Biofluorescent	Resins and resin covered buds	Always, resin covered buds are best observed in winter
Prunus spinosa	Herbal plant	Biofluorescent	Flowers (nectary)	Spring (April-May)
Scilla siberica	Herbal plant	Biofluorescent	Flowers (stamens)	Spring (March-April)
Trifolium pratense	Herbal plant	Biofluorescent	Yellowish or brownish seeds (seeds containing darker pigments do not glow)	Seeds ripen from July till October, dried seeds glow always
Xanthoria parietina	Lichene	Biofluorescent	Full thallus	Always

Fig. 2. *a) pupils at night expedition, b) participants create their own glowing organism prototypes, c) examples of "bioluminescent" prototypes, d) biofluorescent body painting*

In three years (starting since 2017) we have organized several paid and over 20 free seminars, lectures, with or without prototype creating workshops and night expeditions.

Our educators voluntarily worked with different age and interests' groups: pre-school children, basic school, pre-gymnasium and gymnasium pupils, university students, employed persons, seniors in retirement, foresters, teachers, artists and educators of natural sciences. Around 1000 of participants now are well acquainted with local and global bioluminescent and biofluorescent diversity and their "glowing behaviour". As a feedback we attain requests to organize more seminars on the topic with following night expeditions and workshops for teachers, pupils and students from all around the country, which shows that experiential learning is well appreciated by Lithuanian society.

REFERENCES

[1] Malakauskienė, A. Reported and Potential Bioluminescent Species in Lithuania. Biologija, 2018, v. 64(3), pp. 181-190.
[2] Hammer, M., Andrade J. D. Bioluminescence as a Classroom Tool for Scientist Volunteers. Methods in Enzymology, 2000, v. 305, pp. 660-672.
[3] Lim, S. M., Kim Y. S., Lee, T. S. Analysis of Elementary School Teachers' Perception on Field Application of STEAM Education. Journal of Science Education, 2014, v. 38(1), pp.133-143.
[4] Nery, A. L. P., Liegel, R. M. Fluorescence and Chemiluminescence: Teaching Basic Principles by Simple Demonstration Experiments. Chemical Education Journal, 2010, v. 13, p. 22.
[5] Meishar-Tal, H. Teaching Sustainability via Smartphone-Enhanced Experiential Learning in a Botanical Garden. International Journal of Interactive Mobile Technologies (iJIM), 2014, v. 8(1), pp. 10-15.

Can we Dare Say Modern Society Doesn't Need Raw Material? Reflecting about the Increasing Demand for Teaching Geoethics

Tiago Ribeiro[1], Alexandra Cardoso[2], Tânia Pinto[3], Clara Vasconcelos[4]
Science Teaching Unit, Faculty of Sciences of the University of Porto & Institute of Earth Science (Porto), Portugal[1,2,3]
Science Teaching Unit and Department of Geosciences, Environment and Spatial Planning's, Faculty of Sciences of the University of Porto & Institute of Earth Science (Porto), Portugal[4]

Abstract

In today's society, there are many raw materials employed in our daily lives. Without them, our quality of life would be seriously compromised. Besides, the exploitation of these resources is crucial for leveraging their own scientific and technological development and thus enabling social and economic advancement. Differently, the world's population is growing, and complex societal issues are rising, creating a greater need for the consumption of mineral resources and the demand for its exploitation. To mediate these dimensions – scientific, technological, social and economic –, geoethics, as an interdisciplinary field of study, can contribute to a better relationship between the humans and the Earth. To reflect on the need to teach geoethics, the educational resource "Can we dare say modern society does not need mineral raw materials?" – developed by the GOAL Erasmus+ Project – was applied to 12 graduate students divided into five groups. Students were asked to identify competencies expected to be developed during the application of the educational resource. A content analysis was done after gathering the data. Data showed the development of system-thinking and interpersonal competencies in all groups. Strategic competency was addressed by three groups and anticipation competency was also mentioned only by one group. When asked what the consequences of incorrect dissemination of mining procedures by all actors involving in the process, the students stated that non-transparent communication potentially perpetuates the ignorance within the population (n=10). Concerning how important is the mining process dissemination given by the media to inhabitants, the responders (n=10) consider that media plays a crucial role in dissemination, which has to be imparted impartially and on a scientific basis so citizens can form grounded opinions. The students also advocated ways to minimize the impacts in the environment and local communities as environmental (n=8) and socio-economic impact studies (n=5). The educational resource asked students to suggest a plan of rehabilitation, based on environmentally and socially sustainable standard elements and management systems in a mining site and the answers included: landscape requalification (n=10), exploitation for geoeducational (n=5) and geotourism initiatives (n=8).

Keywords: Geoethics; Georesources; Higher education; Society

1. Introduction

The human species, like any other, depends on the Earth to survive. It is from the materials present on the planet's crust, and from the conditions that it provides, that life could develop and complexify [1]. In the human case, from the Stone Age, the applicability of raw materials in everyday life becomes more evident. According to Chatterjee (2009), in this period, a quarzitic shaped stone – today is known as "flint" – turns out an important element for our species' early economy. With this stone, human beings could start to defend themselves, hunt for food, and search or construct their own shelters [1, 2]. The human dependence on Earth has intensified in recent centuries [1].

The growing and complex needs, inherent in human civilizational development, have led us to a constant search for other raw materials and minerals. Prove of this Earth dependency is that, since the beginning of this millennium, more than 3000 minerals have been reported and named, of which 1800-2000 have been totally studied and described [3]. Today, in addition to referred previously, humanity has extended the application of rocks and minerals to other and diverse areas such as, for example, medicine or food industry [3].

However, the exacerbated or incorrect exploitation of these georesources is co-responsible for the existence of a possible new geological epoch – the Anthropocene, which underlines the beginning of a geological time heavily characterized by human activity on the planet [4]. Since every action triggers a consequence, modern society faces serious dilemmas related to our relationship with the planet. Any action of our quotidian requires, in a directly or indirectly way, materials extracted from Earth. Without these materials, our quality of life could be seriously compromised and, consequently, our prosperity on the planet and itself [5].

The world's population is growing, and at the same time, complex societal issues are rising, creating a greater need for the consumption of georesources and, consequently, the demand for new/or other resources that can be exploited [2]. Moreover, being unable to reduce, reuse, and recycle all materials extracted from the Earth, it is impossible to live without mining activity. From another perspective, the exploitation of these resources is critical for leveraging our scientific and technological development and thus also enabling social and economic development. This fact is substantially important since the exploitation activity and georesources must be considered as economic and politic strategical elements for a country, especially for the developing ones.

Universities and Schools – as institutions devoted to personal, academic, and professional development – cannot be alienated regarding citizens' life-long education.

These must prepare them for informed, full, and democratic participation in society [6], especially in the opinion-forming process about relevant topics, like mining activity, its value, and impacts on the environment, people and country's strategic socio-economic development [2]. To mediate the dimensions presented – scientific, technological, social and economic –, geoethics, as an interdisciplinary approach and emergent scientific field, could contribute to a better, integrated, and ethical relationship between the humans and the Earth, bringing a more holistic view of the societal issues discussed [7]. According to the International Association for Promoting Geoethics (IAPG), geoethics "*consists of research and reflection on those values upon which to base appropriate behaviour and practice where human activities intersect the geosphere*" (p. 1) [8]. The integration of geoethics on education institutions and public debate may help to a better understanding of mining activities, underling its ethical, social and cultural geoethical values [7].

2. Methodology

2.1 Sample

The convenience sample was comprised of 12 graduate students (n=12) of the master's course in science teaching, from a northern Portuguese university. Concerning gender, the sample comprised nine female students (n=9) and three male students (n=3). The participants' academic background included biology (n=8), geology (n=1), chemistry (n=1), physics (n=1), and environmental sciences (n=1).

2.2 Procedure

To reflect on the need to teach geoethics, particularly in higher education, the educational resource "Can we dare say modern society does not need mineral raw materials?" (accessible in https://goal-erasmus.eu/educational_resource) – developed by members of the GOAL (Geoethics Outcomes and Awareness Learning) Erasmus+ Project – was applied to a convenience sample. Following a case-based teaching methodology the students were distributed into five groups and were asked to identify some key competencies needed to answer some questions. Answers obtained were the target of a content analysis.

3. Results

After analysis, and considering the competencies developed when solving the educational resource, all groups considered that improved their system-thinking and interpersonal competencies. Moreover, strategic competency was addressed by three groups and anticipation competency was also mentioned by one group.

When asked what the consequences of an incorrect dissemination of mining procedures by all actors involving in the mining process, the students stated that non-transparent communication potentially perpetuates the ignorance within the population (n=10).

In relation to how important is the mining process dissemination given by the mass media to inhabitants, the respondents (n=12) consider that the media play a crucial role in the dissemination of information, which has to be imparted impartially and on a scientific basis so that citizens can form grounded opinions.

The students also advocate ways of how to minimize and mitigate the negative impacts in environment and local communities as environmental (n=8) and socioeconomical impact studies (n=5).

A list with a plan of rehabilitation based on environmentally and socially sustainable standard elements and management systems in a mining site was written by the students and included: landscape requalification (n=10), exploitation for geoeducational purposes (n=5) and geotourism initiatives (n=8).

4. Conclusions

The results of this investigation show us that students recognized the importance and relevance of maintaining a geoethical perspective when taking decisions about Earth problems. For the resolution of the complex problems that society faces on a daily basis, it is essential to underpin the procedures to take under a geoethical perspective.

Students involved also point out that the lack of transparency between the actors engaged in the mining exploitation process is one of the biggest problems faced when new exploitation is being formalized. The need to improve this communication should be one of the first steps assured on the process, as well as plans to minimize and mitigate the negative exploitation impacts and to benefit from the positive ones.

The implementation of educational resources based on a geoethical perspective was efficient in reaching the initial aim and the application on other samples and contexts can reinforce its quality and importance for the needed change of perspective, concerning both ethical decision-making on Earth-related problems and on science education itself.

Students must be challenged to develop new competencies. Following the reality of nowadays society Students must be challenged to develop new competencies and to follow the reality of nowadays society and science education is the best way to do it.

Acknowledgement

This work was developed on the scope of GOAL – Geoethics Outcomes and Awareness Learning – (2017-1-PTO1-KA203-035790) Project, funded by the European Commission, through Erasmus+ Programme (https://goal-erasmus.eu).

REFERENCES

[1] Vasconcelos, C., Ribeiro, T., Vasconcelos, L. & Ferraz, S. “Checking the scientific literacy of humanities and science students: They say minerals are everywhere – is that so?”, 11th International Conference of Education, Research and Innovation, Seville, IATED, 2018, pp. 263-267.

[2] Chatterjee, K. K. “Introduction”, Uses of Industrial Minerals Rocks and Freshwater, New York, Nova Science Publishers, 2009, pp. 1-6.

[3] Keilman, N. “Erroneous Population Forecasts”, Old and New Perspectives on Mortality Forecasting, Cham, Springer International Publishing, 2019, pp. 95-111.

[4] Crutzen, P. J. “Geology of mankind”, A Pioneer on Atmospheric Chemistry and Climate Change in the Anthropocene, Cham, Springer International Publishing, 2016, pp. 211-215.

[5] Vasconcelos, C., Ribeiro, T., Vasconcelos, M. & Cardoso, A. “Educating for Geoethics: raising students’ awareness and public engagement”, Education and New Developments 2019, Volume I, Porto, In Science Press, 2019, pp. 355-357.

[6] Vasconcelos, C., Cardoso, A. & Vasconcelos, M. L. “Socio-scientific issues and scientific literacy”, 11th International Conference of Education, Research and Innovation, Seville, IATED, 2018, pp. 7500-7505.

[7] Peppoloni, S. & Di Capua, G. “The meaning of Geoethics”, Geoethics: ethical challenges and case studies in Earth Science, Massachusetts, Elsevier, 2015.

[8] Peppoloni, S., & Di Capua, G. “Introduction”, Geoethics: the role and responsibility of geoscientists, London, Geological Society, 2015, p. 1.

Intellectual Legal Aspects of New Media in the Modern Media Ecosystem

Evelina Zdravkova[1], Tereza Trencheva[2], Dimitar Velichkov[3]
University of Library Studies and Information Technologies – Sofia, Bulgaria[1,2,3]

Abstract

The 21st century man is immersed in the information society at the heart of which stands information. His life is impossible in the absence of media – both traditional and new. Press, radio, television, social networks, the Internet, blogs function as a conglomerate of companies, mechanisms, organizations that are engaged in business relationships between people, business, management, information. The main actors in this world are journalists and their professionalism. In an information-driven global infrastructure, the role of the journalist, who by his or her knowledge and skills, social competence, ability to attract the attention of others, and create trust between himself and the audience, impacts individuals or groups, is increasingly important. Technological developments over the past two decades have contributed to this blurring of the boundaries between creators and consumers. Twenty years after the onset of the digital revolution, it is crucial to discuss the role of intellectual property rights (IPRs), in particular copyright, of creativity and deserved renumeration of media content creators. The European Commission has introduced stricter rules on copyright, but this has not benefited creators. The lack of literacy with regard to copyright policy and intellectual property (IP) as a whole in the media field necessitates urgent discussions and education on the issues that lead to a systematic accumulation of knowledge and the formation of appropriate thinking and perception of media production. The modern man - the person of the 21st century who creates media content, needs a broader media education to include IP. Collaboration between journalists, owners, and users of media content is an important area of protection for journalistic work and plays a key role in improving the effectiveness of their management. Dialogue is needed to build a stable media ecosystem so that all of them are informed about the applicable legal framework.

Keywords: media, journalism, intellectual property, copyright, the digital revolution

1. Introduction

The media is the new challenge for today's high-tech information society. The volume of information is growing at an increasing rate and the ability to create and consume media content is becoming an increasingly relevant issue in the present. People communicate through images, sounds, text, and need to be legally aware of the many media messages that overwhelm/surround them – ads, movies, online content. New digital technologies are drawing more and more users into a world of sharing, engagement and creativity where anyone can produce their own content, use the media competently and with creative input. Today’s media and their journalistic teams are part of today’s information society [3]. In the context of the digital revolution, it is becoming increasingly difficult to preserve the foundations of quality journalism and to evaluate the work of journalists as the fruit of their creative mind. Their concern is for media to follow the basic principles of journalism, namely to follow the principle of "truthfulness, honesty, accuracy of information" [1]. In a new age where everyone can be a source, an author, and a user, who will be responsible for the information being provided, the copyright of the journalists and who will be the corrective for the consumer.

2. The Journalist in the Communication Flow

Both the media world and the way the audience is reaching information are changing at a rapid pace. Media are no longer just a mainstream media, but a medium of communication. Global social communication flow and journalism create news every minute, thanks to the techniques and mechanisms used by modern media to get messages across to different segments of the audience. Clara Shi distinguished the development of new communication technologies from the creation of computers (such as electronic computers in the 1970s) to the emergence and dynamic development of social networks in the early third millennium by introducing the term Fourth Internet Revolution [6]. Online news portals, forums, blogs, social media, social networks are just some of the current Internet spaces that set alternative writing and journalistic standards.

In this information-rich environment, the role of the journalist is increasingly important, with his articles and journalistic material influencing on an individual or group level with his knowledge and skills, his social competence, his ability to attract the attention of others and create trust. [12]. With the development of the Internet, the advent of mobile TV, 3D television, smartphones and tablets, the tremendous leap in communication technologies has led to a merger of communication flows from the interpersonal and media levels of human interaction.

3. Copyright and Creation

The European Commission (EC) has introduced stricter rules on copyright, but this has not benefited creators. According to a study by Queensland University of Technology (QUT) that looks at "Australian artists' reuse practices", copyright can be as easy a stimulus for the author as a deterrent to creativity [5]. They interview creators of creative products, such as documentary directors, writers, musicians, artists, to determine how authors reuse content, whether they have sought permission (license) to use copyrighted content; how long it took to obtain such permits; what actions the creator took in case the permit was refused or was too costly to obtain. However, researchers do not address the problems of journalists as creators. And in the new media, creators are consumers and consumers are creators.

Copyright laws around the world are usually structured in such a way that they give creators exclusive rights and try to balance them with a limited set of user rights (in the form of copyright exceptions or restrictions). Based on this model, it is widely accepted that most (or stronger) exclusive rights are created for the benefit of creators, while most (or broader) copyright exceptions are in the interest of consumers. According to this concept, media content authors benefit from the exclusive rights granted to creators as they stimulate the creation and development of culture and knowledge. Moreover, both journalists and consumers have roles that overlap to a large extent. Many creators are also users of copyrighted material and vice versa. Digital technologies greatly facilitate both the reuse of existing creative works and the dissemination of derivative works. This development led to the emergence of the category "consumer content" or "user-generated content" and concepts such as "prosumer" (the person who is both the creator and the user). These concepts, arising from the blurring of the distinction between user and creator, illustrate the need to introduce an exception on user-created content within the EU copyright framework.

4. Media Production as Intellectual Property

The lack of IP literacy as a whole in the media field necessitates urgent discussions and education on the issues that will lead to a systematic accumulation of knowledge and shaping of appropriate thinking and perception of media production. The scientific community introduces two terms – **media literacy**, as "the ability to use, understand, evaluate and create media critically, independently and responsibly" [8] and **media education** as a concept adequate to the modern development of civil society and respectively about the knowledge of media workers. The modern man – the person of the 21st century who creates media content, needs a broader media education that includes IP. The journalistic profession faces a major challenge.

The term "Online Journalism" has many common features with traditional journalism such as "truthfulness of information; analysis and processing of information; studying the origin of the observed event; the use of accessible language; criticality to the information flow; opportunity for feedback from the audience, etc." [11]. In the context of modern times, the specifics and how they fit into media IP protection policies are more interesting. The traditional and the new media complement each other, expanding the possibilities of the journalistic profession as a modern profession in line with modern technologies.

Following the entry into force of the Treaty on the Functioning of the EU (TFEU) in 2009, the Union has explicit competence in the field of IPRs (Article 118), on the basis of which it develops and implements its strategic documents in this field [2]. The developed Green Book on copyright and patent law sets out the framework for future action as an advisory document. It sets out the priority of IP for achieving prosperity and benefits for the research space, societies of society, unification of the legal framework and standards in the field of science, research and IP, increasing the level of competition within the research space, etc., promoting free access to research results, enabling IP protection and ensuring equal and fair treatment of participants in international research projects by Member States and third countries in respect of ownership and access to IPRs, for the mutual benefit of all partners and to build a European market based on knowledge. [10]

5. Legal Framework

IPRs are within the scope of EU law and are governed by the various national laws.

The EU's legislative activity is mainly about harmonizing specific aspects by creating a single European system that sets clear standards and facilitates their implementation.

There is no copyright protection system for journalists and their copyright material.

Collaboration between journalists, owners and users of media content is an important area of protection for journalistic work and plays a key role in improving the effectiveness of their management. Dialogue is needed to build a stable media ecosystem so that all of them are informed about the applicable legal framework. Traditional and new media to exchange good practices and develop measures, such as codes of conduct, that summarize generally accepted media and journalistic standards. Take individual or collective action to promote the enforcement of IPRs in the media industry. A common practice in recent years has been that, in the case of infringement alerts, access to pages that offer copyrighted material is voluntarily blocked without going to court. It could also be applied in the media.

It is permissible to introduce a system whereby each author's journalistic work has its own digital identification code. Thus, when entering the unique number of the work on the screen, the title, the names of the rightsholders, the companies representing the entitled persons, the territories for which the use is allowed, under what financial conditions the use is allowed to be easily readable. This number can be inserted into any record of the work. Thanks to it, collective management organizations will be able to identify any work that participates in the media market, as well as retrieve certain data about right holders of it. This will facilitate the allocation of the amount received by the content providers to the rights holders. There is a tendency for journalists to pay more attention to the new conditions facing IP in the media, but at the same time, the preparation and consultation processes must be conducted to create a sustainable and effective strategy for improving the IP competency of workers in media. A consistent policy will raise the awareness of journalists. Media literacy initiatives in the field of IP such as hours devoted to the topic, organizing scientific conferences, festivals, performances and other projects that focus on informing journalists about their work would encourage journalists to consider protecting their work as a creative product of their particular work. Some European and American universities study in-depth the on-screen language codes described by Umberto Eco [9]. The reason is that communication is a common ground for journalists and PRs, as well as eloquence, rhetoric, public speaking or, in general, the formulation of messages. [7, 10].

Modern media companies rely on the professionalism of journalists, who must be as flexible and as capable as possible. But the results of their work are measured by criteria that are far from the criteria for unique creative contribution and added value. Measures of good and quality media production are revenue, audience engagement, number of views or number of visits, etc. Media owners produce a media product by investing their funds, but expect a high return on the commercial messages they publish. In other words, it is a common practice to use good product marketing, not to chase the educational, educational or entertainment function of the media [4].

6. Conclusion

The increasing positions of new media in today's media ecosystem require patience and time to attract followers, inspire confidence, and find their place in the flow of useful or unnecessary information. Just as in real life, confidence and good reputation are gradually being built, so in new media modern practices do not always find their way to the target audiences without problems. The poor knowledge of the new media proves the need to reconceptualize and redefine concepts that adequately take into account changes in the media market and thus stimulate the retraining of professionals in the field of traditional media in the field of new media. New technologies are part of our daily lives, but we must believe in the accuracy of the information we receive. The negative message is gaining popularity very quickly. And journalists need confidence. And it is the result of quality work and high appreciation of their work as the fruit of a creative process and the result of shared tendencies with the public. Moreover, guaranteed IPRs encourage media companies to invest in innovation and creativity. Measures and initiatives are needed to facilitate the control of infringements of IPRs and to improve enforcement of IPRs and to encourage investment in the development of media products in Europe.

Acknowledgements

This research would not have been possible without the financial assistance of the following project: “Model for research and increase copyright literacy at the media in the university environment”, financed by National Science Fund of the Ministry of Education and Science of the republic of Bulgaria with Contract № KP – 06 – M35/1 from 18.12.2019, led by Eng. Evelina Lyubomirova Zdravkova-Velichkova, PhD.

REFERENCES

[1] Angelov, A. 2012. Journalistic Ethics, Cameo-Sofia, Bulgaria.

[2] Denchev, S. & Trencheva, T. “Intellectual Property as a Basic Part of the University’s Information Literacy”, Proceedings of ICEMS 2016 Conference, 28-29th May, DEStech Publications, Beijing/China, 2016, pp. 74-78.

[3] Georgieva, G. 2019. International cooperation in mass media. DioMira, Sofia, Bulgaria.

[4] E. Zdravkova. Media literacy as a key competency for the safe and effective use of media, In Conference Proceedings: 12th International Conference on Education, Research and Innovation, Seville, Spain, 2019, pp. 7467-7473.

[5] T. Trencheva, S. Denchev, E. Zdravkova. The Media Industry and Intellectual Property Integration: Abstraction or Reality, In Conference Proceedings: 17th International Conference of e-Society 2019, Utrecht, The Netherlands, IADIS Press, pp. 12-20, 2019.

[6] Mavrodieva, Ivanka, 2009. Communication Features in WEB 2.0. Semarch, Sofia, Bulgaria.

[7] Nikolova, Eugenie, 2010. The Words of Media Transition. Media Literacy. Faber, Veliko Tarnovo, Bulgaria, pp. 144-150.

[8] Peteva, I. & Denchev, Stoyan & Trenchev, Ivan. (2019). Mixed reality as new opportunity in the preservation and promotion of the cultural and historical heritage. pp. 2451-2456.

[9] Stoitsova, Tolya, 2004. Face to face with the media. Sofia Publishers, Sofia, Bulgaria.

[10] K. Planska-Simeonova. Copyright Protection of Photographic Information in Compliance with the New Regulations of the European Union, 11th annual International Conference on Education and New Learning Technologies Palma de Mallorca, Spain, 2019, pp. 5040-504.

[11] S. Dimitrova. E-content – intellectual property aspects // 11th International Conference on education and new learning technologies, EDULEARN19 Proceedings, Palma, Mallorca, Spain, Vol. 11, 2019, pp. 6061-6065.

Managing Intellectual Capital: Increasing Performance of Higher Education Institutions in Romania

Cristina Raluca G. Popescu[1]
University of Craiova – University of Bucharest – The Bucharest University of Economic Studies – National Institute of Research and Development for Environmental Protection (I.N.C.D.P.M.), Romania[1]

Abstract

Intellectual Capital is a key notion that refers to different intangible variables, such as human capital, structural capital, and relational capital, that have the immense power to provide an essential value to organizations worldwide and ensure entities' competitive sustainability. Additionally, Intellectual Capital represents one of the most vital intangible assets of our knowledge society, based on the fact that, one the one hand, it enriches individuals' abilities to develop and, on the other hand, it offers entities the opportunity to increase their performance, quality and value. Thus, investigating Intellectual Capital is a continuing concern for knowledge management, business process management and information and communications technology, since information in society and social development represent major areas of interest in a constantly challenging and increasingly competitive environment. This research aimed at presenting the advantages and the challenges of managing intellectual capital with the purpose of increasing performance of higher education institutions in Romania. Due to this, the work examined the results obtained by using the following research methods in both public and private higher education institutions in Romania: surveys, interviews, focus groups. Firstly, this paper has shown that Intellectual Capital plays a paramount role in the field of educational management in Romania, in general, and in the higher education institutions in Romania, in particular. Secondly, this paper has emphasized the opportunities and the challenges related to intellectual capital in Romanian higher education institutions. Thirdly, this paper has proposed a scientific model capable to value intellectual capital in Romanian higher education institutions based on the idea that, by exploiting intangible assets, the quality of higher education and the services provided by higher education institutions will increase substantially in time.

Keywords: Intellectual capital, human capital, performance, higher education institutions, intangible variables, quality of education

1. Introduction

Recent developments in the field of economic sciences and business administration have led to a renewed interest in analysing and explaining the importance and the role played by Intellectual Capital in increasing the performance level of organizations [13, 14].

In particular, researchers (especially belonging to the accounting, audit, and economic and financial analysis domains) have shown the increased power played by Intellectual Capital in supporting the entities' management business processes [19], knowledge management assessment [18] and information and communications technology influences, demonstrating the need to evaluate intangible variables and their inputs in the organizations' performance level [17].

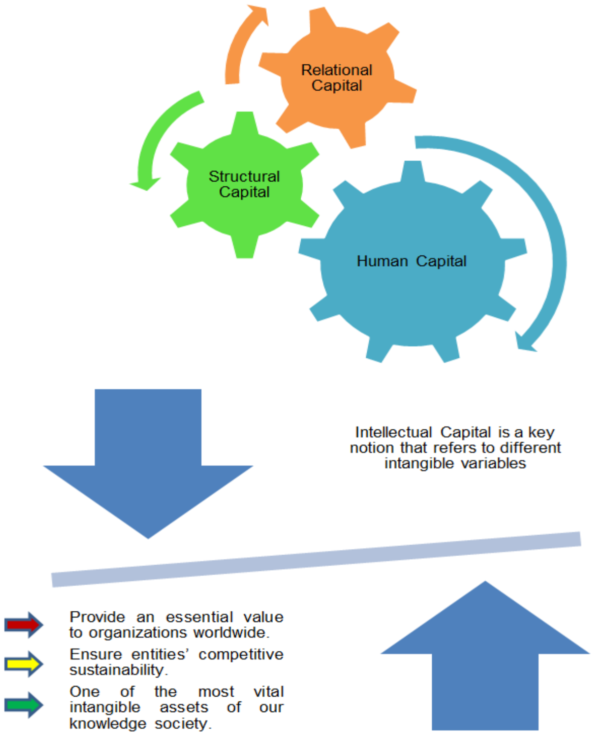
Until these days, numerous attempts have been made to link the activity of managing Intellectual Capital to the results obtained by companies worldwide [20, 24], however only a few have chosen to address the manner of increasing performance of higher education institutions in Romania by the aid of intangible capital – and especially by the use of Intellectual Capital components [15, 16].

Concerning this study's significance and rationale, it should be pointed out that specialists all around the world have come in their works on several occasions to the conclusion that Intellectual Capital represents "the new wealth of organizations" [22], which represents a clear argument to continue to explore and examine the advantages brought by intangible variables to the efficiency, performance and sustainability of institutions [23].

2. Literature Review

A large and growing body of literature has investigated contemporary economy through a double perspective: firstly, by addressing the challenges that occurred from the economic and financial crisis [17], and secondly, by outlining the changes that appeared as a result of the new economy and knowledge society [21].

Fig. 1. *Intellectual Capital: key components and importance*



Legend: This figure underlines the main components that constitute the process of managing Intellectual Capital, targeting the discovery of new solutions meant to increase performance of organizations, in general, and of higher education institutions in Romania, in particular.

Traditionally, it has been argued that the new economy and the knowledge society have based their foundation on the principles of certain dominant elements, such as: creativity; individuals' skills and values; information management skills; innovation; intangible assets; intelligence; know-how; and knowledge (see Figure 1) [12].

However, the generalizability of much published research on this issue is problematic, since the results of investing in intangible assets – such as, for instance, human capital, know-how, research, innovation and development, knowledge development and management, creativity and innovation, are still subjective and difficult if not even impossible to measure [6] – especially according to the traditional accounting indicators and parameters [4], or the generalized economic value accounts [5].

3. Methodology

To date, various methods have been introduced and described to measure the processes responsible for managing Intellectual Capital [7, 8].

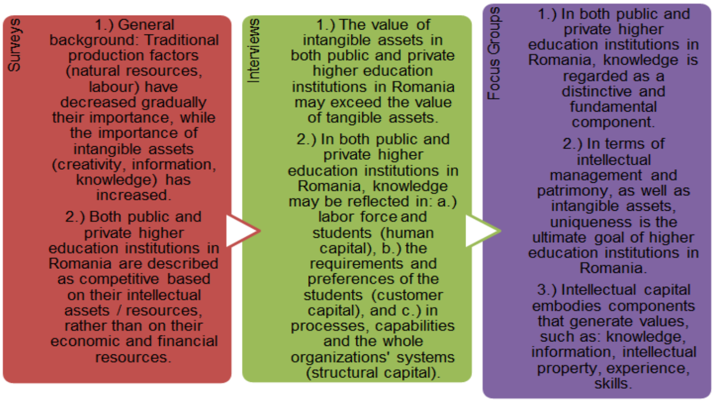
Given the importance of intangible assets in universities and especially the relevance and significance of Intellectual Capital in educational organizations, this current scientific work aims at providing substantial data referring to the consequences of analysing Intellectual Capital in the process of increasing performance of higher education institutions in Romania.

Thus, a variety of methods are used to assess managing Intellectual Capital and to discover the ways of increasing performance of higher education institutions in Romania, as follows: in order to present the advantages and the challenges of managing intellectual capital with the purpose of increasing performance of higher education institutions in Romania, the work examined the results obtained by using surveys, interviews, focus groups in both public and private higher education institutions in Romania.

4. Data Analysis and Discussions

In terms of data analysis and discussions this scientific paper suggestively entitled "Managing Intellectual Capital: Increasing Performance of Higher Education Institutions in Romania" points out the valuable results obtained using surveys, interviews, focus groups in both public and private higher education institutions in Romania.

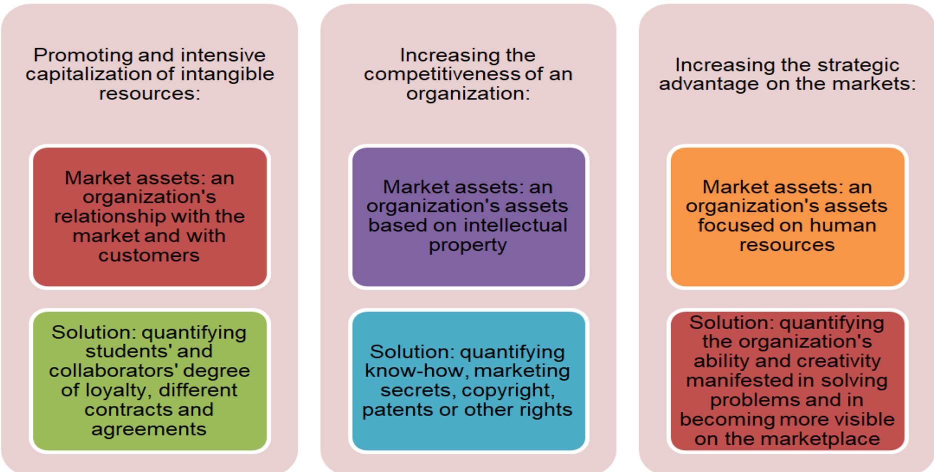
Fig. 2. *Assessing and managing Intellectual Capital: ways to discover the potential of increasing performance of higher education institutions in Romania*



Legend: This figure underlines the results of assessing and managing Intellectual Capital, as well as the manner to discover the potential of increasing performance of higher education institutions in Romania. In like manner, this figure portrait the main results obtained by using surveys, interviews, focus groups in both public and private higher education institutions in Romania.

In addition, it should be stressed that a variety of methods were used to assess managing Intellectual Capital in order to establish the manner of increasing performance of higher education institutions in Romania, having in mind the idea of presenting the most relevant and significant ones, since each method has its advantages and drawbacks (see Figure 2 and see Figure 3).

Fig. 3. *A scientific model capable to value intellectual capital in Romanian higher education institutions based on the idea that, by exploiting intangible assets, the quality of higher education and the services provided by higher education institutions will increase substantially in time*



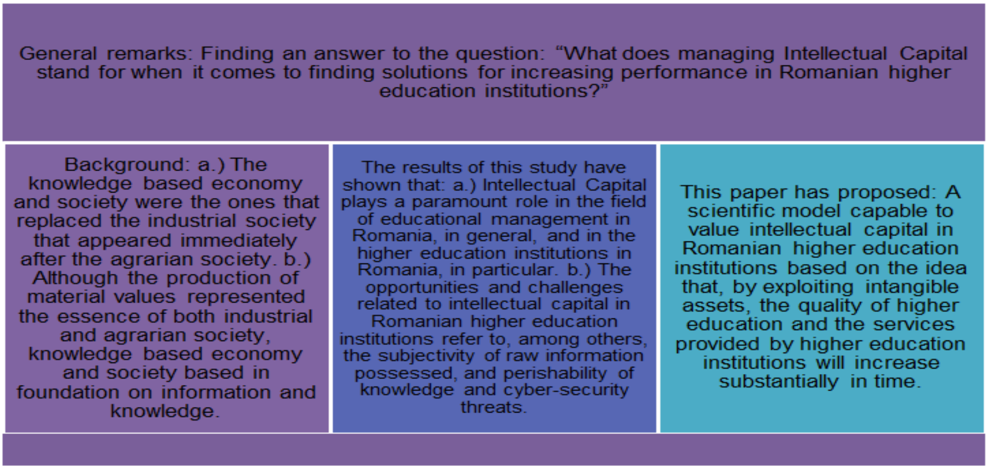
Legend: This figure describes a scientific model capable to value intellectual capital in Romanian.

5. Conclusions, Limitations and Future Work

The general conclusions of this study are shown in the figure below (see Figure 4).

These results come to complete previous works and research on intellectual capital [1-3], as well as the interpretation of intellectual capital's crucial role in our knowledge-based society [7-11].

Fig. 4. *Conclusions: What does manage Intellectual Capital stand for when it comes to finding solutions for increasing performance in Romanian higher education institutions?*



Legend: This table underlines the results of assessing and managing Intellectual Capital, as well as the manner to discover the potential of increasing performance of higher education institutions in Romania.

REFERENCES

[1] Baker, R. J. (2007), "Mind Over Matter: Why Intellectual Capital is the Chief Source of Wealth", Publisher: Wiley, ISBN: 978-0-470-05361-4.

[2] Berg, M. (2006), "The Genesis of 'Useful Knowledge'," International Economic History Congress, Helsinki, Session 38.

[3] Bhatti, W.A., Khan, M.N., Ahmad, A., Hussain, N., Rehman, K. (2011), "Sustaining Competitive Advantage through effective knowledge management", African Journal of Business Management, 5(8), pp. 3297-3301.

[4] IAS 38 Intangible Assets (2017), https://www.pkf.com/media/10031776/ias-38-intangible-assets-summary.pdf (accessed online on 15th December 2019).

[5] International Federation of Accountants (IFAC) (2018), https://www.ifac.org/ (accessed online on 15th December 2019).

[6] Lev, B. (2001), "Intangibles Management, Measurement, and Reporting", Brookings Institution Press, Washington DC.

[7] Lewis, A. (1954), "Economic Development with Unlimited Supplies of Labour", The Manchester School.

[8] Organization for Economic Co-operation and Development (OECD) (2001), "The Well-Being of Nations. The Role of Human and Social Capital, Centre for Educational Research and Innovation", http://www.oecd.org/site/worldforum/33703702.pdf (accessed online on 15th

December 2019).
[9] Organization for Economic Co-operation and Development (OECD) (2016a), “Better Policies for 2030. An OECD Action Plan on the Sustainable Development Goals”, https://www.oecd.org/dac/Better%20Policies%20for%202030.pdf (accessed online on 15th December 2019).
[10] Organization for Economic Co-operation and Development (OECD) (2016b), “Better Policies For 2030: An OECD Action Plan on the Sustainable Development Goals”, https://www.oecd.org/dac/OECD-action-plan-on-the-sustainable-development-goals-2016.pdf (accessed online on 15th December 2019).
[11] Organization for Economic Co-operation and Development (OECD) (2018), “The OECD measurement of social capital project and question databank, Centre for Educational Research and Innovation”, http://www.oecd.org/sdd/social-capital-project-and-question-databank.htm (accessed online on 15th December 2019).
[12] Peters R. H., Taylor, L.A. (2017), “Intangible capital and the investment-q relation”, Journal of Financial Economics, Volume 123, Issue 2, pp. 251-272.
[13] Pike, S., Roos, G. (2000), “An introduction to intellectual capital”, Works Institute Journal, 42, pp. 21-27.
[14] Piketty, T. (2015), “Capitalul în secolul XXI”, Editura Litera, Bucureşti.
[15] Popescu, V.A., Popescu, C.R.G., Popescu, G.N., “Education and New Technologies – Case Study on the Romanian Society”, 2th edition of the International Conference the Future of Education, Pixel, Florence, Italy, 7-8 June, 2012, Conference book “The Future of Education Conference Proceedings 2012”, Simonelli Editore University Press, Volume 2, pp. 124–127, ISBN 978-88-7647-808-6.
[16] Popescu, V.A., Toiba, D., Popescu, C.R.G., “Virtual Learning Communities – a Study Case on Romania’s Nowadays Situation”, 4th edition of the ICT for Language Learning Conference International Conference on the Future of Education, Pixel, Florence, Italy, 16-17 June, 2011, Conference book “The Future of Education Conference Proceedings 2011”, Simonelli Editore University Press, Volume 1, pp. 185-188, ISBN 978-88-7647-647-1.
[17] Popescu, C.R.G.; Popescu, G.N. “An Exploratory Study Based on a Questionnaire Concerning Green and Sustainable Finance, Corporate Social Responsibility, and Performance: Evidence from the Romanian Business Environment”, Journal of Risk and Financial Management, 2019, vol. 12(4), pp. 1-80, October, https://doi.org/10.3390/jrfm12040162.
[18] Popescu, C.R.G. “Corporate Social Responsibility, Corporate Governance and Business Performance: Limits and Challenges Imposed by the Implementation of Directive 2013/34/EU in Romania”, Sustainability, 2019, vol. 11(19), pp. 1-31, September, https://doi.org/10.3390/su11195146.
[19] Popescu, C.R.G.; Banța, V.C., “Performance Evaluation of the Implementation of the 2013/34/EU Directive in Romania on the Basis of Corporate Social Responsibility Reports”, Sustainability, 2019, vol. 11(9), pp. 1-16, May, https://doi.org/10.3390/su11092531.
[20] Porter, M.E. (1990), “The Competitive Advantage of Nations”, Harvard Business Review, New York: The Free Press.
[21] Stam, C., Andriessen, D. (2009), “Intellectual Capital of the European Union 2008: Measuring the Lisbon Strategy for Growth and Jobs”, Electronic Journal

of Knowledge Management, Vol. 7, Issue 4, pp. 489-500, ISSN 1479-4411, Academic Conferences Ltd.

[22] Stewart, T.A. (1997), "Intellectual Capital: The New Wealth of Organizations", Publisher: Doubleday/Currency, New York.

[23] Stiglitz, J.E., Sen, A.K., Fitoussi, J.-P. (2009), "The Measurement of Economic Performance and Social Progress Revisited: Reflections and Overview", Sciences Publications, 2009-33, Sciences Po.

[24] Sveiby, K.E. (1997), "The Intangible Assets Monitor", Journal of Human Resource Costing & Accounting, Vol. 2 Issue: 1, pp. 73-97, https://doi.org/10.1108/eb029036.

Micro- Meso- and Macro-Pedagogy For Innovative Science Outreach

Veronica McCauley[1], Kevin Davison[2], Paul Flynn[3]
School of Education, National University of Ireland Galway, Ireland[1,2,3]

Abstract

The selection of science as an examinable subject at both second and third level is seen as less favourable by Irish students. This decline has prompted universities, as key stakeholders, to respond with a surge of science outreach strategies and interventions. We argue that teachers and teacher educators are well placed to play a strategic role in science outreach efforts by considering micro- meso- and macro-pedagogical innovations. Micro-pedagogy involves the application of effective lesson hooks, and creative approaches to science teaching. Meso-pedagogy involves integrating outreach strategies into science lessons in formal education settings. Macro-pedagogy outreach strategies involve larger initiatives to bring science out of the classroom into the public view, working in tandem with micro- and macro-pedagogic strategies to produce meaningful learning experiences that yield greater engagement and personal interest. This paper will highlight the critical role of teachers and teacher educators in promoting science and offer examples of micro- meso- and macro-pedagogical innovations.

Keywords: Science outreach, science teaching, pedagogical innovation, lesson hooks

1. Introduction

Policy makers internationally recognise the capacity of science to drive economic ambition [16]. Despite high progression rates of Irish students to higher education [1] the uptake of science at second level, in particular the physical sciences, is a concern. As key stakeholders, universities have responded with a surge of science outreach and communication initiatives [2], [15] to support Irish teachers and their students [3]. We argue that teachers and teacher educators may have a more active role to play in science outreach by considering micro- meso- and macro-pedagogical innovations. Micro-pedagogy and Meso-pedagogy are in-class innovations involving the strategic use of lesson hooks, and the explicit integration of subject promotion by teachers, respectively.

Macro-pedagogy consists of larger initiatives to bring science out of the classroom into the public view, working in tandem with micro- and macro-pedagogy toward greater science engagement and personal interest. This article highlights the potential of teachers and teacher educators in promoting science and science careers.

2. Science Outreach

In response to a decline in student interest and achievement in the sciences, the authors have been working in the area of public science engagement for over a decade.

As teacher educators, we wanted to play a role in the research and design of innovative approaches that acknowledge the naturalistic context of teaching in Ireland.

While it was evident that a diverse range of, although uncoordinated, science outreach initiatives had been implemented nationally, we felt that a dedicated conference in STEM Outreach would instigate a more cohesive dialogue between outreach providers, practitioners, policy makers, teachers, teacher educators, and scientists. A key outcome from the first conference, held in 2007, was the publication of a report [2] that mapped the diverse nature of STEM outreach initiatives across Ireland. Challenges were identified that indicated difficulty in terms of inter-stakeholder collaboration, evaluation, and a need to shift away from simply providing information about science.

Instead, subsequent conferences, between 2008-11, sought to advance a more cohesive and strategic approach that attempts to influence social behaviour toward science engagement, informed by international best practice. Although this initiative broadened knowledge of both theory and practice in the science outreach community, teachers and teacher educators were not explicitly considered as key stakeholders.

Indeed, we regularly encountered evidence of outreach practitioners questioning the way science is taught in the classroom. Outreach strategies are often designed to address a deficiency, which can position teachers as bystanders, or one step removed in science outreach [5]. This can have a negative impact on students' future participation in STEM subjects [17].

While many primary teachers do not have a comprehensive background in science and may be less prepared to teach foundational science [4], it is, perhaps, a little reductionist to blame poor science teaching. Science outreach providers are less constrained by curricular and institutional structures and are better positioned to craft innovative science lessons to supplement formal science education. However, when educational innovations emerge from research as actionable knowledge, are aligned with the curriculum, and are situated in pedagogy, long-term success is more likely [5].

Such initiatives are highly valued by science teachers as they do not function simply as supplemental material. As such, we are proposing micro- meso- and macro-injections of pedagogy as opportunities to advance a more holistic science outreach strategy.

3. Micro-Pedagogy: Lesson Hooks

A lesson hook is a short introductory pedagogical moment that captures what is interesting and engaging about the material to be covered [9]. However, from our school placement observation experience we have found the quality of the hook is often poor.

Responding to this issue, we engaged with pre-service teachers to research and collaboratively design effective lesson hooks for lower secondary-level science teaching [10]. This afforded a greater understanding of the design sensitivities that inform the development of effective lesson hooks [13]. Actively engaging students from the outset of a lesson has the potential to enhance student interest in a topic and result in a more persistent, intrinsic personal interest. Initially, the pre-service teachers found that adding a video clip to the beginning of a lesson had limited capacity to engage students. A subsequent redesign and application of Interest Theory [8] allowed learners to move from where their interest is triggered or situational interest, toward an intrinsically generated personal interest.

Chemistry, Physics, and Biology hook iBook's were created to serve as micro-pedagogical resources for preservice and in-service science teachers. We believe that the strategic use of well-designed lesson hooks can pique student interest not only in the lesson that is to unfold, but also in science more broadly. Recognising the value and potential of a well-designed lesson hook [13] may bring science teachers back to a more central role in the delivery of science outreach activities.

4. Meso-Pedagogy: Science Teaching as Outreach

We argue that outreach is an inherent part of a science teachers' work. However, science teacher education rarely makes explicit reference to the fact that the very way teachers teach, their pedagogical practice, is a valuable tool to promote interest in science. Examination pressure and curricular constraints can often limit the time available for teachers to diversify their pedagogy, yet we have found that science teachers are quite enthusiastic about opportunities to try new methodologies. While it may seem like a daunting task for teachers to both teach science and provide outreach opportunities, this can be supported by connecting with extant networks of science outreach providers and practitioners. Such hybrid conversations [11] and collaborations between teachers and outreach practitioners may open up a 'third space' where both parties can work together to engage students in science [7] and make the promotion of science an ordinary part of the way science is taught at this meso-pedagogical level.

5. Macro-Pedagogy: Unexpected Science

Preservice teachers are often reminded of the pedagogical value of the unexpected.

Such occurrences can shake-up preconceptions and reorient their students' relationship with science. In addition to employing micro- and meso-pedagogical strategies in the classroom, teachers might also draw on societal resources to enhance their teaching. Unfortunately, informal science education opportunities may not always be available to teachers. In 2011 the authors ran a pilot project called Guerrilla Science which involved pairing local artists with scientists to create public art. The aim of the project was to place science-art in public locations so people would have greater opportunity to encounter science in the everyday environment. These pop-up science projects aimed to take people by surprise, create curiosity, and pique interest.

Fig. 1. *Guerrilla Science of 'Latch-On' haustoria art. This parasitic plant science-art was attached to buildings and lampposts throughout Galway drawing people to the exhibit*

Building on the success of Guerrilla Science, we have engaged virtual reality and augmented reality artists to help teach both teachers and students about astronomy as a new element of the Irish science curriculum, and through a large-scale public performance of an embodied orrery. This Immersive Classroom project aims to create opportunities to inject science engagement into society as both education and spectacle in the grey areas between formal and informal education.

Additionally, outreach providers working in schools had told us that they sometimes met with resistance from teachers due to the overcrowded curriculum and the lack of time for additional elements [7]. In response we designed a thematic e-Book with both a topical and a curricular Table of Contents so that teachers could continue to teach core elements of the science curriculum (cell structure, photosynthesis, etc.) through the use of an engaging interactive resource [12]. We found this to be an effective way of layering science outreach over the existing curriculum, so that it was not an additional element, but rather a stealthy pedagogical injection.

6. Conclusion

Science teachers and science teacher educators have a lot to contribute to the promotion of science but currently find themselves on the margins of diverse outreach initiatives. However, subtle micro- meso- and macro-pedagogical shifts may be a viable way to foster wide-spread personal interest in science without placing significant additional demands on classroom practitioners. Science teacher educators may impart these pedagogical approaches to the next generation of science teachers through a focus on lesson hook design and science outreach theory as pedagogical practice, and direct, active, involvement in broader outreach activities in society. Lesson hooks and conscious outreach teaching approaches facilitated by new hybrid relationships between teachers and outreach practitioners are small steps toward a common goal of the advancement of science and Irish society.

REFERENCES

[1] Central Statistics Office Ireland. “Educational Attainment Thematic Report”, https://www.cso.ie/en/releasesandpublications/er/eda/educationalattainmentthematicreport2018/, 2018.
[2] Davison, K., Domegan, C., McCauley, V. & McClune, W. “A review of science outreach strategies North and South: With some recommendations for improvement”, Belfast: Centre for Cross Border Studies, http://scotens.org/site/wp-content/uploads/science_booklet.pdf, 2008.
[3] European Commission. “Science Education for Responsible Citizenship”, http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf, 2015.
[4] Eivers, E., & Clerkin, A. “PIRLS and TIMSS 2011: Overview. National schools, international contexts: Beyond the PIRLS and TIMSS test results”, pp. 1-13, 2013.
[5] Flynn, P., Thompson, K., & Goodyear, P. “Designing, using and evaluating learning spaces: the generation of actionable knowledge. Australasian Journal of Educational Technology”, 34(6), 2018.
[6] Gomes, D. “Dialectic dividends: Fostering hybridity of new pedagogical practices and partnerships in science education and outreach”, Unpublished Doctoral Thesis, National University of Ireland Galway, Galway, Ireland, 2015.

[7] Gomes, D., & McCauley, V. “Dialectical dividends: fostering hybridity of new pedagogical practices and partnerships in science education and outreach”, International Journal of Science Education, 38(14), 2016, pp. 2259-2283.
[8] Hidi, S. & Renninger, K.A. “The four-phase model of interest development”, Educational Psychologist, 41(2), 2006, pp. 111-127.
[9] Lemov, D. “Teach like a champion”, Hoboken, NJ: Jossey-Bass/Wiley, 2010.
[10] McCauley, V., Davison, K., & Byrne, C. “Collaborative lesson hook design in science teacher education: advancing professional practice”, Irish Educational Studies, 34(4), 2015, pp. 307-323.
[11] McCauley, V., Martins Gomes, D., & Davison, K. “Constructivism in the third space: challenging pedagogical perceptions of science outreach and science education”, International Journal of Science Education, Part B, 8(2), 2018, pp. 115-134.
[12] McHugh, M., McCauley, V., Davison, K., Raine, R., & Grehan, A. “Anchoring ocean literacy: participatory iBook design within secondary science classrooms”, Technology, Pedagogy and Education, https://doi.org/10.1080/1475939X.2020.1715241, 2019.
[13] McHugh, M., and McCauley, V. “Designing physics video hooks for science students”, Physics Education, Bristol: Institute of Physics Publishing, 2016.
[14] Osborne, J., & Dillon, J. “Good practice in science teaching: What research has to say: What research has to say”, Columbus, OH: McGraw-Hill International, 2010.
[15] Regan, E. “I liked the experiment because there aren’t too many people who come into school to burn money: promoting participation in the sciences with chemical magic”, Improving Schools, 13 (3), 2009. pp. 261-276.
[16] STEM Education Review Group. “STEM Education in the Irish school system: Analysis and Recommendations”, November 2016: https://www.education.ie/en/Publications/Education-Reports/STEM-Education-in-the-Irish-School-System.pdf, 2016.
[17] Zachary, L. W., Sharp, J. M., & Adams, B. M. “Engineering Connections: Teaching Engineering Mechanics to K 12 Teachers”, In 2000 Annual Conference, 2000, June, pp. 5-259.

Online Gaming to Understand and Explain Forced Migration School-Wide

Georgeta Chirleșan[1], Dumitru Chirleșan[2]
University of Pitești, Romania[1,2]

Abstract

As European societies become more multicultural, we need to raise awareness about the push factors forcing people to leave their own countries. Europe needs more cohesive and inclusive societies which allow citizens to play an active role in democratic life. Education is key to prevent violent radicalization by promoting common European values, fostering social integration, enhancing intercultural understanding and a sense of belonging to a community. Education and training will be central to successful integration efforts. The paper presents the results of a field research achieved in Romania in the framework of the Erasmus+ project "ODISSEU: Online gaming and Digital tools to promote the asylum seekers Integration and increase awarene SS amongst schools of the refugees' crisis in Europe" financed by the European Commission. The research aimed at identifying (i) the school needs in terms of new technologies and innovative approaches to discuss global issues; (ii) educational issues related to asylum seekers in connection with civic engagement; (iii) teachers' competences and training needs to support intercultural education. The research results are to be valorised in the development of the holistic and inclusive ODISSEU online simulation game which envisages to be a real support for teachers in engaging young people in informed discussion about forced migration and asylum, in teaching tolerance, fostering asylum seekers' and refugees' civic engagement via role playing. The research was achieved in Romania through focus group discussions and involved three different categories of participants: pupils aged 11 to 18, teachers and educational stakeholders.

Keywords: online gaming, migration, asylum seekers, refugees

1. Introduction

As European societies become more multicultural [1], [2] we need to raise awareness about the push factors forcing people to leave their own countries, as a series of certainties and uncertainties for migration by 2030 have been already identified [3].

Europe needs more cohesive and inclusive societies (achieving a more Social Europe is one of the five investment priorities of the EU Regional Development and Cohesion Policy 2021-2027 [4]), which allow citizens to play an active role in democratic life. Education is key to prevent violent radicalization [5], [6] by promoting common European values, fostering social integration, enhancing intercultural understanding and a sense of belonging to a community, as recommended by the EU Council [7]. Education and training will be central to successful integration efforts, as shown by the European Commission: "*Education plays a crucial role in guiding refugees and other migrants from third countries in adapting to a new country and culture, as well as in establishing social relations within their host communities*" [8]

2. Methodology

The research was implemented within the framework of the Erasmus+ project titled *“ODISSEU: Online gaming and Digital tools to promote the asylum seekers Integration and increase awareness amongst schools of the refugees’ crisis in Europe”* [9], a project financed by the European Commission, in the countries of the project consortium, namely in Italy, Germany, Romania, Cyprus, Malta and Ireland.

Our research objectives were to identify: (i) the school needs in terms of new technologies and innovative approaches to discuss global issues; (ii) the educational issues related to asylum seekers in connection with civic engagement; (iii) the teachers’ competences and training needs to support intercultural education.

The research questions were: (1) Which are the EU policies and legislation in the envisaged field (i.e., education on the usage of online game to raise awareness on forced migration issues)?; (2) Which are the needs of schools & teachers and the best practices in the field of online civic engagement and intercultural education?; (3) Which recommendations could be useful for the development of contents and materials that ODISSEU consortium will develop?; (4) Which are the schools’ needs in terms of new technologies and innovative approaches to discuss global issues?; (5) Which are the issues related to asylum seekers in connection with civic engagement?; (6) Which are the teachers’ competences and training needs to support intercultural education?

The research was performed according to the Research Guidelines priorly developed and agreed by the entire research team, a reference instrument presenting the aim of the research, the methodology and plan, the research tools and the template for the research report.

The research was a field-based one, achieved through three Focus Groups (FGs), organised with the following categories of participants: FG1: young persons aged 11-18 years (10 persons); FG2: teachers (9 persons); FG3: stakeholders at local, national and EU level (e.g., policy makers, professional bodies, etc.) AND representatives of adult educator organizations dealing with asylum seekers and refugees (9 persons). The research was achieved in Romania, in the period February – April 2019. Its results are to be valorised in the development of the holistic and inclusive ODISSEU online simulation game which envisages to be a real support for teachers in engaging young people in informed discussion about forced migration and asylum, in teaching tolerance, fostering asylum seekers’ and refugees’ civic engagement via role playing.

3. Results

3.1 Socio-demographic data

The socio-demographic profile of our participants in the Focus Groups is presented in Table 1 below.

Table 1. *Respondents' profile*

Age profile of the participants in FGs		FG1	FG2	FG3
	11 years	-	-	-
	12 years	2	-	-
	13 years	4	-	-
	14 years	1	-	-
	15 years	-	-	-
	16 years	1	-	-
	17 years	2	-	-
	18 years	-	-	-
	19-25 years	-	-	-
	26-35 years	-	-	3
	36-45 years	-	4	2
	46-55 years	-	4	3
	Above 55 years	-	1	1

Number of participants in each FG and their gender split			
	No. of participants in FG1: Females:	8	Males: 2
	No. of participants in FG2: Females:	8	Males: 1
	No. of participants in FG3: Females:	7	Males: 2

The distribution of institution types (in total, for all 3 FGs)	Schools (in FG1)	Schools (in FG2)	Adult Education org. (in FG3)	Org. working with asylum seekers/ refugees (in FG3)	Authorities (in FG3)	Professional bodies (in FG3)	Other (in FG3)
	6	7	0	1	5	0	2 NGOs

The former experience and involvement of our participants in the social field (i.e., increasing awareness, civic engagement and working with asylum seekers and/or refugees) is shown in Table 2.

Table 2. *Previous experience of participants in the Focus Groups*

No. of participants that have been involved before in a project or activity for increasing awareness and civic engagement regarding an issue of high social impact, or in a project or activity targeting social issues in general (in total, for all 3 FGs)	Total number: 20 (7 from FG1; 7 from FG2; 6 from FG3) Per category: - Environment 9 (4 from FG1; 2 from FG2; 3 from FG3) - Migration 4 (1 from FG2; 3 from FG3) - Gender equality 5 (1 from FG1; 1 from FG2; 3 from FG3) - Social integration 5 (2 from FG2; 3 from FG3) Inter or multi-cultural education 6 (1 from FG1; 2 from FG2; 3 from FG3) - Citizens' safety 3 (1 from FG2; 2 from FG3) - Volunteering 11 (4 from FG1; 3 from FG2; 4 from FG3) - Community collaboration 4 (3 from FG2; 1 from FG3) - Foster homes 5 (2 from FG1; 3 from FG3) Other*:* combating xenophobia 4 (2 from FG1;2 from FG 2)

No. of participants that have been involved before in a project or with or for asylum seekers and refugees (in total, for all 3 FGs)	Total number: 5 (1 from FG1; 1 from FG2; 3 from FG3) Per category: - Support for labour market integration 4 (1 from FG2; 3 from FG3) - Support for social integration 3 (1 from FG2; 2 from FG3) - Educational support 2 (1 from FG1; 1 from FG3) - Professional training support 2 (1 from FG2; 1 from FG3) - Language support 1 (1 from FG3) - Legal support 3 (3 from FG3) - Other: 1 family reunification, citizenship, long-term residence (from FG3)

3.2 Main research findings

The main findings that we obtained after analysing the Focus Groups transcripts are rendered below.

Regarding the schools' needs in terms of new technologies and innovative approaches to discuss global issues:

FG1: Students are accustomed to the new technologies that are being used in school to discuss global issues: educational games, 3D printers (used to create casts for biology, geography, computing, etc.), Internet (used for communication, documentation).

Students prefer the use of new teaching technologies (e.g., tablets) and consider that new technologies could be more used in school. Students have suggested other methods and ways used to discuss global issues such as role-plays, migrant encounters, visits to asylum centres.

FG2: Teachers are interested in new technologies to discuss global issues with students and are aware that they need to adapt to the need for technology, innovation and for the demands of today's students who need to be trained for the future, not for the present. In some schools, there are no requirements for using new technologies; there are no laboratories/computers. Teachers emphasize that students prefer educational software (Kahoot, Edu), the Internet. Often, the topics that are taught are very complex and difficult to be assimilated by the students. The current intercultural education manuals are arid, difficult to understand, without CD/educational games, with tasks difficult to be solved by students, due to the lack of IT skills. The competences created by the intercultural education discipline are: teamwork, creativity, project development on specific topics on migration/interculturality.

FG3: Representatives of institutions and NGOs are familiar with the new technologies and innovative approaches that can be used in school to discuss global issues: short videos, plays, the Internet. A small number of schools have been equipped with laboratories, multimedia rooms, laptops, interactive boards, tablets, educational software, Internet connection, but it depends on how teachers use them. Most schools are in the process of being equipped with computers/new technologies or do not have these technical facilities. Students are interested in global themes but also in new technologies, interactive projects, online games and teamwork. Even if new technologies are useful some teachers are reluctant to use them in the classroom. Other means of involving students in discussing global issues include visits, role-playing games with pupils and pupils' parents, examples of good practice in schools (for example, special school program, chess classes for students of other religions).

On the issues related to asylum seekers in connection with civic engagement:

FG1: Students know that migrants are those people forced to leave their country because of war, poverty, hunger, for a better life. The obstacles encountered by migrants identified by students are: language barriers, difficult adaptation, cultural differences, habits, traditions, reluctance of the local people, stereotypes, difficulty in recognizing graduated studies, emotional difficulties in adapting to another environment, lack of family, friends. There are certain stereotypes and prejudices about asylum seekers which derive from the differences between people (skin colour, different language accents, social status, poorer country origins, the idea that they are terrorists or belong to a certain minority). The online game ODISSEU must: contain concrete data, stories inspired by reality; have a realistic design, be animated; be complete (refer to all aspects of integration); have requirements that are easy to understand by students; show the contrast between good and evil and allow the choice between good and evil; present the steps taken by an asylum seeker, critical situations, obstacles, difficulties, habits of asylum seekers; allow the designing of the character (asylum seeker) based on a questionnaire, depending on some characteristics desired by the student (age, race, social status, etc.); make students make choices while travelling from their native country to the destination country; have characters (asylum seekers) who can move in their journey step by step and offer different perspectives of integration; challenge the students to make choices during their journey from their native country; show other characters who want good or bad things for him/her, highlight the consequences of their choices; have real life questions, the student to can answer and can compare his/her answer with the correct answer; the game can be created by age categories (for younger ages and for older students to face reality, sometimes painful); the game can be played on a laptop/mobile phone. Students should, through the ODISSEU game, learn to be empathic, put themselves in the skin of an asylum seeker. The game should not contain traumatic, violent images, avoid exaggerations, not offend children of a particular ethnicity. In designing the game, there should be available native students and migrant students as well.

FG2: Teachers consider that there are certain stereotypes regarding the race or the minorities in the Romanian society that leave the family. There is also a need to continue to teach intercultural education in high school to enable students to empathize with others, to know them, to respect traditions and to accept others. The problems faced by asylum seekers are the language barriers, the difficulty of accepting others, the requirements of the curriculum, the lack of teachers who know how to deal with these students. To manage an intercultural group, teachers need to be open and have conditions to provide support. School and teachers should provide support to students belonging to the asylum-seeking group, especially for learning Romanian. It was stated that the requirements for completing the studies are not adapted in Romania, neither to foreigners nor to persons with special needs. Teachers consider that students are open to help asylum seeking students integrate, but the integration process is difficult. There are people in the category of asylum seekers who have integrated and who develop civic involvement (e.g., doctors, university professors, researchers, etc.).

FG3: Representatives of institutions/NGOs appreciate that the integration of refugees is a complex process. The main challenges are receiving student registration files in school, organizing the process of learning the Romanian language, involving the school counsellor. In order for the school/community to become more inclusive, it is necessary to change our conception, to be more interested in receiving and integrating asylum seekers, not to be so reluctant towards them. Participants consider success stories regarding integration whenever the asylum seeker learns Romanian, finds a job. It was emphasized that the Maramureş Asylum Centre is an example, at a national level, regarding the procedure of integration of the children of asylum seekers into the national education system. Refugees/asylum seekers make themselves hard to be listened to because there is some reluctance towards them; there are some organizations that try to interview refugees or organize festivals for refugees. In smaller localities, refugee's/asylum seekers are more visible, they integrate better, while in large localities they are lost in the crowd. The civic engagement of refugee's/asylum seekers is influenced by the following factors: the level of integration, the number of years spent in Romania, the involvement of authorities in the integration process, the participation of NGOs. The proposed improvements to the civic engagement of refugees were: implementation of some projects concerning capacitating the refugees, organization of dissemination meetings/sessions; increasing the refugees' desire for integration into the Romanian society.

With respect to teachers' competences and training needs to support intercultural education:

FG2: Teachers must be empathic, understanding, good psychologists, hence "ideal teachers". At the university, they should go through intercultural education. Teachers are considered to need training to cope with the challenge of teaching students. The implementation of intercultural projects would help students distinguish discriminatory attitudes in society, become more aware of the forced migration.

The online game ODISSEU must be based on real life stories, present aspects of migrants' traditions, show different scenarios (the positive and negative side of integration); to allow the game to resume or to choose another way from a labyrinth of situations; the game can have characters that overcome obstacles and succeed in integration; it can have the character that helps other to integrate. The ODISSEU curriculum should be personalized to the children's level: a 20-minute, 30-minute or more scenarios. It should be possible to select the ODISSEU curriculum as optional curriculum, at least.

FG3: School teachers/principals are considered to be involved in a number of activities to harness the traditions of refugee's/asylum seekers; teachers need to know the specificities of different nations/minorities; to have openness to interculturality, to be tolerant. For refugees, there are training modules in several pilot counties within the country. The "Second Chance" Program is also available for refugees. There seems to be a manual for learning the Romanian language as a foreign language, but it is not available. Categories of "actors" could work together to integrate asylum seeking students by: enhancing the capacity of the integration school, by knowing what is specific to refugees by creating a positive attitude of parents. ODISSEU's resources are considered to be very useful: they help create people-to-people relationships, culinary traditions, the traditional costumes, create an open framework for diversity. The characteristics of the ODISSEU game, desired by the participants, are to: present a touching history with short sequences; be animated, coloured/sound; present the parallels between the habits of the refugees/citizens of the country of destination so that students learn from each other, present as objectively as possible the issues (both positive and negative issues), describe the situation in the countries of origin, what actually means the asylum seekers' journey. It should not violate the principle of intimacy; it should not have violent scenes. Refugees could tell about their travels, only under the sign of anonymity. There are few people (5%) who are willing to become characters in these stories (they may relive trauma and do not want it, they fear the authorities, they are looking for a destiny, for a country to accept them). They may be motivated to speak if they are told that what they say might impact others; it might appeal to family members more willing to speak. The challenges and difficulties that we might face in creating the electronic library are the following: ensuring translation, because many asylum seekers cannot express themselves without translation, and the costs are high, often the cases involve rare languages; the difficulty of responding positively to the request to present their own story. A workshop could be useful because there are many active NGOs that assist foreigners and refugees.

4. Conclusions

In general, there is a lack of national policies and strategies regarding online civic engagement, online gaming for migration and asylum seekers issues. There are no national practices that promote the design and development of educational materials and tools to efficiently support the integration of asylum seekers and refugees through the use of online gaming/digital tools.

To a certain extent, the educational system implements some integration programmes for immigrant pupils, inside and outside school, but in general, schools do not exploit on a larger scale the use of technology in the daily school curriculum (excepting in ICT classes).

In some cases, teachers are willing to implement intercultural education but they lack appropriate training to do so. Those teachers who cover global issues in class often do not use new technologies or digital tools as frequent as they would like to do due to the time pressure to cover the syllabus, which is not flexible. In many cases, the use of online games in classroom is, thus, understood more as an additional option and is not regarded as compulsory.

There are still certain stereotypes and prejudices about migrants in schools. Students in most of the cases do not have sufficient knowledge about the topics of migration, asylum seekers and refugees.

Acknowledgements

This work has been carried out within the project "ODISSEU: *Online gaming and Digital tools to promote the asylum seekers Integration and increase awareness amongst schools of the refugees' crisis in Europe*" (www.odisseu-project.eu; ref. no. 2018-1-IT02-KA201-048187), funded by the Erasmus+ Programme of the European Union. The coordinator is Oxfam (Italy) and the partners are University of Erlangen-Nurnberg (Germany), University of Pitesti (Romania), Center for the Advancement of Research & Development in Educational Technology (Cyprus), KOPIN (Malta) and Meath County Partnership (Ireland). The authors wish to thank to all of them.

REFERENCES

[1] Byram, M. "Multicultural Societies, Pluricultural People and the Project of Intercultural Education", Language Policy Division, DG IV/EDU/LANG (2009)15, pp. 3-4.

[2] Canivez, P. "On European Multiculturalism", Alexandre Dupeyrix, Gérard Raulet, European Constitutionalism. Historical and Contemporary Perspectives, P.I.E. Peter Lang, pp.127-138, 2014, Euroclio. Studies and Documents, 978-2-87574-192-9. halshs-01098511, p. 2.

[3] Szczepanikova, A., Van Criekinge, T. "The Future of Migration in the European Union: future scenarios and tools to stimulate forward-looking discussions", EUR 29060 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-90207-9, doi:10.2760/000622, pp. 18-21.

[4] European Commission, "New Cohesion Policy", available at https://ec.europa.eu/regional_policy/en/2021_2027/, accessed on 03.01.2020.

[5] European Commission/Radicalisation Awareness Network, “Education and radicalisation prevention: Different ways governments can support schools and teachers in preventing/countering violent extremism”, 2019, p. 1, p. 11.
[6] “Declaration on Promoting citizenship and the common values of freedom, tolerance and non-discrimination through education”, Paris, 17 March 2015.
[7] EU Council, “Council Recommendation on Common values, Inclusive Education and the European Dimension of Teaching”, available at https://ec.europa.eu/education/education-in-the-eu/council-recommendation-on-common-values-inclusive-education-and-the-european-dimension-of-teaching_en, accessed on 06.01.2020.
[8] European Commission, “Education and Migrants”, available at https://ec.europa.eu/education/policies/european-policy-cooperation/education-and-migrants_en, accessed on 8.01.2020.
[9] ODISSEU Project, https://odisseu-project.eu/en/

Reward System: Perspectives in Health Education

Dora Dragoni Divrak[1]
University of Bologna, Italy[1]

Abstract

Health education involves people studying scientific topics: lots of people, both during their university studies, and their working activity formation. Health education involves also common people, so to make them aware of their condition of health rights, of life needs, and of healing strategies.
Reward system is the neural pathways ruling all these: infact reward, meaning the pleasant perception that central nervous system elaborates, means also life needs and human rights. Its core is placed in the midbrain, linking all the centres regulating life functions: basal ganglia (automatisms), insula (autonomous nervous system), HPA hypothalamus-hypophysis axis (hormones), amygdalae (deep emotions), nucleus accumbent (pleasure), limbic system (cortical emotions), frontal lobes (behaviour). From these first centres it regulates: breathing and cardiovascular functions, hormone glands and reproduction, eating and digestion, fitness activities.
All these features are related between them and they also are the heart of human life needs-rights: like for example diet being 2000 kcal for everyone, fitness a need of 30 minutes per day, affective life that is also a human right, sleep being 7-8 hours per night. I also remember that, like World Health Organization says, health is not only the absence of diseases, but also the real effective perceived wellness everyone can live.
People are empowered, no matter if they are health professionists or common persons, when they are fully aware of the fact that life needs are human rights.

Keywords: health education, health right, life needs, reward system, wellbeing, empowerment

1. Introductive Panel

World Health Organization define: “health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”. [1] Always according to WHO, is a value for all the promotion and protection of health [1]. So, health is a human right: “the enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being” (WHO) [1]. So, teachers must transmit these values to their pupils, being them from primary schools but also medicine and surgery students. Also, during our studies and formation after university we should all be aware of this. But what are health needs? These are strictly related with life needs and since we are science experts, we can relate this to our physiology: life needs are all regulated by reward system. [2], [9]

2. Reward System

Reward pathway is a group of neural structures having core in VTA ventral tegmental area (midbrain). From this centre of dopaminergic and serotoninergic neurons, links of neural webs spread along the CNS central nervous system: the first connections take place with basal ganglia and they are origin for automatisms, then we have some links toward the insula to regulate the autonomous nervous system (sympathetic + parasympathetic), again with HPA hypothalamus-hypophysis axis balancing the hormonal arrangement of our body-mind unity, other links take place with amygdalae important centres for deep emotions, then with nucleus accumbens pleasure centre, finally with both cortex of limbic system place for emotions and with frontal lobes centre of cortex regulating behaviour. [2], [9]

All the centres in the brain regulating life functions are connected or coincident with reward pathway centres and webs: reward system regulates life functions, like brain and mind needs, breathing physiology, heart regulation, gastro-enterical metabolism, but also muscles activity, and reproductive balance [9].

From a conceptual point of view, we could define reward system needs: (1) nutrition (2) fitness (3) mind functions (4) affective needs (5) sleep. We see that we have also defined life needs, referring to life brain centres before then to practical categories too [9].

3. Life Needs

Health is a human right. Concretely reward system regulates all physiological functions.

For traditional oriental medicine life needs and life rules are basically to well-being: like also Antonovsky in 1970s wrote and studied, at first, we should live in the right way and only then recur to alternative or occidental medicines. So, for Ayurveda ("the knowledge of good life") and Traditional Chinese Medicine being healthy means following the rules of good life, and practitioners at that time used to teach and prescribe them [9].

Coming back to the categories, we see their features – and we have to know them in order to be aware and to teach them, being them related with health education:

3.1 Diet

The word diet comes from the ancient Greek work "diaita" meaning "lifestyle". So, nutrition is strictly related with lifestyle. We cannot teach how to eat without knowing how to live, we cannot prescribe a diet table without helping the person reaching the best lifestyle. From the oriental traditions: it is important eating not only according to the correct quantity but also to the right quality of food. 2000 Kcal diet is a must: and this is also a human right. It is natural to compare obese people with malnourished people: obesity involves at least 10% of persons all over the world, being there more or less 2 billion people overweight, and there are 462 million underweight or malnourished persons. This is absurd since both are humanity big problems. For these reasons we should all feeling involved in diffusing this idea: 2000 Kcal should be a must for everyone.

We should choose at best food resources, reducing red meat since at first it is less health than white meat, secondly since it means lots of CO_2 produced for the atmosphere. Infact we should follow on the contrary the Mediterrenean diet, UNESCO world heritage since 2013, studied by Ancel Keys: 2 L water per day, lots of vegetables and fruit (they can be of all the 5 main colours to get the right amount of vitamins), whole ancient cereals, basic protein sources foods like eggs, fish (rich in omega 3), dairy, and of course nuts and dry fruits rich in omega 6 unsaturated fats; sweet foods maximum once a week [3]. Quality is important since we have yang and yin foods, and also rich in jing: yang is the hot element, yin the cold element, jing the energy reproductive element.

Moreover, even how we cook a food impacts on the quality: hotter is the way more the food will get yang energy: the ideal is steam cooking, preserving also vitamins; we can have high temperatures slower way of cooking apporting more yang. We should prescribe a diet following people features [4]. A diet should also be rewarding: we can eat less on the overall but some chocolate or some peppers can be ideal if we want to add flavours to our intake. Social aspect of conviviality is also fundamental: eating together brings happiness [9].

3.2 Fitness

It is also a human need and we should all find time and energy to have physical activity. I can say that 30 minutes of fitness every day is a target. Why? One reason is the secretive function of the muscle, another reason is the vessel metabolic function of muscular system, then there is the social involvement. Muscle regulates insulin metabolism via endorphins functions and via the way how they dissipate energy by peripherizing it. Endorphins are one of the four endogenous opioids acting on reward system. Another important thing is that if when we have a centralized blood circle we have the so called apple obesity and Cushing risk (excess of cortisol and stress conditions), so we are not in health; having a very important quantity of muscles peripherizing blood is essential: we have reduction of insulin-resistance and improvement of the glucose pattern [5]. Yoga from Ayurveda, is the ensemble of posture exercises accompanied with asana training the breathing calming techniques; traditional Chinese medicine applies qi-gong to all persons: out of offices and in parks people do outdoor activity in order to distress and relax. Every personal trainer suggesting to us the best fitness exercise should also be aware of and diffuse and teach the fact that everyone of us needs fitness to be better. Not diet but physical activity is the first to improve life quality and quantity [6]. So, fitness too is regulated by reward system and is a human life need and right [9].

3.3 Mind and Mindfulness

Mind should also relax, and we should empower on the idea that we can find time to meditate, to focus on our life needs and reach them. Brain waves only if related with relax are linked with well-being: gamma waves very cortical and typical of Parkinson’s disease, beta waves cortical related with activity, alfa waves linked with vagal high tone (and typical of oriental relaxing techniques), theta and delta present in sleep conditions [7]. Mindfulness is an aware condition in which we are relaxed, a sort of awake meditation. After work we should focus some dozens of minutes on our day, on what we are enjoying on something rewarding we want to plan. Mantra are the formulas to repeat, like OHM; for extreme orient we have the zen culture based on the zazen practice repeating sutra and koan in order to reach the life peace, satori; in parallel monks put some order outside giving origins to the wonderful zen gardens [8]. Mind relaxation is also a human right since it is basis to health [9].

3.4 Affective Life

It is a strong human instinct strictly related with emotions, species and individual preservation, and it is clearly a life need and a human right. When we are born, we all need protection and affective care from our parents, being there only for us and ready to give us all we need, materially and sentimentally: this is the attachment. We produce dopamine, oxytocin, serotonin when we keep in our arms our baby feeling the same.

Later on, the first social interactions start: children love have fun playing with peers.

After puberty and with mature age couple life is a human need: of course, it is a reproductive species preservation due need, but is also related with well-being. Affective life is important at every age: even seniors can feel good in couple, and are always an emotive and practical resource for their children and grandchildren. So affective life, the first regulated by reward system, is a life need and is strictly related with well-being, so it is a human right [9].

3.5 Sleep

It is maybe the most important human right since it is not guaranteed for everyone on this planet. Lots of disease are related with night working conditions: obesity, and some tumours. We should all have both these conditions true: 7-9 hours of sleep per night and good in quality. Sleep is strictly related with reward system functions [9].

4. Conclusive Perspectives

All life needs should be something we are aware of. Empowerment is at first awareness. When we are aware of the fact that health is real well-being, that health is a human right, and that health is life needs, and all these life features are regulated by reward system we can see that reward system regulates human rights functions.

We should know this as teachers, in order to deepen our knowledge, as formators, in order to spread information toward peers and colleagues, as students' educators, in order to improve their consciousness their power, to empower them and to make them conscious of their real life needs and as citizens, since it is fundamental and essential to form a society based on truth and on global wellbeing.

REFERENCES

[1] World Health Organization website: www.who.int
[2] Dreher JC, "Handbook of reward and decision making", Academic Press, 2009, p. 474.
[3] Oxford Handbook of nutrition and dietetics, Oxford ed.
[4] Maciocia G, I fondamenti della medicina cinese, Masson Edra, 2005, p. 1202.
[5] DePascalis P, A scuola di fitness, Calzetti Mariucci, 2014, p. 266.
[6] Spector T, Diet myth, Bollati Boringhieri, 2015, p. 371.
[7] Canevaro S, Zen, Key Book, 2011, p. 95.
[8] Pazzaglia, Clinica neurologica, Esculapio, p. 545.
[9] Dora Dragoni Divrak, articles, in Medicina Integrata etc.

Socio-Scientific Controversy over the Use of Plastics: Argumentation with Pre-Service Teachers with a Role-Playing Game

José Manuel Hierrezuelo-Osorio[1], Daniel Cebrián-Robles[2], Vito-Battista Brero-Peinado[3], Antonio Joaquín Franco-Mariscal[4]
University of Málaga, Spain[1,2,3,4]

Abstract

The construction of arguments to defend different points of view is a common practice in different contexts of our daily life. In the educational sphere, we refer to argumentation as a social, rational and verbal activity [1]. The experience presented here shows the use of a ludic strategy, such role-playing, to improve the argumentation capacity in 66 Pre-Service Elementary Teachers (PSETs) of the University of Malaga (Malaga, Spain). This activity, part of a broader training programme to develop critical thinking, is focused on the current issue of plastics consumption, specifically the elimination of its use from 2021, with the objectives of identify students' perceptions of role-playing as a teaching strategy for dealing with a complex problem such as this controversy and analyse the emotions developed in the role-playing game. Often, role-play, as an educational resource, has limited acceptance in the educational field [2], probably because its benefits are not known, such as the development of argumentative capacity, the motivation of students, or promote attitudes such as empathy or tolerance, among others. In the case of science education, it is ideal for establishing a debate with different points of view. The role-play used eight roles in favour (e.g., ecologist, fisherman, environmental scientist) and another eight against (e.g., lobby, oil extractor, packaging chain consultant) the agreement in order to stimulate debate. Overall, the PSETs considered the experience to be very positive, as their involvement in the game was high. Also, they showed an excellent predisposition to use this strategy to foster the development of argumentation capacity, expressing it with ideas such as "it creates empathy", "it develops critical thinking", or "it encourages the capacity to argue". Concerning the academic potential of role-playing, the PSETs evaluated it better after the implementation in the classroom (8.6/10.0) against a rating of 8.3 out of 10.0 before it. Likewise, before the implementation, 54.1% of the PSETs showed interest, and 20.3% indicated insecurity in defending their role; passing to values of 64.4% and 3.4%, respectively, after it. Therefore, this experience highlights the need to train PSETs in these types of strategies to allow them to transfer successfully to the primary classroom.

Keywords: Pre-service teachers, role-playing, plastic consumption, scientific argumentation, socio-scientific issues

1. Introduction

At present, one of the most important aspects of science learning is scientific argumentation [3]. Argumentation has implications in the daily life of students because it not only allows them to construct arguments and defend their ideas but also offers them a tool for analysing other arguments with which they can develop their critical thinking.

In this way, the argument becomes a tool at the student's disposal to be able to make informed decisions based on scientific knowledge about current issues, as well as to allow him to distinguish the veracity of the information he receives daily. Scientific argumentation is therefore fundamental to understand some complex social problems related to science and technology, called socio-scientific issues in the literature [4]. In most cases, decisions are made based on personal assessments [5], which must be supported by scientific evidence [6]. From an educational point of view, the treatment of socio-scientific issues allows us to approach different scientific knowledge linked to the issues. For instance, they could be related to the environment, health or energy and allow students to connect scientific knowledge with real problems of their daily life [7]. In the same way, students can develop different scientific competences through the study of the issue, which allows them to develop their critical thinking by questioning different perspectives of the same issue. Despite its importance, in most cases, argumentation is not a practice used too much in elementary and secondary classrooms. Most likely, because teachers do not know their educational possibilities or the strategies to put them into practice, or they have not received adequate previous training to perform this type of tasks, especially in current controversies.

Among the different tools for dealing with the argumentation of social-scientific issues in the classroom, role-playing stands out, recognised as a teaching strategy that allows improving knowledge, attitudes, beliefs, and values in the face of social-scientific issues [8], [9]. This strategy requires a staging, in this case, the socio-scientific issue to deal with, and a series of characters with different roles involved in the issue, which will serve to know its complexity and make visible the different points of view. Each role must defend its position on the controversy [10] and build counterarguments to refute contrary ideas. At a primary education level, in addition to the development of argumentation competence, role-playing also enhances other relevant aspects of this stage, such as how to construct scientific understanding in a significant manner, reading/writing skills, comprehension and oral expression, motivates students to learn this content, develops collaborative work, or promotes attitudes such as empathy, tolerance or socializing [11].

In the case of science education, it is particularly appropriate to debate some scientific aspects with some degree of social controversy, such as the use of plastics presented herein, in the classroom. Recent findings [12] using role-playing with PESTs indicate that they learn the scientific concepts by searching for evidence in order to be able to put forward good and reasoned arguments.

This work presents the consumption of plastics as a relevant socio-scientific issue today. It provides a role-playing methodology implemented with pre-service elementary teachers (PSETs). The methodology used aims to favour the search for evidence to argue in science and foster a climate of argumentation and counter-argumentation in the classroom, with which to develop the critical thinking of teachers.

2. Role-playing Game on the Use of Plastics

This paper presents the teaching strategy of role-playing put into practice with 66 PSETs aged between 19 and 43, in their third year from the Elementary Education Teaching Degree at the University of Málaga (Málaga, Spain). This role-playing game was developed within a broader training programme that sought to improve the critical thinking of PSETs through scientific argumentation. It raises the controversy that involves the production and consumption of plastics, taking as a starting point the agreement recently established by the European Union to eliminate single-use plastics in that continent from 2021. The main purpose of this paper is to present the design of a role-playing game for PSETs and to identify their perceptions of this teaching strategy to address a complex issue such as the controversy over the use of plastics. The activity consists of three tasks: role-playing, role-play staging and perceptions test on the role-play administered before and after the game.

Task 1: Presentation of the role-play and assignment of roles

The teacher presents the role-playing scenario to the PSETs, being a context framed in a television debate program that addresses the proposed issue. Then, there is an assignment of the roles that will participate in the role-playing: 8 in favour and 8 against the agreement (figure 1), which allows for a balance of opinions. Figure 2 shows an example of the description of each character that PSETs have to prepare.

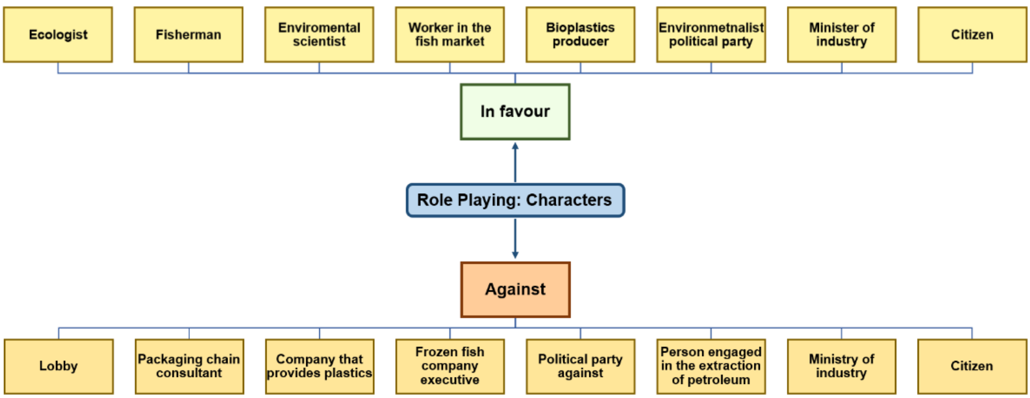


Fig. 1. *Roles in favour of and against in the role-playing*

Fig. 2. *Examples of roles description*

During the game, in addition to the roles indicated, two PSETs act as presenters and moderators of the debate. Before the staging, the PSETs filled out a card of the assigned role where they had to collect, on the one hand, different arguments to defend their position in the debate and, on the other hand, arguments with the possible weaknesses and strengths of the rest of the roles to be able to counterargument. The PSETs had a week to prepare their role and search for evidence, such as data collection, photographs, graphs.

Task 2: Role-play staging

The staging consisted of the following structure:

- A 3-minute introduction by presenters where the issue arises.
- A 1-minute turn for each role to offer its arguments for or against the issue. In

this turn, there is no interruption or counter-argumentation.

- A 5-minute break, where the characters prepare the debate with the help of their advisors.
- A 25-minute debate, where the different roles can defend or counter-argue their different positions.
- A final stage where the presenters give answers to the question posed in the debate.

Task 3: Role-play perceptions test

Before and after the experience, the PSETs filled out a test of four open items on their perception of the use of this strategy in the classroom and their emotions felt (table 1). Items 1 and 2 intended to evaluate the activity for application in an elementary classroom and to determine how important they consider this type of teaching strategy as regards developing argumentation and critical thinking capacities in their students.

In both cases, they had to explain their answers. Concerning their emotions, two items, in which they had to select the emotions they were experiencing at that time from a list, were posed at two key moments in the activity, namely before and after staging (items 3 and 4). Again, they had to explain their answers.

Table 1. *Questions in the test perceptions of the socio-scientific issue*

Item	Question
1	Do you think role-playing is an interesting activity for study with elementary school students? Justify your response.
2	Score the role-playing activity from 0 to 10 based on its ability to develop argumentation and critical thinking capacities in students. Justify your response.
3	How did you feel when preparing the role-playing? Justify your response.
4	How did you feel when staging the role-playing? Justify your response.

3. Results

The proposed role-playing activity around plastics consumption was well received by the PSETs, as they showed in full in the perceptions test both before and after the experience that role-playing was an interesting strategy for the elementary classroom (*item* 1, table 1). Some PSETs phrases were: “it creates empathy”, “it develops critical thinking”, or “it encourages the capacity to argue”.

Likewise, the score given to the role-playing was high (8.3 points out of 10 pre-test-, 8.6 post-test) in both moments, being slightly higher after the staging (*item* 2). Figure 3 represents the overall percentages of the emotions experienced by the PSETs before and after the role-play (*item* 3 and *item* 4). In this case, emotions can fall into two different categories: a) positive emotions such as confidence, concentration, satisfaction, interest, and b) negative emotions such as rejection, insecurity, shame and boring.

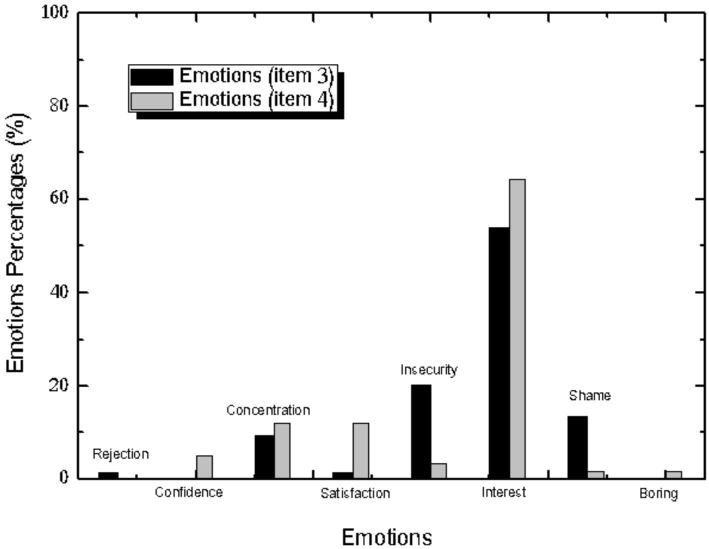


Fig. 3. *Emotions global percentages before and during the role-playing (items 3 and 4)*

As can be seen (figure 3), the PSETs initially showed interest before staging the role-play (54.1%, *item* 3), as well as 20.3% indicated insecurity when defending their role.

However, these percentages increased to 64.4% before and 3.4% after the staging (item 4). Another important aspect to highlight is the change experienced in the emotions, shame and satisfaction. In the first case, 13.5% remarked that they felt shame before the staging, perhaps related to the insecurity reflected at that time by the PSETs.

However, after the staging, this percentage decreased considerably to 1.7%. It seems to be linked to the increase in positive emotions such as concentration, confidence and interest mentioned above. Concerning satisfaction, we could observe a considerable increase before and after the role-playing game, going from 1.4% to 11.9% respectively, which can be related to the small increase in the concentration of the PSETs from 9.5% (before) to 11.9% (after).

4. Final Considerations

After the preliminary study, we can say that the implementation of role-playing in the classroom has shown mainly positive emotions (confidence, concentration, satisfaction, interest). So that, together with the results of perceptions obtained, seems to indicate that role-playing can be an excellent strategy to teach future elementary teachers to argue science. As next lines of work, it remains to investigate the quality of the arguments and counterarguments produced by the PSETs in the debate and how to help them improve them, as well as the scientific knowledge they acquire around the issue. These results will make it possible to verify the potential of role-playing as a strategy for developing scientific argumentation.

Acknowledgements

This work is part of two projects, an Excellence R&D Project (EDU2017-82197-P), funded by the Ministry of Economy, Industry and Competitiveness in 2017, and the Project PIE19-139 funded by the University of Málaga through its 2019 call.

REFERENCES

[1] Chin, C., Osborne, J. (2010). Supporting argumentation through students' questions: Case studies in science classrooms. *Journal of the Learning Sciences*, 19(2), pp. 230-284.

[2] Grande, M., Abella, V. (2010). Los juegos de rol en el aula. *Teoría de la Educación. Educación y Cultura en la Sociedad de la Información*, 11(3), pp. 56-84.

[3] Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, 84(3), pp. 287-312.

[4] Sadler, T. D. (2009). Socioscientific issues in science education: labels, reasoning, and transfer. *Cultural Studies of Science Education*, *4*(3), pp. 697-703.

[5] Fang, S.C., Hsu, Y.S., & Lin, S.S. (2019). Conceptualizing Socioscientific Decision Making from a Review of Research in Science Education. *International Journal of Science and Mathematics Education*, *17*(3), pp. 427-448.

[6] Bravo-Torija, B., & Jiménez-Aleixandre, M.P. (2018). Developing an Initial Learning Progression for the Use of Evidence in Decision-Making Contexts. *International Journal of Science and Mathematics Education*, *16*(4), pp. 619-638.

[7] Andrée, M. (2005). Ways of Using "Everyday Life" in the Science Classroom. In K. Boersma, M. Goedhart, O. de Jong, & H. Eijkelhof (Eds.), *Research and the Quality of Science Education* (pp. 107-116). Dordrecht: Springer, Netherlands.

[8] Cronin-Jones, L. (2000). Science Scenarios. *The Science Teacher*, 67(4), 5.

[9] Howes, E.V., & Cruz, B.C. (2009). Role-Playing in Science Education: An Effective Strategy for Developing Multiple Perspectives *Journal of Elementary Science Education*, 21(3), pp. 33-46.

[10] Simonneaux, L. (2008). Argumentation in socio-scientific contexts. In S. Erduran (Ed.), Argumentation in science education: perspectives from classroom-based research (pp. 179-199). Dordrecht: Springer.

[11] McSharry, G., & Jones, S. (2000). Role-play in science teaching and learning. *The School Science Review*, *82*(298), pp. 73-82.

[12] España-Ramos, E., Cebrián-Robles, D. & Franco-Mariscal, A.J. (2018). Role-playing as an activity to work on students' perceptions of nuclear energy and its risks. New Perspectives in Science Education, 7th edition (pp. 409-414). Florence (Italy): Pixel.

Scientific Works as Intellectual Property Objects

Stoyan Denchev[1], Tereza Trencheva[2], Svetoslava Dimitrova[3]
University of Library Studies and Information Technologies, Bulgaria[1,2,3]

Abstract

The university information environment is dedicated to science. Every day scientists, scholars, researchers, devote their own life to science and that is for the well-being of all humanity. That's why these people of science should be protected, and mainly their creations. The potential value of scientific researchers can change lives; to help governments, industries, society, etc. The scientific works are part of the national and the world cultural heritage. The scientific work is a result of the creative activity of its creator who explores the surrounding world; the processes that occur in it; the elements that build it, and the connections between them; and expresses them through his own scientific views, understanding, knowledge, attitudes, competences. All these are only intellectual efforts and they end with intellectual product – so called scientific works. The aim of this paper is to define the specific characteristics of scientific works and the principles of protection, set in the Berne Convention for the protection of literary and artistic works. In order to achieve that goal, an analysis of the types of works will be made, based on different criteria – according to the number of authors; the means of expressions; the basis of creation; the type of scientific knowledge. An overview of the objects that cannot be recognized as copyrighted, such as scientific discoveries, official translations of regulations, will be made. Last, but not least, a categorization of the rights owners of scientific works will be made and that includes authors, heirs of the author, employers of the ones that create works of science, users of works of science, etc. The scientific works give us mainly knowledge that we all benefit from and the protection of works of science is a right of every creator.

Keywords: intellectual property, scientific works, copyright, university information environment, the Berne Convention

1. Introduction

Intellectual property has long, historical based live, become an essential part of our daily lives, finding application in every field and aspect. The role of intellectual property in the university information environment is also crucial. The scientific content that is created in it requires a continuous process of protection, since scientific works should not be vulnerable in any way. Based on the intellectual efforts put in the creation of intellectual products, they can be conditionally divided into two groups:

- *industrial property*, and that category includes inventions, utility models, trademarks, designs, etc.,
- *objects of copyright*, and that category includes works of literature, art and science.

Therefore, the scientific works are classified as an object of copyright and enjoy the full protection it provides.

The use of scientific works is regulated both in international treaties for the protection of intellectual property, which Bulgaria has ratified (the Convention establishing the World Intellectual Property Organization (WIPO), the WIPO Copyright Treaty, the Berne Convention for the Protection of Literary and Artistic Works), and in national laws, such as the Copyright and Related Rights Act. However, none of the acts defines what a scientific work is.

2. Types of Scientific Works

According to the basis of creation, scientific works are:

- Primary (original);
- secondary (derivatives).

Primary works are those works that were created for the first time and have no prototype. Secondary are those works which are created on the basis of an already existing primary work, in such a way as to discover the similarities of the secondary with the primary.

According to the type of scientific knowledge contained in scientific works, they are:

- theoretical;
- applied.

Theoretical-oriented scientific works offer knowledge of laws, regularities, processes, phenomena, etc., and the knowledge contained in them cannot be represented in the form of objects in the real world. These are the work of scientific fields such as politics, law, economics, history, and more. Applied scientific works present knowledge of chemistry, physics, biology, anatomy, metallurgy, and more.

According to the number of authors of scientific works, they are:

- individual;
- co-authored.

The individual presupposes that it was created by one person, while the co-authored is created by several authors, who made concerted efforts to create the scientific work.

According to the number of works that the scientific works contain, they are:

- single;
- combined.

A single scientific work is a self-contained and complete work, such as a thesis, dissertation, etc. Combined is that work that includes individual works, which are compiled as a whole. Combined works, in turn, are divided into collective and composite.

Collective are those works whose creation the authors know beforehand and prepare their copyrighted materials to be included in this collective work. Compiled are those works whose creation the authors do not know in advance, and when they prepare their copyrighted material, they do not know that they will be included in this compiled work.

Usually, a compiled work is the work of a single composer, and he has a copyright of the entire compiled work, but the individual authors, whose works are included in it, keep their own copyright of their individual work.

According to the means by which scientific works are expressed, they are:

- literary;
- photographic;
- audio-visual;
- graphic;
- combined.

Literary are those scientific works where the main means of expression is the text – an article, a report, a dissertation, etc., and the form of presentation can be either written or oral. Photographic are those works that use a visual expression that contains a specific moment, result of scientific research. Audio-visual are those works that also use visual expression, but they represent a larger segment, i.e., more dynamic, result of scientific research. Graphic are those works that contain signs and symbols, such as diagrams, sketches, maps, graphics, and more. Combined scientific works use different means of expression and are not limited to one of them – such as text with tables, figures and photographs. [1], [2]

3. Objects that are not Recognized as Copyrighted

Scientific discovery does not enjoy the protection of intellectual property rights, in particular copyright, and the reason lies in the very nature of scientific discovery as such.

The definition of scientific discovery is the identification of phenomena, properties, or laws of the material world, unknown before and is a subject to verification. Therefore, based on that definition, scientific discovery cannot be created by man and added to the surrounding real world. Official translations of regulations also do not enjoy the protection of intellectual property rights. The reason is that the initiative for this translation is from the authority which issued the act, or, as in the case of international treaties, by the authority which is authorized to ratify it. Having an official translation of a normative act does not necessarily mean that it is impossible for a private person to make a translation of that document. This private translation is for commercial use and the translator is copyrighted for the translation he has made. Other objects that do not enjoy the protection of intellectual property rights are ideas and concepts, folklore works, news, facts, information. [3], [4]

4. Rights Holders of Scientific Works

Rights holders of scientific works include:

- the author of the scientific work;
- the heirs of the author of the scientific work;
- employers or persons creating a scientific work;
- the contracting authorities of scientific works;
- users of a scientific work;
- persons who have publicized a scientific work on specific terms.

The author is the person who, after research, creates a scientific work. After the death of the author, copyright is exercised by his heirs, and they exercise that right until the period of protection, that is fixed by law, expires. The employer of a person who creates scientific works may also own the rights to them – in cases where the works are created within the framework of an employment contract whose object is precisely the creation of such works. Contracting authorities of scientific works may also own the rights of them, in the cases where the work is custom-made, by assigning it. The users of a scientific work are publishing houses, radio and television organizations, etc., who use scientific works in their activity or in connection with it and their delivery to the end user. A copyright may also be held by a person who has disclosed it publicly, but on condition that the work has been anonymously publicized, nicknamed or publicized after the end of the copyright term. [5], [6].

5. Basic Principles in the Protection of Scientific Works

The basic principles of protection are set out in the Berne Convention for the protection of Literary and Artistic Works, adopted by WIPO in 1886, and ratified by Bulgaria as early as 1921, and they address the principles and all other fundamental issues of the intellectual protection of authors. They have also been reflected in all national copyright laws, including the Copyright and Related Rights Act, adopted in 1993.

The principles underlying the above-mentioned Bern Convention on the protection of scientific works are:

- the principle of the automatic emergence of protection by the very creation of a scientific work;
- the principle of the protection term;
- the principle of territorial limited protection;
- the principle of the national regime;
- the principle of the convention minimum.

The principle of the automatic emergence of protection means that copyright arises by the very creation of a scientific work in an objective form, without any legal action being taken. The principle of protection term means that intellectual property rights are limited over time, including in scientific works. In other words, copyright is recognized and exercised only for a period, fixed by law, and after that period is over anyone can use the scientific work freely. The principle of territorial limited protection means that a country recognizes and guarantees the protection of copyright in a scientific work only within its territory. The principle of national regime means that a state, part of the Berne Convention, grants copyright protection to foreign nationals, representatives of countries, also members of the Convention, who are in its territory, following the same principles as their nationals. The principle of convention minimum means that the protection afforded to citizens in one-member state of the Convention in another state cannot be below the level of protection enshrined in the Convention. Also, the level set out in the Convention is only minimal, and each country must adopt reinforcing measures in its national legislation. [5]

6. Conclusion

The scientific work is the result of research presented in an objective manner.

Scientific works and especially the knowledge they offer find their application in the industries and other different fields of activities. Their application increases the scientific and educational potential of society. The created scientific content only increases the global mass of knowledge. That’s why the nature and the intellectual property aspects of scientific works need to be an object of future researches, in order for authors of scientific works to work in a secure environment in this respect.

7. Acknowledgements

This research would not have been possible without the financial assistance of the following project: “A Conceptual Educational Model for Enhancing Information Literacy in a University Information Environment”, financed by National Science Fund of the Ministry of Education and Science of the republic of Bulgaria with Contract № KP – 06 – H35 / 10 от 18.12.2019, led by Prof. DSc Stoyan Denchev.

REFERENCES

[1] Denchev, S. & Trencheva, T. “Intellectual Property as a Basic Part of the University’s Information Literacy”, Proceedings of ICEMS 2016 Conference, 28-29th May, DEStech Publications, Beijing/China, 2016, pp. 74-78.
[2] E. Zdravkova. Media literacy as a key competency for the safe and effective use of media, In Conference Proceedings: 12th International Conference on Education, Research and Innovation, Seville, Spain, 2019, pp. 7467-7473.
[3] K. Planska-Simeonova. Copyright Protection of Photographic Information in Compliance with the New Regulations of the European Union, 11th annual International Conference on Education and New Learning Technologies Palma de Mallorca, Spain, 2019, pp. 5040-504.
[4] Titu, M., Oprean, C., Stan, S. & Titu, S. “The Place and Role of Intellectual Property Policies in an Advanced Scientific Research and Education University”, International Conference Knowledge-Based Organization, 2017, vol. 23, no. 1, pp. 479-488.
[5] Tsakova, V. “Works of science as Intellectual Property Object”. Sofia: University Publishing House “Stopanstvo”, 2009.
[6] Yordanova, D. “Development of Complex’ Measures for Copyright Protection in Universities”, Proceedings of 5th National Seminar with International Participation “Intellectual Property, Innovations and Science in a Global Environment, Sofia, “Za bukvite – O Pismeneh”, 2017, pp. 55-62.
[7] S. Dimitrova. E-content – intellectual property aspects // 11th International Conference on education and new learning technologies, EDULEARN19 Proceedings, Palma, Mallorca, Spain, Vol. 11, 2019, pp. 6061-6065.
[8] M. Traykov, M. Trencheva, R. Mavrevski, A. Stoilov, I. Trenchev, Using Partial Differential Equations for Pricing of Goods and Services // Scientific Annals of Economics and Business, vol., 63(2), 2016, pp. 291-298.

Science Education and Special Needs

Accessible Tourism: Experience from Academic Course

Tania Todorova[1]
University of Library Studies and Information Technologies (ULSIT), Bulgaria[1]

Abstract

This paper highlights a good practice by studying the experience from teaching the mandatory academic course "Accessible Tourism" for the education and qualification degree "Bachelor", specialty "Information Resources for Tourism" at the University of Library Studies and Information Technologies (ULSIT). The course has been taught since AY 2012/2013, it is well received by students, and is new in the professional field 3.5. Social Communications and Information Sciences in Bulgaria. The course gives students theoretical and practical knowledge on accessible tourism for people with special needs. The course 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+, families with children, travelling with a lot of luggage etc. This paper introduces the contents, the teaching methods and the student assessment mode applied in the course. We highlight the teaching methods that enhance student empathy and motivation and increase students' involvement in a variety of extra-curricular activities such as on place interviews and case studies at cultural institutions and other tourist sites for evaluation of the accessibility achievements and problems. Special attention is paid to the Access City Award of the European Commission as source of best practices and inspiration, which could be followed. In 2019, a Bachelor Thesis was realized about Plovdiv (Bulgaria) as an accessible town (Plovdiv held the title of European Capital of Culture in 2019, together with Matera (Italy).

Keywords: accessible tourism, people with special needs, higher education, Bulgaria, European Disability Strategy 2010-2020, Access City Award

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 [3]. In pursuance of its engagements as an 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) [8, 9, 2]. The implementation of the NSPD (2008-2015) requires the introduction of courses on this topic in universities' curricula.

The University of Library Studies and Information Technologies (ULSIT) has met this need of academic study of students by means of the introduction of such thematic courses as *Access to Information for People with Special Needs* [10] and *Accessible Tourism*. This paper highlights a good practice by studying the experience from teaching the mandatory academic course *Accessible Tourism* for the education and qualification degree "Bachelor", specialty Information Resources for Tourism at the University of Library Studies and Information Technologies (ULSIT). The course has been taught since AY 2012/2013. It is well received by students, and is new in the professional field 3.5. Social Communications and Information Sciences in Bulgaria. The course gives students theoretical and practical knowledge on accessible tourism for people with special needs. The course 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+, families with children, travelling with a lot of luggage etc.

2. Terminology and Goals

The term *'persons with disabilities'* is defined in article 1 of the Convention on the Rights of Persons with Disabilities (CRPD) of the United Nations (UN) 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 [3].

Accessibility refers to how easy it is for everybody to approach, enter and use buildings, outdoor areas and other facilities, independently, without the need for special arrangements. Providing information on accessibility and improving access benefits a wide range of people who want to travel, but who may find it difficult [7]. The term '*accessible tourism*' has been defined by Darcy and Dickson as: it enables people with access requirements, including mobility, vision, hearing and cognitive dimensions of access, to function independently and with equity and dignity through the delivery of universally designed tourism products, services and environments. This definition is inclusive of all people including those travelling with children in prams, people with disabilities and seniors [4]. According to the European Network for Accessible Tourism (ENAT), accessible tourism includes:

- Barrier-free destinations: infrastructure and facilities;
- Transport: by air, land and sea, suitable for all users;
- High quality services: delivered by trained staff;
- Activities, exhibits, attractions: allowing participation in tourism by everyone;
- Marketing, booking systems, web sites & services: information accessible to all [6].

The main goal of this paper is to introduce the contents, the teaching methods and the student assessment mode applied in the academic course *Accessible Tourism* for education and qualification degree "Bachelor", specialty Information Resources for Tourism at Faculty of Library Science and Cultural Heritage at ULSIT.

3. Accessible Tourism Course Content

The course *Accessible Tourism* gives students theoretical and practical knowledge on the specificity of accessibility when providing tourist services. The concepts of *'accessible tourism'*, *'tourism for all'*, *'barrier-free tourism'* are clarified as requirements in the tourism sector. Legislative framework and legislative documents related to the rights of persons with disabilities are studied. The financial tools and legal aspects of the provision of tourism services to disadvantaged people are explained. Forms for interaction with organizations of and for persons with disabilities are presented. The students receive knowledge about: accessibility of the architectural environment and interior; mandatory requirements for the development of tourist services: for people with various disabilities; for the elderly and sick; for people with allergic diseases; for pregnant women and young children and other special needs groups. Models for providing accessible services before and during the use of the tourist package by people with disabilities are studied. Students acquire knowledge related to information provision and Public Relations (PR) of tourist services in terms of the 'accessibility for all' aspect in the information and advertising activities. National good practices from Austria, Belgium, Finland, France, Germany, Greece, Ireland, Israel, Italy, Luxembourg, the Netherlands, Spain, Sweden, USA, etc., and the maintained databases of useful information are consulted. The achievements of the Tourism for All Consortium, as well as the activities and projects of the United Kingdom Equal Opportunities and Human Rights Commission, are discussed [11]. Particular attention is paid to European Union policy – documents, manuals, programs and databases are examined, which contain information on the accessibility of services in European countries. Special attention is paid to the Access City Award of the European Commission as source of best practices and inspiration, which could be followed [1]. The practical seminars aim at developing problem-solving skills, finding interdependencies, and justifying relationships, analysing and applying certain theoretical knowledge to new situations. As a component of the assessment of students' knowledge, during the examination, every student has to make a presentation of the self-designed model of tourist package for different categories of people with special needs and a PR-program for their promotion among the target consumer group and society.

4. Example for Student Achievement

In 2019, a Bachelor Thesis was realized about Plovdiv (Bulgaria) as accessible town, which held the title of European Capital of Culture in 2019, together with Matera (Italy).

The aim of the Bachelor Thesis, entitled "Plovdiv – accessible European Capital of Culture 2019" (author: M. Velkova; Scientific advisor T. Todorova, defenced on 4th July 2019, ULSIT, Sofia) is to study the achievements and problems of the city of Plovdiv in terms of the accessible environment for people with special needs to cultural institutions and tourist sites. The study is an up-to-date and unique moment for the development of tourism in Plovdiv – its emergence as the European Capital of Culture in 2019. The thesis (consists of 72 pages) has the following structure: introduction, three chapters, conclusion, applications and references. The first chapter looks at the European Union legal framework on people with disabilities and the annual Access City Award of the European Commission. The second chapter presents a brief historical overview of the development of Plovdiv from ancient times to the present day. Chapter three focuses on the study of accessibility for all citizens of several cultural and tourist sites and institutions in the city of Plovdiv, significant for its establishment as a European and world tourist destination, namely: Regional Library Ivan Vazov, Roman Antique Stadium (Figure 1), Ancient Theater (Figure 2), Ethnographic Museum (Kuyumdzhieva House) and the Little Basilica.

Fig. 1. *Ancient Roman Stadium in Plovdiv – accessible cultural site*

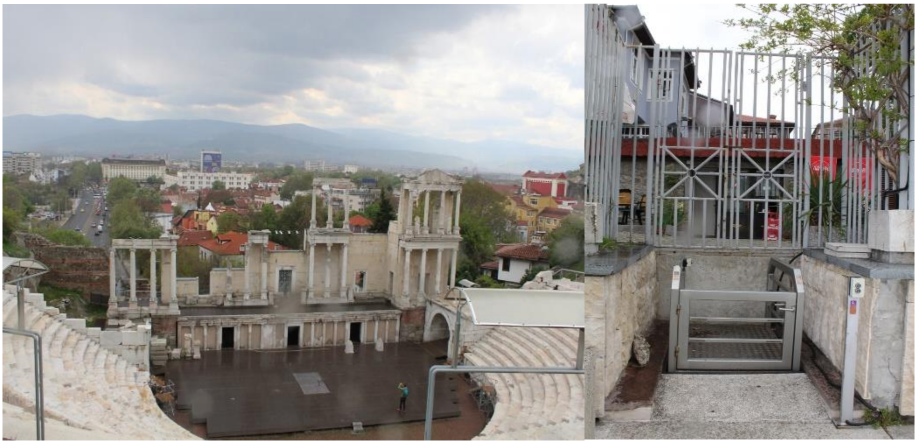


Fig. 2. *Ancient Theatre in Plovdiv*

The general conclusion is that the touristic sites in Plovdiv have accessible facilities for people with special needs, but the main problem is the lack of accessibility information in its various aspects, clearly announced in advertising and information materials, on the Internet, and through different formats. Recommendations have been formulated to improve the current situation, such as:

- Development of an information and public relation strategy for popularization of the accessibility of cultural and tourist sites in Plovdiv;
- Continuing collaboration with experts of universal design for further improvements;
- Diversification of services related to the cultural and tourist experience of people with special needs by applying different adapted formats, technologies and interactive approaches;
- Digital capture and presentation of objects and use of a virtual 3D tour to attract the interest of visitors;
- Review of information and advertising packages and strategies for promoting the cultural wealth of the city of Plovdiv with a view to reaching all target audiences, incl. people with special needs.

In conclusion, the city of Plovdiv has many of the necessary qualities to be a worthy candidate for the annual Access City Award of the European Commission. It is important for the city government, in partnership with business and all citizens, to embrace the vision of an 'accessible town' as a cause, to invest efforts in making the necessary improvements, and to make a statement on the European stage.

5. Conclusions

Our society is increasingly aware of the concept of integration of people with disabilities. Steps have been taken to promote guidelines and best practices for the purposes of academic and continuing education and for the professional needs. The academic community has to contribute to the implementation of the knowledge triangle of education – science – business with the modern content and high-quality activities.

Achieving this goal requires in-depth scientific knowledge, entrepreneurial skills, creative and innovative attitude and intensive interaction between all stakeholders to disseminate and utilize the knowledge gathered to achieve socially significant results. In the *Accessible Tourism* 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 on place interviews and case studies at cultural institutions and other tourist sites for evaluation of the accessibility achievements and of the existing needs for improvements. We could highlight course results and proposes the course as a potential best practice for other institutions interested in meeting the goals of the EU Disability Strategy 2010-2020: A Renewed Commitment to a Barrier-Free Europe as well as their own national efforts to improve accessibility.

REFERENCES

[1] Access City Award, <https://ec.europa.eu/info/access-city-awards_en>
[2] Action Plan of the Republic of Bulgaria on the implementation of the UN Convention on the Rights of Persons with Disabilities (2015-2020), <http://www.strategy.bg/StrategicDocuments/View.aspx?lang=bg-BG&Id=967>
[3] The Convention on the Rights of Persons with Disabilities and its Optional Protocol (A/RES/61/106), 13 December 2006: <https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html>
[4] Darcy, S., Dickson, T. "A Whole-of-Life Approach to Tourism: The Case for Accessible Tourism Experiences", Journal of Hospitality and Tourism Management, 2009, 16(1), pp. 32-44.
[5] European Disability Strategy 2010-2020: A Renewed Commitment to a Barrier-Free Europe, <https://ec.europa.eu/eip/ageing/standards/general/general-documents/european-disability-strategy-2010-2020_en>
[6] The European Network for Accessible Tourism (ENAT), <http://www.accessibletourism.org/>
[7] Improving information on accessible tourism for disabled people. Ed. by Jacqueline Westcott. Luxembourg, Office for Official Publications of the European Communities, 2004, p. 32.
[8] National Strategy for Persons with Disabilities (2008-2015) <http://www.strategy.bg/StrategicDocuments/View.aspx?lang=bg-BG&Id=445>
[9] National Strategy for Persons with Disabilities (2016-2020), <http://www.strategy.bg/FileHandler.ashx?fileId=9439>

[10] Todorova, T., S. Eftimova. “Access to Information for People with Special Needs: Experience from Academic Course”, *New* Perspectives in Science and Education, 8th ed., 21-22 March 2019, Florence, Italy. Bologna, Filodiritto International, 2019, pp. 321-325.
[11] Tourism for All: Making Accessible Travel Better, <https://www.tourismforall.co.uk/>

Auditory-Verbal Therapy: A Systematic Review for the Effectiveness of Intervention to Children with Hearing Loss

Paris Binos[1], Marina Charalambous[2], Despo Minaidou[3]
University Rehabilitation Clinic, Department of Rehabilitation, Cyprus University of Technology, Cyprus[1,2,3]

Abstract

This systematic review was designed to investigate the effectiveness of auditory-verbal therapy (AVT) based on recent research findings of the literature. AVT is seen today as the primary treatment approach for developing spoken language in children with cochlear implants despite the debate about educational options for these children. The AVT effectiveness should be examined by systematic reviews. The present review was conducted following PRISMA guidelines (preferred reporting items for systematic reviews). Search terms were chosen based on the research question and used in a search in PubMed/Medline. Last decade's published peer-reviewed papers meeting inclusion criteria were reviewed. The reviewed articles measured many levels of language development and parent's use of alternative communication models. The result of this review reveals AVT as an important clinical approach that improves young cochlear implant (CI) children to outperform peers in bilingual-bicultural programs in receptive vocabulary and speech perception or at the least be at a similar level on speech, language and self-esteem. Other aspects related with voice seemed also benefited, placing young CIs in the normal range for receptive vocabulary development. Less improvement noted in the area of reading. AVT approach can positively assist infants develop spoken language and support full integration into mainstream society despite the limited evidences presented. This position is supported by research findings of young CIs comparable to their hearing peers. Overall studies suggest AVT as a positive clinical approach for spoken language of young CIs and provide evidences that there is no advantage for the use of other alternative communication models before or after CI.

Keywords: Cochlear implant, AVT, Language development, rehabilitation approach, review

1. Introduction

Parents of infants who receive cochlear implants (CIs) have already chosen as their primary concern how their child will develop spoken language. Infants will develop spoken language comparable to their hearing peers, only if they receive the best primary treatment approaches there are today which are evidence informed (EIP). The early identification alone will not lead to better developmental outcomes but the quality of the intervention services which follow affect the communication outcomes [1]. Auditory-Verbal Therapy (AVT) is a Listening and Spoken Language (LSL) approach which has been practiced since the 1930s in the USA. The AG Bell Academy for Listening and Spoken Language is the only academy responsible for the certification of professionals

[2]. Hearing deprivation affects mainly the development of speech and communication and many of these children struggle to develop communication skills comparable with their typically developing peers [3, 4]. Early intervention for infants and toddlers focuses on the development of the language skills based on the context of their families [5].

AVT is an approach targeting to the development of spoken communication regardless of the level of hearing impairment enabling full integration into mainstream society. This approach is provided by trained and certified speech and language therapists, audiologists or teachers of the deaf. The aim of this (re)habilitative method is children with hearing impairment to reach the expressive and receptive level of their hearing peers following a set of ten principles of practice. These specific techniques and strategies aim to develop the child's auditory cortex while at the same time support parents to promote their child's listening and expressive language skills [6]. Nowadays, children with hearing impairment are diagnosed at a very primary stage (few days after their birth) and therefore they have access to sound and hearing input at a very early stage. As such, audition is not a link between things they already know. The following research question was investigated:

- What is the effectiveness of AVT approach in speech and language skills of early fitted babies and infants with cochlear implants?

2. Objective

To assess the effectiveness of auditory-verbal therapy (AVT) in communication skills in children who are hearing impaired.

3. Method

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines formed the basis of this systematic review [7, 8]. PRISMA guidelines provide an evidence-based guide for reporting in systematic reviews. The present systematic search was based on the database of PubMed with Full Text and conducted in December 2019 (Fig. 1).

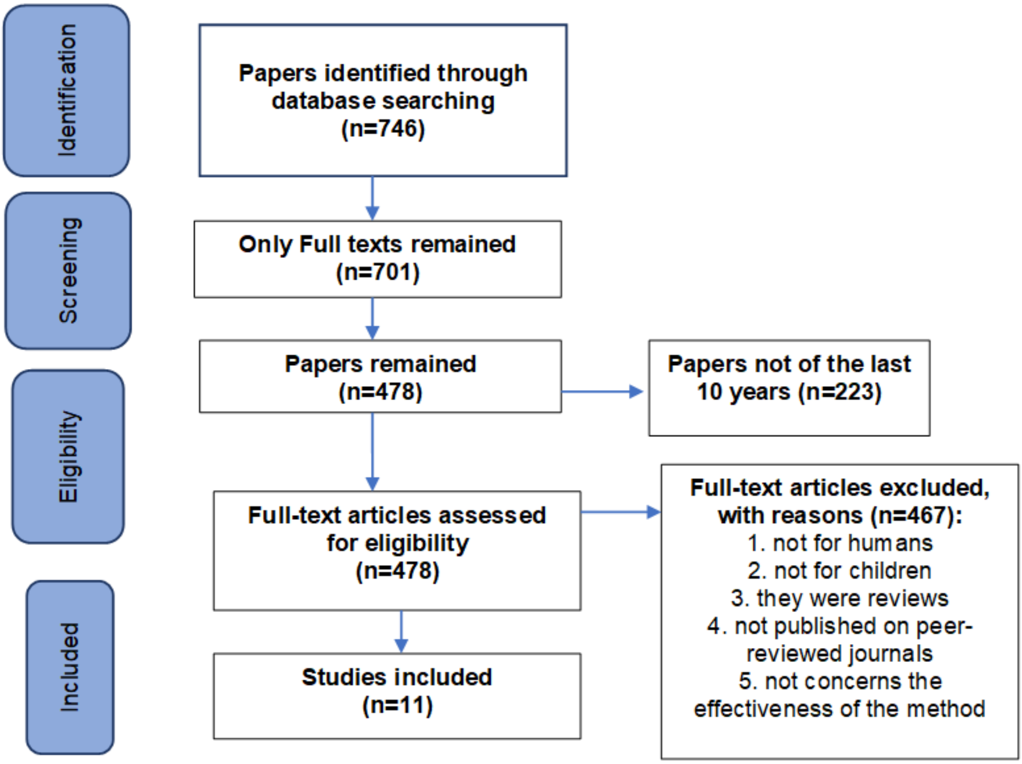
3.1 Inclusion Criteria

The search strategy comprised the following term of "Auditory-verbal therapy" or "auditory-verbal therapy AND cochlear implants". Studies were considered eligible if they were research reports of the last decade, if they were published in English and concerned only babies, infants and children. The search included also all journal articles, classical articles, clinical studies and trials, comparative studies and only if the database involved them as full texts. The search concerned only published papers from 01/01/2009 onwards. Older studies provide valuable findings but current SLP and paediatric clinical practice and hearing technology no longer represent their participants who fitted with implants over 10 years ago.

3.2 Exclusion Criteria

After removal of papers concerning adult population, more exclusion criteria were implemented. The search excluded also papers of non-humans, any published reviews and if they were not published on peer-reviewed journals. Other papers were also excluded due to their aim which was different than studying the effectiveness of the AVT method to communication levels of participants.

Fig. 1. *Flow chart of the search*



4. Results

Table 1. *Details of studies investigating effects of AVT on speech and language outcomes in children with hearing impairment*

Study	**Number of participants/age range**
Sharma *et al*., (2017) [9]	180 children/below 4 years
Monshizadeh *et al*., (2018) [10]	30 CI children/mean age 7.96±0.91y
Dettman *et al*., (2013) [11]	39 children (only 8 received AVT, PTA>80 dB HL)/ mean chronological age 1.7y & mean device experience: 3.7y
Yanbay *et al*., (2014) [12]	42 prelingual children with HL (implanted 3;6y)
Percy-Smith *et al*., (2018a) [13]	130 children (34 received AV)/Mean CA 48m, Mean Post-Implant Age 24m). Participants received 3y AVT
Percy-Smith *et al*., (2018b) [14]	36 CI children with bilateral hearing impairment, 19 children with Hearing Aid-Bahs vs NHs/median age of diagnosis 6m, median age at intervention 12-13m
Necula *et al*., (2013) [15]	84 CIs (G1 received CI<5y, G2 subgroup received CI>5y) vs 50 HA children (<18m years old)/CI group aged between 19-219m while age at implantation ranged from 12-191m, PIA ranged from 6-92m)

Sahli (2019) [16]	169 CI children with bilateral S/N HL/mean CA 26.4m with unilateral CI
Jackson & Schatschneider (2014) [17]	24 children with HL received AVT. Eleven of them were CIs/Mean CA 3m-6;6y old
Yoshinaga-Itano *et al*., (2010) [18]	87 children with bilateral childhood hearing impairment (49 with CI)/CA 48-87m of age. Mean CI activation 30.5m
Fulcher *et al*., (2012) [19]	45 CIs (≤12m) vs 49 CIs (>12m to <5y)
	What was studied
Sharma *et al*., (2017) [9]	1 y AVT as factor that influence hearing perception and speech intelligibility
Monshizadeh *et al*., (2018) [10]	Effectiveness of AVT in social interaction
Dettman *et al*., (2013) [11]	Comparison effectiveness of AVT, AV & BB (bilingual-bicultural)
Yanbay *et al*., (2014) [12]	Comparison between sign-spoken vs AO vs AV in receptive vocabulary, auditory comprehension, expressive language and SES
Percy-Smith *et al*., (2018a) [13]	Effectiveness of AVT
Percy-Smith *et al*., (2018b) [14]	Effectiveness of AVT in early vocabulary development of CIs vs HAs with 3y habilitation
Necula *et al*., (2013) [15]	Assess the CI benefits not only on auditory-verbal performances but in terms of health-related quality of life
Sahli (2019) [16]	The performance of CIs with AVT evaluated on personal-social skills, language, fine and gross motor field capabilities
Jackson & Schatschneider (2014) [17]	Evaluate responsiveness to AVT
Yoshinaga-Itano *et al*., (2010) [18]	Describe language growth of HI children who received AVT
Fulcher *et al*., (2012) [19]	Assess if early CIs achieve and maintain age-appropriate speech/language outcomes by 3,4,5y of age. All participants received AVT
	Post-AVT outcomes
Sharma *et al*., (2017) [9]	Improvements in audioty perception and speech perception. More AVT (re)habilitation greater speech emphasis
Monshizadeh *et al*., (2018) [10]	Final comparable abilities of CIs to NH children in social interaction abilities
Dettman *et al*., (2013) [11]	AVTs achieved optimum spoken communication outcomes better than other methods
Yanbay *et al*., (2014) [12]	No significant differences in language outcomes across the 3 groups but participants who fell more than 1 SD below the normative mean was AO>AVT>BB. Also, for PLS-4 the results were AO>AVT>BB (1 SD below the normative mean)
Percy-Smith *et al*., (2018a) [13]	AVTs had better results from the Standard Habilitation (Speech Therapy) in all 3 subjects which were investigated

Percy-Smith *et al*., (2018b) [14]	Hearing Impairment group had lower vocabulary development than NH peers after 3y AVT
Necula *et al*., (2013) [15]	For younger CIs (<5y) the difference was in favour of AVTs in sound perception, production, self-esteem, activity and socialization
Sahli (2019) [16]	When AVT started <6m of age the results gave normal fine and gross motor capabilities, 95.2% normal personal-social outcomes and 90.5% normal language development
Jackson & Schatschneider (2014) [17]	Degree of severity of HL and duration of AVT contribute to differences in AVT outcomes. CIs did not significantly outperform HA children in language growth
Yoshinaga-Itano *et al*., (2010) [18]	HAs deviated more than CIs to the age equivalent trajectory. The combination of oral-aural and sign language gives appropriate language levels in expressive vocabulary and receptive syntax (for 4-7 y old participants)
Fulcher *et al*., (2012) [19]	Early CIs significantly outperformed the late ones in speech, understanding vocabulary and receptive/expressive language

5. Discussion

To our knowledge, this is the first study to evaluate the effects of AVT based on papers of the last decade on various areas of speech and language development. Many advances in hearing amplification technology and diagnosis of hearing loss have been accomplished and AVT seems to play a crucial role as the main communication model after surgery, especially in young infants with CI. Nevertheless, there are results that suggest that more research should be made involving larger samples, longer application of AVT and controlled prospective studies.

REFERENCES

[1] Yoshinaga-Itano C., “Levels of evidence: universal new born hearing screening (UNHS) and early hearing detection and intervention systems (EHDI)”, Journal of Communication Disorders, 2004, 37: pp. 451-465.

[2] Estabrooks, W. *et al*., “Auditory Verbal Therapy, for young children with hearing loss and their families, and the practioners who guide them”, Plural Publishing, San Diego, 2016.

[3] Davis, A. “Epidemiology of permanent childhood hearing impairment. In: Newton VE editor(s). Pediatric Audiological Medicine. 2nd Edition. Chichester, UK: John Wiley & Sons, 2009, pp. 1-26.

[4] Niparko, J. K., Tobey, E. A., Thal, D. J., Eisenberg, L. S., Wang, N. Y., & Quittner, A. L., … The CDaCI Investigative Team, “Spoken language development in children following cochlear implantation”, Journal of the American Medical Association, 2010, 303, pp. 1498-1506, doi:10.1001/jama.2010.451.

[5] Centers for Disease Control and Prevention, “Treatment and intervention services”, 2015.

[6] AG Bell Academy, “AG Bell Academy for Listening and Spoken Language”, www.listeningandspokenlanguage.org/AGBellAcademy/ (accessed 27 December 2019).

[7] Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G., “Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement”, Annals of Internal Medicine, 2009, 151, pp. 264-269.

[8] Moher, D., Liberati, A., Tetzlaff, J., & Alman, D. G., “Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement”, International Journal of Surgery, 2010, 8, pp. 336-341.

[9] Sharma S, Bhatia K, Singh S, Lahiri AK, Aggarwal A., “Impact of socioeconomic factors on pediatric cochlear implant outcomes”, Int J Pediatr Otorhinolaryngol. 2017, Nov; 102: pp. 90-97. doi: 10.1016/j.ijporl.2017.09.010.

[10] Monshizadeh L, Vameghi R, Sajedi F, Yadegari F, Hashemi SB, Kirchem P, Kasbi F., “Comparison of Social Interaction between Cochlear-Implanted Children with Normal Intelligence Undergoing Auditory Verbal Therapy and Normal-Hearing Children: A Pilot Study”, J Int. Adv Otol. 2018, 14(1): pp. 34-38. doi: 10.5152/iao.2018.3663.

[11] Dettman S, Wall E, Constantinescu G, Dowell R., “Communication outcomes for groups of children using cochlear implants enrolled in auditory-verbal, aural-oral, and bilingual-bicultural early intervention programs”, Otol Neurotol, 2013, 34(3): pp. 451-9. doi: 10.1097/MAO.0b013e3182839650.

[12] Yanbay E, Hickson L, Scarinci N, Constantinescu G, Dettman SJ., “Language outcomes for children with cochlear implants enrolled in different communication programs”, Cochlear Implants Int., 2014, 15(3): pp. 121-35. doi: 10.1179/1754762813Y.0000000062.

[13] Percy-Smith L, Tønning TL, Josvassen JL, Mikkelsen JH, Nissen L, Dieleman E, Hallstrøm M, Cayé-Thomasen P., “Auditory verbal habilitation is associated with improved outcome for children with cochlear implant”, Cochlear Implants Int, 2018, 19(1): pp. 38-45. doi: 10.1080/14670100.2017.1389020.

[14] Percy-Smith L, Hallstrøm M, Josvassen JL, Mikkelsen JH, Nissen L, Dieleman E, Cayé-Thomasen P., “Differences and similarities in early vocabulary development between children with hearing aids and children with cochlear implant enrolled in 3-year auditory verbal intervention”, Int. J Pediatr Otorhinolaryngol, 2018, pp. 108:67-72. doi: 10.1016/j.ijporl.2018.02.030.

[15] Necula V, Cosgarea M, Necula SE., “Health-related quality of life in cochlear implanted patients in Romania”, Int. J Pediatr Otorhinolaryngol, 2013, 77(2): pp. 216-22. doi: 10.1016/j.ijporl.2012.10.026.

[16] Sahli, AS., “Developments of children with hearing loss according to the age of diagnosis, amplification, and training in the early childhood period”, Eur Arch Otorhinolaryngol, 2019, 276(9): pp. 2457-2463. doi: 10.1007/s00405-019-05501-w.

[17] Jackson CW, Schatschneider C., “Rate of language growth in children with hearing loss in an auditory-verbal early intervention program”, Am Ann Deaf, 2014, 158(5): pp. 539-54.

[18] Yoshinaga-Itano C, Baca RL, Sedey AL., “Describing the trajectory of language development in the presence of severe-to-profound hearing loss: a closer look at children with cochlear implants versus hearing aids”, Otol Neurotol, 2010, 31(8): pp. 1268-74. doi: 10.1097/MAO.0b013e3181f1ce07.

[19] Fulcher A, Purcell AA, Baker E, Munro N., “Listen up: children with early identified hearing loss achieve age-appropriate speech/language outcomes by 3 years-of-age”, Int J Pediatr Otorhinolaryngol, 2012, 76(12): pp. 1785-94. doi: 10.1016/j.ijporl.2012.09.001. Epub 2012 Oct 17.

The Special Needs in Polytechnical Institutions Students – Case Study in ESTGL

Ana Branca Carvalho[1], Nídia Menezes[2], Ricardo Almeida[3]
Instituto Politécnico de Viseu/ESTGL, Portugal[1]
Escola Superior de Tecnologia e Gestão de Lamego, Portugal[2,3]

Abstract

Special needs in higher education are currently a concern about the teaching methodologies, the assessment system and the information and communication technologies used.
In the case of amblyopia, associated with a wider and lack of lateral vision, students are limited by tubular vision. The need to increase words and decrease sentence length requires new teaching-learning methodologies (Awan et al., 2010) [1]. The use of information technologies, e.g., computers and interactive whiteboards, allows for greater reading flexibility and knowledge acquisition. Audio-visual media, with image projection and sound reproduction, allow students to more easily view contents and understand the material. Computer-based assessment with increased spelling and answers using the same technological means allows students to feel motivated and satisfied, with equal opportunity and equal evaluation regarding dates, text and material used. Using B-On, students can access books that have grown and use updated bibliography. We used feedback from students to develop an educational/motivational intervention pack to improve amblyopia treatment (Pradeep et al., 2014) [2]. This research addresses a case study with special educational needs for visual impairment – amblyopia. The results of two years were analysed, and a synthesis of the methodologies made in the various curricular units, with spatial emphasis of the evaluation and the results.
We have investigated the effect of amblyopia on reading using eye movement recordings and find that there are often subclinical deficits present for example when reading with both eyes open or the non-amblyopic eye open (Kanonidou et al., 2010, 2014). [3]. The social work course was the degree analysed. It takes at least three years to obtain a degree and to enter the job market. This student has already been assessed in at least 60% of the curricular units and in at least 50% has obtained approval. Nowadays is currently attending the 2nd year. Teamwork develop skills and participation knowledge. In extracurricular activities its performance is always accompanied by the mentor who is only a process advisor. Burchinal et al., (2008) [4], alerts to School Programs and make an analysis to Working Meeting. This study aims to create an information for the learning system in higher education institutions.

Keywords: Inclusion, Special needs, Higher Education Institutions, Assessment

1. Introduction

Nowadays, it is normal to find students in higher education who have special educational needs. The total number of students with disabilities placed in higher education in the academic year 2018/2019 was 231. There are several public services to help students with disabilities: GTAEDES [5] in the inclusion of Students with Specific

Needs in Higher Education – Working group to support students with disabilities in higher education; the Balcony incluIES; the Directory of Support Offices for Persons with Disabilities in Higher Education; BAES - Open Library of Higher Education | Accessible content library(it has a collection of more than 3000 titles in braille, audio and text); PLACES – Accessibility Platform for Higher Education | Tutorials for anyone who wants to learn how to build accessible content in Word, PowerPoint, HTML and PDF.

Based on the assumptions of inclusive education and the growing democratization of higher education, we have been verifying the progressive opening of the university and polytechnics to several minorities, namely students with Special Educational Needs (SEN).

The inclusion of students with SEN in Higher Education (ES) has not been consensual. Their participation and academic success encounter several constraints that need to be analysed and it is important to respond in order to guide institutional change and lead to the assumption of the responsibilities that HEIs have for social development (Abreu, 2011 [6]; Antunes & Faria, 2013 [7] [8]; Berggren, Rowan, Bergbäck, & Blomberg, 2016 [9]; Bisol & Valentin, 2012 [10]).

Many of the studies that state that goodwill is not enough for the inclusion of ENEE to be a reality and that it is necessary to overcome barriers with regard to accessibility, but also the barriers that affect the inclusion of these students (Cabral *et al*., 2015 [11]; Fossey *et al*., 2017 [12]).

2. The case of António in ESTGL

Polytechnic institutes and Universities, confronted, on the one hand, with the increase in the number of ENEE, and, on the other hand, with the international and national policies in favour of inclusive education, have sought to implement appropriate support measures internally for needs of this audience (Working Group to Support Students with Disabilities in Higher Education [GTAEDES], 2014) [8]). In 2017/18, 1644 students with special educational needs enrolled in higher education institutions are referred, 91.5% in public education (1504) and 8.5% in private education (140). Of the 231 students with special educational needs who are not enrolled in 2017/18, 57.1% (132) were enrolled in undergraduate study cycles and 23.4% (54) in integrated master study cycles in 2016/17.

Some of higher education institutions were subdivided by their organic units. ESTGL is an organic unit of Polytechnic Institute of Viseu. In 54 organic units (20.4%) there is a training offer in the domain of the inclusion of diversity and universal design, either in curricular units or in structured programs for undergraduate, master's and doctoral programs and in higher professional technical courses. In 79 organic units (29.8%) research is carried out in the area of disability or in the field of inclusion of diversity through units or lines of research.

António is a student in the Social Work Course with special educational needs for amblyopic. Amblyopia (or black eye) is shown by the reduction or loss of vision in one or both eyes, without having a structural abnormality, that is, it is purely functional. It corresponds to a deficiency in the development of the visual system during the maturation period of the central nervous system (which cannot be corrected by glasses), which usually occurs until 6 or 7 years of age. Amblyopia that lasts longer is irreversible.

This low visual acuity must be an incomplete development of foveal vision. A fovea is a central region of the retina, where an image is formed of what is focused on by vision and sent to the brain. So, amblyopia is not just an alteration of the eye, but also of the brain region of vision, which was not properly stimulated at the right time.

2.1 Training offer

The director of the Social Work Course, in the Course Council, raised the question of "adapting the course to the profile of students with SEN" due to the implications it has for their success, both academic and professional. The problem arises when the choice of the course proves to be inadequate due to the characteristics and limitations arising from the problem presented by the student, proving to be incompatible with the future professional practice.

In **António** situation, it was found that this was not the case, because this type of disability is not limiting in the exercise of professional functions. It is also important to note that this concern does not seem to stem from an exclusionary stance, but an inclusive one. Some faults and problems in the infrastructure and accessibility are pointed out by all the players in this educational scenario. For example, "access to classrooms" in the way they are identified and "inappropriate classrooms". The course director used computer equipment to improve the assistance to classes and developed the concept of support sessions to fill some gaps in the teaching-learning process. In this sense, both the teachers and the course director reveal that, when dealing with students with SEN, they seek to respond to their needs by making different pedagogical adjustments, namely the "adaptation of the evaluation process", using Information and Communication Technologies.

In classroom there is a large screen, where **António** write some notes from the class and can compare with the documents provided by the teacher and placed on the platform. The assessment is done using the laptop and questions and answers are sent to the Moodle platform.

António participates in all social activities and performs his duties without any need for support. In most cases, it is prepared in advance in order to identify the spaces and the sequence of intervention.

However, it is recognized that these students need to be supported more than the rest and that they can fail or give up more easily, especially "when there is no" support.

In terms of socialization, academic and social inclusion, António has a good interaction with other students.

3. Results

The Social Work course has a minimum duration of 3 years, it's an 1st Cycle – Bachelor consisting of 6 semesters. This course has 30 Curriculum Unit (UCs), an observation internship and an internship in the 6th semester.

António enrolled in 2018-2019. He is in his second year and has been successful in at least 100% of UC's in the first year, and almost 80% of UC's in the first semester of the second year. In the summative assessment based on tests and research work, in a score from 0 to 20, he scored two 10, two eleven, two dozen, two thirteen, one sixteen and one seventeen. It is necessary to train teachers and staff in order to understand this type of students and promote their performance to achieve greater success in the training course.

In the case of this student, he managed to interact with colleagues and even though he was a large class, he managed to develop technical and emotional skills that led him to succeed.

4. Conclusions

It is necessary to carry out further studies in order to have a perception of what the process of inclusion in Higher Education is, of the difficulties that remain and of what must be done to move towards Higher Education for All.

The assumption of this policy would allow more targeted and concerted work, namely combating attitudinal barriers, which continue to be one of the main obstacles to inclusion.

We must give a voice to students with SEN so that we can have the information necessary to promote a more inclusive and more supportive academic community.

REFERENCES

[1] Awan M, Proudlock F, Grosvenor D, Choudhuri I, Sarvananthan N, Gottlob I. (2010) An Audit of the Outcome of Amblyopia Treatment: A retrospective analysis of 322 children. Br J Ophthalmol. 94 8 1007-11 Pradeep *et al*., 2014.

[2] Pradeep A, Thomas S, Roberts EO, Proudlock FA, Gottlob I. (2008) Reduction of congenital nystagmus in a patient. Strabismus. 2008 Jan-Mar; 16(1): pp. 29-32.

[3] Kanonidou E, Proudlock FA, Gottlob I. (2014) Reading strategies in mild to moderate strabismic amblyopia: an eye movement investigation. Invest Ophthalmol Vis Sci. 2010 Jul 51 7 3502-8.

[4] Burchinal, M., Kainz, K., Cai, K., Tout, K., Zaslow, M., Martinez-Beck, I., *et al*., (2008). Child care quality and child outcomes: Multiple studies analyses. Paper presented at the Developing a New Wave of Quality Measures for Early Childhood and School-Age Programs: A Working Meeting.

[5] GTAEDES Grupo de Trabalho para o Apoio a Estudantes com Deficiência no Ensino Superior. (2014). Inquérito nacional sobre os apoios concedidos aos estudantes com necessidades educativas especiais no Ensino Superior. Disponível em: http://gtaedes.ul.pt/gtaedes/inq_superior

[6] Abreu, S. M. (2011). Alunos com necessidades educativas especiais: Estudo exploratório sobre an inclusão no Ensino Superior (Dissertação de Mestrado não publicada). Universidade da Madeira, Funchal. Disponível em: http://hdl.handle.net/10400.13/330.

[7] Antunes, A.P., & Faria, C.P. (2013). A universidade e a pessoa com necessidades especiais: Estudo qualitativo sobre perceções de mudança social, institucional e pessoal. Indagatio Didactica, 5(2), pp. 474-488. http://revistas.ua.pt/index.php/ID/article/view/2467/2384

[8] Antunes, A. P., Faria, C. P., Rodrigues, S. E., & Almeida, L. S. (2013). Inclusão no EnsinoSuperior: Percepções de professores em uma universidade portuguesa. Psicologia em Pesquisa, 7(2), pp. 140-150.

[9] Berggren, U. J., Rowan, D., Bergbäck, E., & Blomberg, B. (2016). Disabled students' experiences of higher education in Sweden, the Czech Republic, and the United States – A comparative institutional analysis. Disability & Society, 31(3), pp. 339-356. doi:10.1080/09687599.2016.1174103.

[10] Bisol, C. A., & Valentin, C. B. (2012). Desafios da inclusão: Uma proposta para a qualificação de docentes no Ensino Superior via tecnologias digitais. Revista Portuguesa de Educação, 25(2), pp. 263-280. http://www.scielo.mec.pt/pdf/rpe/v25n2/v25n2a12.pdf

[11] Cabral, L. S. A., Mendes, E. G., de Anna, L., & Ebersold, S. (2015). Academic and professional guidance for tertiary students with disabilities: Gathering best practices throughout European universities. Open Journal of Social Sciences, 3(9), pp. 48-59. doi: 10.4236/jss.2015.39008 Surname, N. "Title of the work",

Name of Journal/Work/Source, City, Publishing House, Year.
[12] Fossey, E., Chaffey, L., Venville, A., Ennals, P., Douglas, J., & Bigby, C. (2017). Navigating the complexity of disability support in tertiary education: Perspectives of students and disability service staff. International Journal of Inclusive Education, 21(8), pp. 822-832. doi: 10.1080/13603116.2017.127879
[13] Wessel, R. D., Jones, J. A., Markle, L., & Westfall, C. (2009). Retention and graduation of students with disabilities: Facilitating student success. Journal of Postsecondary Education and Disability, 117(3), pp. 116-125. Disponível em: http://files.eric.ed.gov/fulltext/EJ831430.pdf

Student's Assessment

Subject Tests vs. General Study Skills Admission Tests – Which Perform Better in Selecting Prospective Successful Bachelor Students in Biology?

Jan Mourek[1], Vanda Janštová[2]
Department of Teaching and Didactics of Biology, Faculty of Science, Charles University, Prague, Czech Republic[1,2]

Abstract

The effectiveness of various types of admission test in selecting prospective successful university students is being intensively discussed. Until 2015/2016, Faculty of Science, Charles University (Prague, Czech Republic) used a combination of a knowledge-based biology test and a general study skills test for selecting students into biological bachelor study programs. Since 2016/2017, the use of the general study skills test was abandoned and only the biology test has been used. The aim of our study is to evaluate the relation between students' scores in both types of admission tests and their academic performance in the bachelor degree. We analysed data from six subsequent academic years (2009/2010-2014/2015; n=1662). There was a rather weak correlation between the students' scores in the general study skills test and their grade average in the 1st study year. Scores of the biology test and the study average correlated moderately and this correlation was stronger than if the scores from both tests were pooled. The results of the admission test in biology quite well reflected the later student outcome of the final bachelor's exam, while in the case of the general study skills this relation was not significant. We therefore consider knowledge tests in biology being a more reliable criterion in selecting prospective students than the general study skills.

Keywords: effectiveness of admission tests, academic performance, bachelor study, biology, general study skills test

1. Introduction

Predicting success and failure of graduate students is difficult when using the easily obtained quantitative data [1]. Yet there is a big demand for such a prediction as all universities and colleges face the challenge of finding the right criteria to choose the best future students from the applicants. In general, there are two main domains tested in entrance exams: the subject(s) important for the study field (Subject test) and/or general study skills (GSS). Some universities also rely on the applicants' study results at secondary schools.

A meta-analysis of US studies concluded that Subject tests were better predictors of student academic performance (SAP) in the first grade than graduate record examination (GRE, standardized test used to measure applicants' aptitude for abstract thinking in the areas of analytical writing, mathematics, and vocabulary), although GRE was a valid predictor as well [2, 3]. To predict future research success, a letter from mentor was the most valid tool [4].

In the Czech Republic, Rubešová on the example of Faculty of Science bachelor students showed that high school assessment and success in faculty entrance exams did partially predict SAP. Gender and length of the gap between high school leaving exam and faculty entrance exams did not have any influence [5], which is in concordance with analysis of medical school students' data [6]. The Subject tests used at Faculty of Science [5] were better predictors of SAP than the GSS test used to predict SAP of future chemists at other faculties [7]. Táborská also explained that one of Czech medical faculties stopped using the GSS test as a part of their faculty entrance exams because an analysis showed it was much worse predictor of SAP than the Subject tests [8]. This is in contrast with the overall situation in the Czech Republic, where an increasing number of universities and colleges are switching from Subject tests to commercial GSS tests.

All these findings made us to wonder, what is the best predictor of SAP of future biologists and biology teachers. Local validation of graduate admissions measures seems to be necessary as the general tests might not be best suited for the profession.

Until the academic year 2015/2016, Faculty of Science, Charles University (Prague, Czech Republic) used a combination of a knowledge-based biology test (Biology) and a GSS test for selecting students into biological bachelor study programs and then switched to using only the biology test. This gives us a good opportunity to use archive data from both types of admission tests and compare their value in predicting the students' academic performance in bachelor degree at this faculty.

2. Methodology

We studied the relation between the students' results in admission tests and their academic performance in the biological bachelor study programs (including the teacher training programs) at Faculty of Science, Charles University. We analysed data from six subsequent academic years (2009/2010-2014/2015). Only the students, who successfully passed the admission exams and finished at least the 1st year of bachelor study were included (n=1662; 1204 females and 457 males; number of students per year ranged from 229 to 302).

The admission exam consisted of a knowledge test in biology (prepared by the academic staff of the faculty) and a GSS test (prepared by of Dept. of Psychology, Faculty of Philosophy, Charles University). A new set of tests was prepared for every year of admission. The biology test consisted of 50 close-ended multiple-choice questions, each with one correct answer (2 points per correct answer; maximum 100 points in total). The GSS test consisted of several parts with multiple test items, focusing on different aspects of general study skills (see above; maximum 100 points in total).

The applicants were accepted according to the pooled scores from both tests.

We used the students' grade average of all exams in the first year of bachelor study and the students' grades in final bachelor's exam as measures of their academic performance. Particular exams were either oral, close-ended written tests or open-ended tests in different forms. In the calculation of the grade average, failed exams attempts were also included. The bachelor's final exam consisted of an oral part and of a bachelor thesis defence. Individual exams, as well as the final bachelor's exam are evaluated from 1 – excellent to 4 – not passed.

We analysed the data in Statistica 13.0. We checked the distribution of the data by a visual inspection of histograms. Because they looked close to normal distribution and because of the high numbers of students, we decided to use parametric variants of statistical tests.

3. Results

3.1 Results of the Biology and GSS admission tests

The students' results in both admission tests showed a weak, but significant negative mutual correlation (Pearson's r=-0.1069; p<0.0005), see Fig. 1 for details. In general, students had significantly better results in the GSS test than in the Biology test (repeated measures ANOVA, p<0.001; observed power 1.0; mean GSS = 71.52 points, SD = 10.44; mean Biology = 62.92 points, SD = 9.54 points). In the Biology test, male students did slightly better than females (one-way ANOVA, p<0.05; observed power 0.70; mean males = 63.96 points, SD = 9.63; mean females= 62.51 points, SD = 9.48 points). In contrast, there was not a significant difference in the GSS test between the genders (one-way ANOVA, p=0.43; observed power 0.12).

3.2 Biology and GSS admission tests as predictors of the students' grade average

We found a moderate negative correlation between the results of the Biology admission test and the grade average in the 1st year of study (Pearson r=-0.426; p<0.01), see Fig. 2. This means, that the students with higher test scores had in general better grades and the test results explained about 18% of variance in the grade average. In contrast, the results of GSS test and the grade average correlated very weakly (Pearson r=-0.095; p<0.0001), explaining less than 1% of variance, see Fig. 3. Surprisingly, the students' score in the Biology test was an even better predictor, than the pooled score from both tests (Pearson r=-0.357; p<0.01), which was used by the faculty as the criterion for the acceptance of students.

We came to very similar results, when the data was evaluated separately for males and females, as well as for each individual academic year.

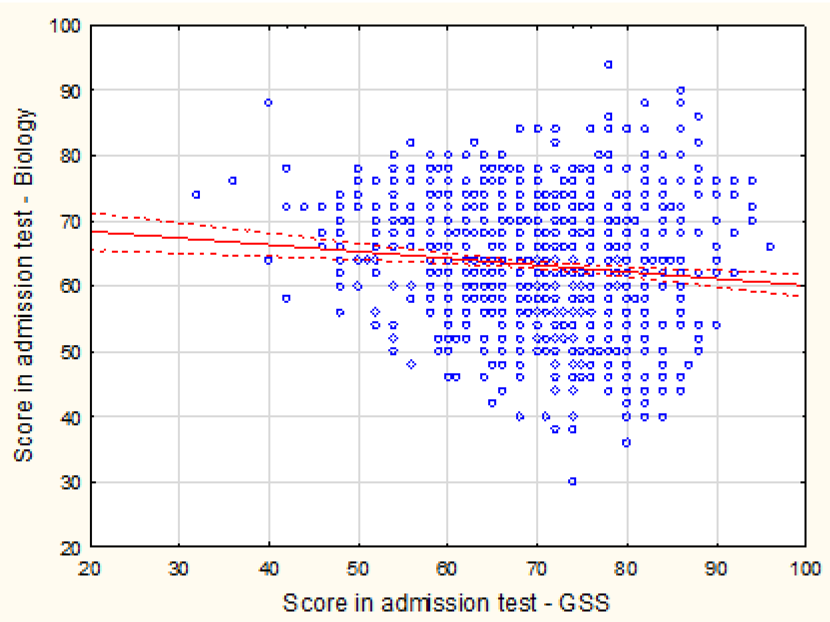


Fig. 1. *Correlation between the results of the GSS and Biology admission test. Red solid line = linear regression fit (y=70.4802 – 0.1038*x; Pearson's r=-0.1069; p<0,0005); dashed red line = ±95% confidence interval*

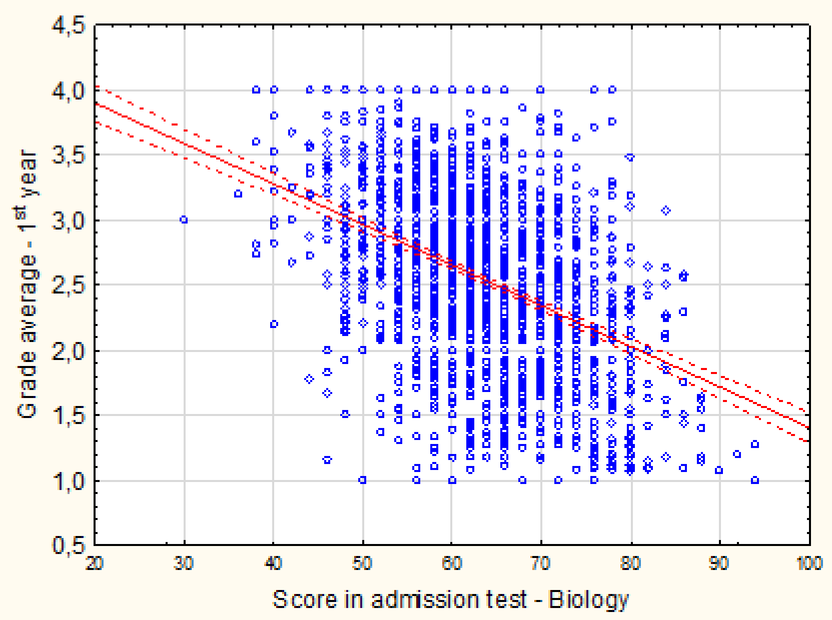


Fig. 2. *Correlation between the results of the Biology admission test and the grade average in the 1st year of study. Grades: 1 – excellent to 4 – not passed. For explanation of symbols see legend of Fig. 1.*

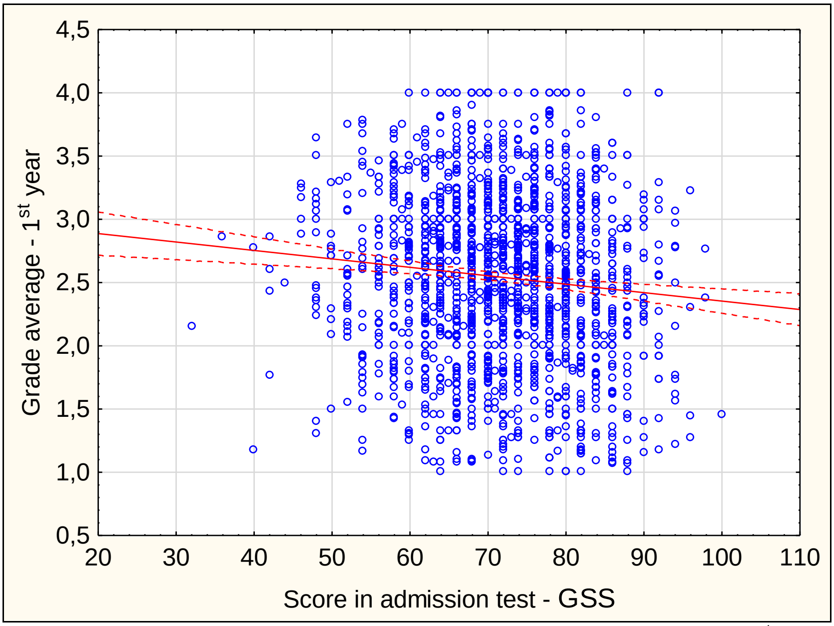


Fig. 3. *Correlation between the GSS test and the grade average in the 1st year of study (y= 3.0203-0.0067*x; Pearson's r=0.0985; p<0.0001). Symbols explained in the legend of Fig. 1*

3.3 Biology and GSS admission tests as predictors of the students' grades in

final bachelor's exam

The results of the Biology admission test quite well reflected the later student outcome of the state bachelor's examination (one-way ANOVA; $p<0.01$), see Fig. 4 for details.

Students with the final grade 1 (excellent) had significantly higher test scores in the Biology test than the rest of students (Tukeys HSD post-hoc test, $p<0.001$). In contrast, there was no difference in the results of the GSS tests (one-way ANOVA; $p>0.1$).

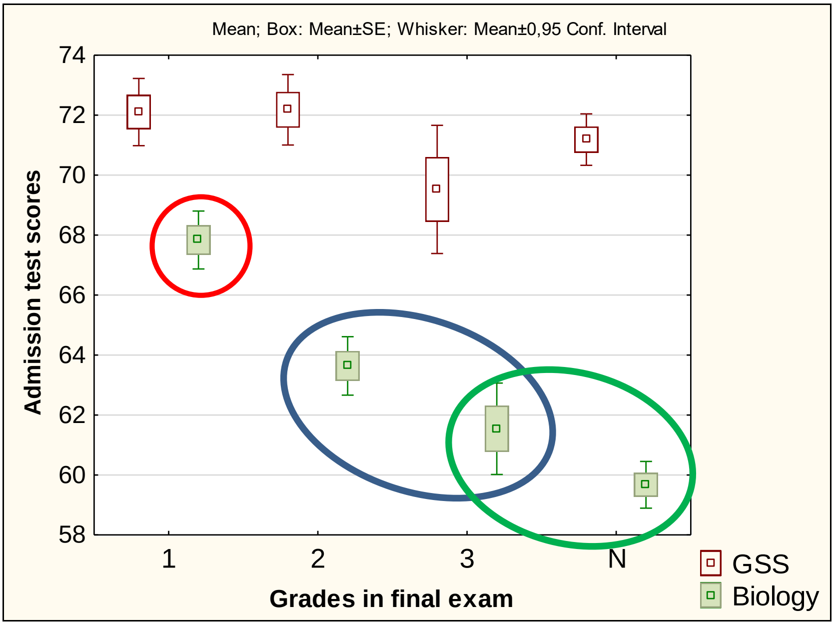


Fig. 4. *Students' results in admission tests (Biology, GSS), grouped according to their grades in final bachelors' exams (grades 1, 2, 3 = successfully passed; N = not passed or abandoned the study before graduating). The ovals in different colours indicate homogenous groups (p>0.05.)*

4. Discussion and Conclusions

Although GSS tests seem to be widely used [2], several studies indicate that Subject tests are better predictors of academic performance, or SAP [2, 5]. These findings are in concordance with our results which showed only a weak correlation between bachelor students' academic performance and their GSS tests scores, compared to a moderate correlation between bachelor students' academic performance and their Biology Subject tests. The Biology test seems to be an even better predictor of SAP than the combination of both types of tests. Consequently, this had led, like in case of one Czech faculties of medicine [8], to abandoning the GSS test as part of admission tests for future biologists and biology teachers at Faculty of Science, Charles University. We conclude that although the GSS tests may reflect important study skills, they lack other important features, such as the students' subject-specific knowledge background, diligence and motivation for the study. These aspects are probably better covered by the Subject tests.

We are well aware of the limitations of our study. First, we included only the students, who passed the process of admission and finished at least first year of study. We therefore could not access data on possible SAP of unsuccessful applicants or of successful applicants, who had decided not to study at Faculty of Science. Second, the grade average in the 1st study year and the grades in the bachelors' final exam, used as measures of SAP in our study, describe only a part of the whole complex picture. We propose a more detailed future study, including measures of the students' performance in subsequent degrees as well as their research activities.

Acknowledgements

The study was financially supported by the Charles University project *UNCE/HUM/024* "*Centrum didaktického výzkumu v přírodních vědách, matematice a jejich mezioborových souvislostech*". We are grateful to our colleague Radim Kuba for help with search for literature.

REFERENCES

[1] Hardgrave, B. C., Wilson, R. L., & Walstrom, K. A. "Predicting graduate student success: A comparison of neural networks and traditional techniques", Computers & Operations Research, vol. 21, no. 3, pp. 249-263, 1994.

[2] Kuncel, N. R., Hezlett, S. A., & Ones, D. S. "A comprehensive meta-analysis of the predictive validity of the Graduate Record Examinations: Implications for graduate student selection and performance". Psychological Bulletin, vol. 127, no. 1, pp. 162-181, 2001.

[3] Kuncel, N. R., & Hezlett, S. A. "Standardized Tests Predict Graduate Students' Success", Science, vol. 315, no. 5815, pp. 1080-1081, 2007.

[4] Hall, J. D., O'Connell, A. B. & J. G. Cook, „Predictors of Student Productivity in Biomedical Graduate School Applications", PLOS ONE, vol. 12, no. 1, pp. e0169121, 2017.

[5] Rubešová, J. "Souvisí úspěšnost studia na vysoké škole se středoškolským prospěchem? Pedagogická orientace", 19(3), pp. 89-103, 2009.

[6] Höschl, C., & Kožený, J. "Predicting academic performance of medical students: The first three years", American Journal of Psychiatry, 154(6), 87, 1997.

[7] Synek, J., & Otřísal, V. "Predikční validita testu OSP – výsledky analýzy", Scio. 2008. https://docplayer.cz/15157738-Www-scio-cz-s-r-o-zpracovali-jan-synek-vaclav-otrisal-15-zari-2008.html

[8] Táborská, E. "Proč Lékařská fakulta nepoužívá TSP?", @muni.cz – Online verze měsíčníku Masarykovy univerzity. 2005. https://www.em.muni.cz/tema/83-proc-lekarska-fakulta-nepouziva-tsp

STEM Education

Challenges Faced by Maltese Students Studying Advanced Level Physics

Nathan Pullicino[1], Charles Bonello[2]
University of Malta, Malta[1,2]

Abstract

One of the aims of the Secondary Education Certificate [SEC] Physics syllabus is "to provide the basis for further study of the subject". This research plans to determine the degree to which the syllabus is fulfilling this aim. In this study, seven post-secondary Physics teachers participated in semi-structured interviews and 200 students provided feedback to a questionnaire. Areas in which the SEC Physics syllabus is not preparing students well enough to further their studies in the subject were identified and suggestions were given to help improve the situation. Findings from this study confirm that there is an academic disparity between SEC and Advanced Matriculation [AM] Physics. This disparity is found mainly in the areas of: the abstract nature of the concepts, problem-solving skills, mathematical physics, and language. The study also confirms that there is a large amount of rote learning involved in SEC level Physics as students tend to memorise knowledge rather than understand the reasoning behind it. As a result of this students learn superficially and struggle to understand the complex concepts taught in A-level Physics. In order to prepare students better for post-secondary education, SEC Physics students should be given the opportunity to answer questions which involve higher level thinking and to solve more complex mathematical problems. Furthermore, more frequent practical sessions, a greater degree of student involvement and a greater emphasis on the link between theoretical ideas and practical work is also recommended. A shift of emphasis is required from teaching content to teaching higher order thinking skills.

Keywords: Physics, Syllabus, Academic disparity, Underprepared students

1. Context of Study

At the end of compulsory secondary schooling, students in Malta sit for the SEC examinations. Students who obtain the necessary grades can then further their studies in the subjects they choose and then sit for the Advanced or Intermediate Level Matriculation Certificate examinations. These examinations allow access to university [1]. While in the past, Physics was the main science being taught in post-secondary institutions; the yearly examiners' reports presented during the last decade indicate a decline in the number of students choosing to further their studies in the subject.

Many students enter post-secondary education underprepared for the content of AM Physics. This results in low course completion rates and underachievement [2], [3].

When the preparatory work presented at the lower level is too basic, or the disparity between the two levels is too large, the grade obtained at SEC level would not be a good indicator of future performance and students may be misled into choosing the subject at AM level.

2. Methodology

Since they are the two main stakeholders involved in the teaching and learning of post-secondary Physics, AM Physics students and post-secondary Physics teachers were asked to participate in this study.

An online questionnaire was completed by 200 of the 3430 students who had applied for the AM Physics examination between 2011 and 2018. This implies that using a 95% confidence level, the statistical inferences resulting from the questionnaire have a margin of error of 6.73%.

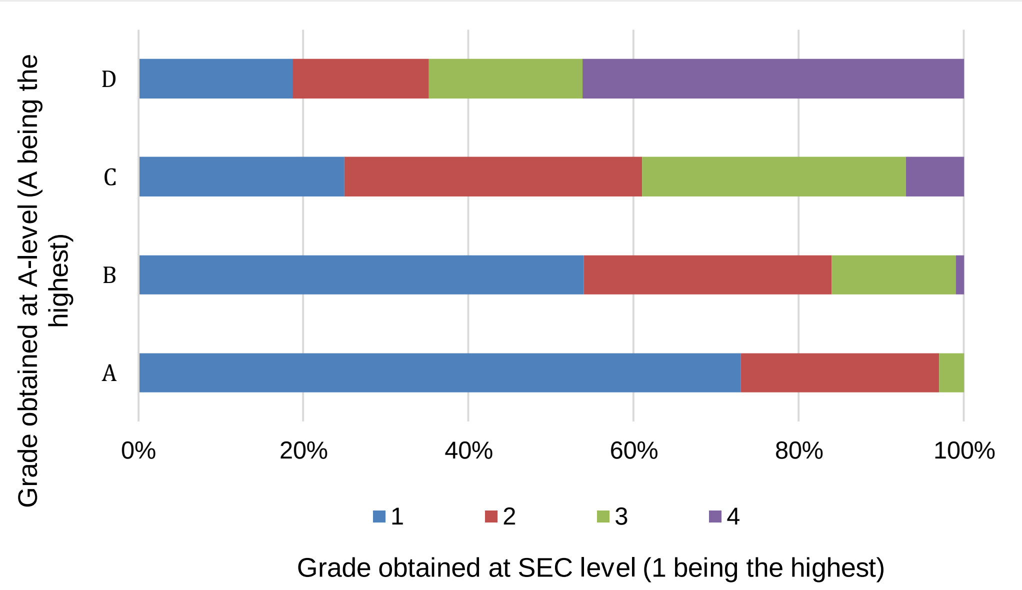
To obtain a more complete picture, the views of post-secondary Physics teachers were also taken into consideration. Seven teachers from six different post-secondary institutions participated in semi-structured interviews and generated data about the challenges faced by Maltese students when studying AM Physics.

3. Results and Implications

3.1 The disparity between SEC and AM Physics

Graph 1 indicates that students who obtain better grades at SEC level tend to perform better at AM Physics.

Graph 1. *Grades obtained at SEC level and the corresponding grade at AM level*



Although the grade obtained at SEC level seems to be a good predictor of performance at AM physics, it does not reveal much about how well-prepared students are to further their studies in the subject. One of the causes of underprepared students is the gap between the skills and requirements for success at SEC level and those required at higher levels [4]. If the skills acquired through SEC Physics are too basic, then students choosing to further their studies in the subject will be underprepared. Data found in Table 1 confirms that a significant percentage of students [59%] find this disparity to be slightly excessive or excessive.

Table 1. *Students' feedback on the disparity between SEC and AM Physics*

The gap between the level of difficulty of SEC Physics and that of AM Physics was:	Very small	Small	Adequate	Slightly excessive	Excessive
Percentage of respondents	2%	8%	31%	32%	27%

Six of the seven interviewed teachers agree that the disparity between the two levels is too large. Three teachers also affirmed that SEC Physics mostly requires lower-order thinking which results in students choosing to memorise content rather than understand it.

3.2 Mathematics and problem-solving skills

Students at secondary level lack problem-solving skills and struggle with mathematical calculations and higher order thinking skills [5]. If students are not being prepared well to solve mathematical calculations at SEC level, it will be hard for them to succeed at a level which requires the application of Mathematics to solve unfamiliar problems [6]. All teachers agreed that while SEC Physics prepares students well to be able to recall and work out simple mathematical problems, it does not prepare them to apply what they know to unfamiliar situations or to solve complex, multi-step problems.

Furthermore, results also showed that 60.5% of student respondents were incorrectly taught fundamental mathematical relationships such as directly proportionality. The general notion students had about 'direct proportionality' was, "one value increases as the other increases". Furthermore, 79.5% of the participating students believe that the use of Mathematics should be emphasized more in SEC Physics.

3.3 Language expression

Past studies showed that most students are concerned about the fact that they may not understand the exam question and find difficulties in expressing themselves in English [7]. 78.5% of participating students agreed that they were able to use proper English to explain concepts, however, six out of the seven interviewed teachers stated that students are not being well prepared to understand the questions being asked and to express themselves using proper English.

This divide between students' and teachers' perspective may be due to the fact that students are trained by teachers to memorise and recall through working many past papers. Therefore, it may be the case that students are given the wrong impression of being well-prepared to describe concepts when in reality, they were well-prepared to recall a particular response.

3.4 Teacher's pedagogy

The teacher's pedagogy can also affect the number of underprepared students [4].

Students confirmed that negative teaching styles, such as teaching for exam purposes, prevented them from understanding concepts well at SEC level. Teachers argued that learning by memorising has negative effects on student preparation and performance. Both stakeholders seem to think that SEC Physics should focus more on teaching students to think rather than recall. In this manner one can ensure that concepts are well understood.

3.5 Content knowledge

Six out of the seven interviewed teachers confirmed that when covering topics in which the students have good grounding from SEC level, students find the concepts easier to grasp. Furthermore, during lessons the students are more confident and participate more. Four of these teachers also observed that they cover material quicker and encounter fewer problems when there is good grounding.

Five teachers believe that misconceptions hinder students from understanding and that it is harder for students to unlearn and adjust previously learned information than it is to learn something completely new. Teachers should therefore be aware of common misconceptions in order to address them.

In an open question on how to better prepare students for AM Physics, thirteen students suggested that compulsory Physics should cover a wider range of topics, such as ‘Quantum Physics’, in order to make learning less strenuous at post-secondary level.

3.6 Experimental work

Four of the interviewed teachers stated that, at post-secondary level, students struggle to conduct experiments on their own. This was especially so when working with circuits. In an open question about how to improve experimental work in SEC Physics, around 20% of the questionnaire respondents mentioned that students should be given the opportunities to work independently. Furthermore, both groups of participants confirmed that at secondary level, students should be asked to do investigations rather than being shown demonstrations or given recipe type instructions to follow.

Thirteen students commented that there needs to be a more evident link between practical and theoretical work. Furthermore, all interviewed teachers agree that SEC Physics does not prepare students well enough to properly consider precautions and errors in practical work. Five of the teachers elaborated that students have a list of precautions and errors learned by heart but cannot relate precautions to their proper errors or apply them properly depending on the experiment.

In considering mathematical calculations related to practical work, four teachers stated that students are able to calculate the gradient of a simple straight-line graph but struggle to arrange equations to straight line form and extract information by associating the gradient to the equation.

3.7 Challenging areas of AM Physics

Both student and teacher participants confirmed that post-secondary students tend to find: ‘Thermal Physics’, ‘Electric Currents’, ‘Electrostatic Fields’, ‘Magnetic Fields and Electromagnetic Induction’, ‘Atomic, Nuclear and Particle Physics’ and ‘Quantum Theory’ difficult. In fact, all interviewees mentioned that students struggle to understand and grapple with the abstract concepts linked to these topics. Furthermore, according to interviewed teachers, students cover ‘Waves’, ‘Electricity’ and ‘Magnetism’ superficially at SEC level. This leads to students not understanding what terms such as ‘Voltage’ and ‘Current’ actually mean and hence relying on their memory to answer exam questions.

3.8 Conclusion

It seems as though SEC Physics teachers can better prepare students for post-secondary Physics courses by ensuring that during the SEC course students focus on higher order thinking skills, language, problem-solving and mathematics.

Four of the seven teachers interviewed would like SEC Physics to cover more content and go into more detail. The remaining three teachers disagreed and said that compulsory Physics should only cover specific topics and ensure that they are well-covered. These teachers argue that since only around 11% of the students who sit for the SEC Physics examinations further their studies in the subject, covering more content would prove detrimental to the majority of students.

The SEC Physics syllabus must therefore take into consideration students who do not wish to further their studies in the subject and who simply need to get a pass in order to satisfy sixth-form entry requirements. This implies that it may be the right time for this syllabus to be reviewed and split up so that one course would focus on preparing students for further studies in physics while another course would focus on creating scientifically literate citizens.

REFERENCES

[1] Sultana, R. G. (1999). *The Secondary Education Certificate and Matriculation Examinations in Malta: A Case Study*. Switzerland: UNESCO International Bureau of Education.

[2] Balduf, M. (2009). *Underachievement Among College Students. Journal of Advanced Academics, 20*(2), pp. 274-294.

[3] Kamphoff, C. S., Hutson, B., Amundsen, S., & Atwood, J. (2007). A Motivational/Empowerment Model Applied to Students on Academic Probation. *Journal of College Student Retention Research Theory and Practice, 8*(4), pp. 397-412.

[4] Dzubak, C, M. (2007). What Skills and Whose Standards: Why are Students Underprepared? *Synergy: The Journal of the Association for the Tutoring Profession, 1*.

[5] Erinosho, S. Y. (2013). How Do Students Perceive the Difficulty of Physics in Secondary School? An Exploratory Study in Nigeria. *International Journal for Cross-Disciplinary Subjects in Education, 3*(3), pp. 1510-1515.

[6] Farrugia, J., & Ventura, F. (2007). Predictive validity of examinations at the Secondary Education Certificate (SEC) level. *Journal of Maltese Education Research, 5*(2), pp. 21-44.

[7] Pace, R. (2005). *Students' difficulties in answering quantitative and qualitative questions in SEC Physics*. (Unpublished B.Ed. (Hons) dissertation). University of Malta, Msida, Malta.

Definition of a Classification of the Difficulties in Linear Algebra in Psychological Terms

Lekë Pepkolaj[1], Siditë Duraj[2], Dritan Gerbeti[3]
Albanian University, Albania[1]
University of Shkodra "Luigj Gurakuqi", Albania[2,3]

Abstract

This article focuses on the discourse on the classification of students' errors and mistakes in linear Algebra. It points to the significance of understanding of student learning difficulties and errors as part of human nature and as a drive to improve student learning and at the same time as crucial for the enhancement of the overall learning process. Identifying mistakes helps the teacher to find out the gaps in students' knowledge and skills, to classify them, and to determine the proper recovery strategies. It also helps the teacher to tailor teaching taking into account students' individual needs, their interests and abilities. The paper points to the importance of setting teaching objectives based on the individual learning needs of students and personalizing teaching and learning to ensure full engagement of students in the learning process. The purpose of identifying and classifying students' errors is not to put the blame on students but to minimize and analyse the causes that lead to the students' errors.

Keywords: difficulty, linear algebra, individualized learning, recovery strategies

1. Introduction

In human existence we are not only accompanied by linear, arranged paths, but also by different paths that can naturally contain errors. The learning process is not only combined with metacognitive attitudes but also with trials and errors, uncertainties and certainties, obstacles and passages. Error and truth are generated from the same source, welded to the anthropological roots of learning, and the error during the complex learning process represents a very useful instant, which gives stimulus to go further, closer and closer to the truth.

An analysis of the classification of difficulties provides information on the status of the student's knowledge representation and the strategies he used to carry out a given problem. The classification reveals the most serious errors by helping teachers to set the questions in such a way that the student accepts the risk of the error and must understand the difference between the source of the error and the error itself. In the context of the identification/observation/evaluation of the "error" is the starting point for new problematic situations with which the student will be able to deal. These activities also allow to give the "error" a significant educational value.

2. Theoretical Framework

2.1 Errors and Mistakes

Very often we are dedicated to the error in the pedagogical-didactic field, but it seems important to us to take into account the difference that exists between error and mistake, which we find in the psychological terms. Such a distinction was already made by H. Wiemer in the 1920s. In his opinion, error and mistake differ in the sense that the error is based on the ignorance of certain facts essential for the exact recognition, while the mistake is generated by the defective activity of the three functions (attention, memory and thought) that govern the completion of each work. Therefore, while error has an objective basis, mistake is essentially a subjective factor [1].

In the following figures we show two examples of errors and mistakes:

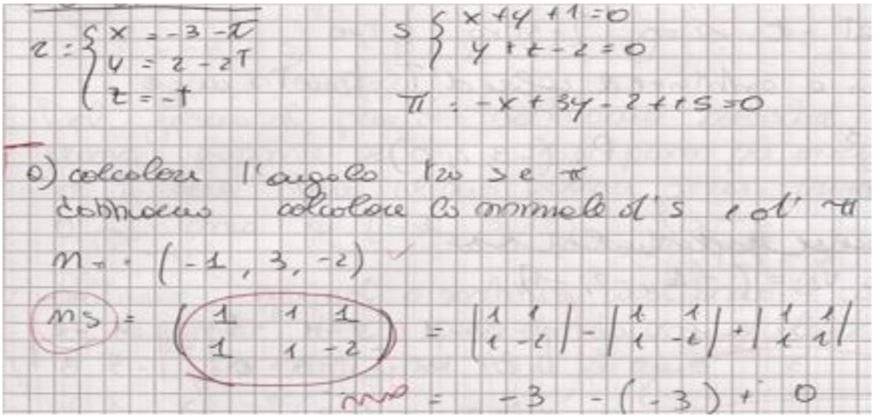


Fig. 1. *Examples of errors*

Directional vector, of a straight line in space represented in the Cartesian form. Then the vector product of two vectors comes out with a number!

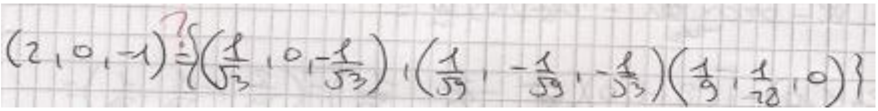


Fig. 2. *Example of mistakes*

Write a 'vector' = 'three vectors'. He doesn't think what he's writing, he's not careful.

We share Pellerey's denomination for mistakes: "wrong manners resulting from a lack of attention or adequate control, wrong habits or incorrectly developed automatisms" [2].

Noticing mistakes is very important because they have so much potential to damage their own consequences.

To better understand the difference between errors and mistakes, we stop for a moment to see the differences that there are between problems and exercises. Both are about a question that requires different skills to be answered. The problem requires a discovery to be made, the exercise is performed because a discovery has already been made [3].

In the case of mathematics, the problems involve the use of several rules or notions, or the succession of operations whose choice is a strategic act, sometimes creative, of the student himself. Instead, the exercises can be solved using rules or notions already learned and in the process of consolidation and therefore fall into the categories: reinforcement or verification [4].

The error is linked to expectations and invention, and therefore can have it in the resolution of problems, while the mistake has been more of a lack of attention and bad memory, and therefore it can be committed in the performance of exercises. Surely there is more learning when you make more errors than mistakes. A good teacher must understand the differences between the two and be able to take advantage of the right opportunity to explain this difference to the pupils to give them the 'elements' where they learn to identify them [5].

2.2 Possible classifications of errors in mathematics

Much of the survey on the type of errors that occur in mathematics dates back to the 80s, but it is still very legitimate for the current survey. Ivan Watson classifies errors based on problem solving, but in the widest way on a cognitive and not on a cognitive level [6]. The categories are:

1. Reading skills – can the pupil read the questions?
2. Understanding – can the pupil understand the questions?
3. Transformation – is the learner able to select the necessary mathematical operations that are required to obtain the solution?
4. Process skills – can the learner carry out the necessary mathematical operations for the task?
5. Coding – is the pupil able to write down the answers in an acceptable form?
6. Motivation – could the pupil have correctly solved the problem if he or she had tried?
7. Inattention – the pupil could perform all the steps but makes a negligent mistake, which is impossible to repeat.
8. Question pattern – the pupil makes an error because of the way the problem was presented.

Watson, like other authors [7], [8], classifies errors throughout the discipline of mathematics, but goes into more detail and creates a very interesting field of investigation. The proposed model, foreseeing difficulties and obstacles, can help teachers to take advantage of this possibility in the planning of teaching, anticipate as soon as possible. He sees them widely on all three levels, cognitive, meta-cognitive and non-cognitive.

3. Definition of a Classification of the Difficulties in Linear Algebra

Context and base of data. About 100 protocols have been analysed, related to 2 tests of the examination of Geometry for the degree course in Electronics, Electrical Engineering. Each track contains 6 problems each, each of which is divided into two or three questions.

Our classification depends on:

- Model to choose from: information/elaboration, problem solving, etc.,
- Nature of the discipline itself and the characteristics of the various areas of mathematics, the error it makes, so cognitive level,
- Attitudes and beliefs of students towards mathematics, who makes the mistake, so metacognitive and non-cognitive level.

The classification scheme is shown in the following figure:

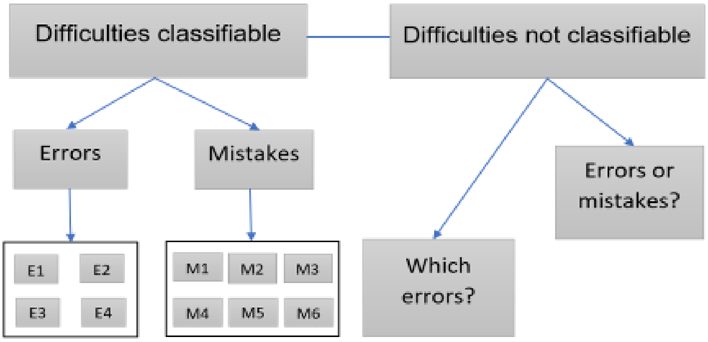


Fig. 3. *Classification of difficulties*

In the classifiable difficulties enter those errors that we know for sure their paternity.

While in the unclassifiable difficulties belong to us those errors that paternity is uncertain. In the typology of errors, the nature of the mathematical arguments is well understood, especially in the case of E3. While most of the mistakes have to do with non-cognitive level.

3.1 Difficulties classifiable

Classification of errors

E1 – Inappropriate use of the data. Association incorrect or rigidity in the information/elaboration of the requisites/answers caused by difficulties in the:

- *reading*, the student does not read the key words or the symbols in the statement of the questions
- *decoding*, the student does not understand the meaning of the words, symbols and text of the questions.
- *coding*, the student understands the data of the problem but she is not able to write them correctly in the semiotic system more suitable to get the answer

E2 – linguistic deficiency. It means that students are not able to understand and to manipulate mathematical objects by means various type of semiotic representations, both at syntactic and semantic levels.

E3 – cognitive and metacognitive deficiency. This kind of error can be caused by: a) *basic deficiencies* b) *constructions of conceptual nodes, lacking from*: – *definitions – proposition and their properties – observations – corollary – theorems – algorithms – procedures.*

E4 – incorrect logical deduction. This kind of error is caused by the application of inappropriate rules or strategies.

Classification of mistakes

M1 – *lack of control and feedback*. The students do not demonstrate step by step what the problem requires; they do not verify the concepts, solutions. They don't carry on the clean sheet the accounts and the steps shown, but they only write the final result.

They do not check their product with respect to theoretical concepts and results. They do not write verbally at all; they use a personal shorthand.

M2 – *technical mistakes*. The students' incorrect calculus. Particular mistakes, signs, brackets, symbols, letters, sign instead of another, etc.

M3 – Harlow *error factors*. The students make a correct procedure which does give a correct answer but which is not what required by the given problem.

It finds the base of the auto space V_2 and normalizes it well but it was not asked by the question.

M4 – *lack of answer to some questions*. The students relinquish some questions corresponding to topics they did not study, leave the problem and the question in half.

M5 – *coding mistakes*. The students do not order the answers or do not make any reference to the related question, they solve subsequent questions without taking into account the relations among them, and they do not put their name on the worksheets or do not number the pages.

M6 – *a priori evaluation of the difficulties*. The students are not able or do not pay attention to evaluate the difficulties of each question or problem, which also includes to be able to choose the easier solution strategy.

3.2 Difficulties not classifiable

The category of unclassifiable difficulties includes those that are not known with certainty whether they are errors or mistakes and which types of errors.

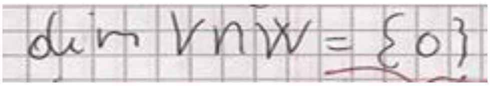


Fig. 4. *Error or mistake*

Error like E3/lack of propositions? Doesn't he know that the size of a vector subspace is a number or type of S2/technical mistake? Write the parentheses you don't need.

What kind of errors?

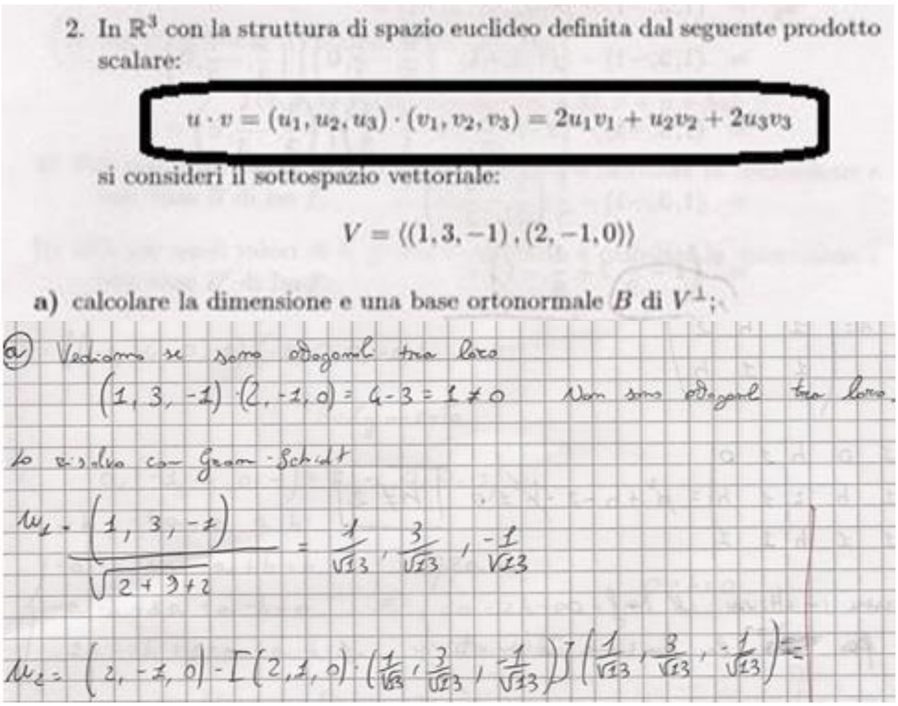


Fig. 5. *What types of errors?*

E1/reading error? Does not read in the question $V^{\perp}$ that takes it for V and does not read the given scalar product or Error type E3/lack of algorithms, does not know how to calculate an orthonormal base of $V^{\perp}$

4. Conclusions

The interpretation of error is very delicate. One cannot dismiss with a simplistic diagnosis how unproductive that of the lack of knowledge, so it is not always a question of error of uncertain origin, unpredictable, but highlighting difficulties in the sense:

- from stimulation to understanding the roots of errors, and not only to eliminating them immediately,
- the effort to take the learner's rather than the expert's point of view,
- the individual or collective control of errors (student-teacher, student-student) and therefore the need for the student to perceive their limits as a prerequisite for correcting them.

From the analysis of the difficulties we have seen that the same error in different subjects comes from different objects and we have a focus of the student who moves from the orientation of the performance to the orientation of learning. The classification of errors communicates how to identify good recovery strategies, especially in the planning of such activities. In the end, priority must be given to personalizing learning, so the paths to be built differ according to the difficulties of the specific student.

REFERENCES

[1] Baldini, M. "Prefazione". In (L. Binanti, a cura di) Pedagogia, epistemologia e didattica dell'errore, Rubbettino, 2001, pp. 7-12.
[2] Pellerey, M. "Lo studio degli errori nella didattica e formazione dei docent a partire nelle ricerche di Luigi Calonghi". In (G. Amenta, a cura di) Docimologia e Ricerca Educativa. Pensa Multimedia. 2014, pp. 7-14
[3] Antiseri, D. "Elogio dell'errore". In (L. Binanti, a cura di) Pedagogia, epistemologia e didattica dell'errore, Rubbettino, 2001, pp. 101-106.
[4] D'Amore B., Fandino Pinilla M.I. "Che problema i problemi!" L'insegnamento della matematica e delle scienze integrate. 6, vol.29 A-B. Editore: Centro Morin, Paderno del Grappa (TV). 2006, pp. 645-664.
[5] Pepkolaj, L. "Difficoltà in matematica: Percorsi in autoformazione in e-learning". La tesi del dottorato in matematica. Università degli Studi di Salerno (Italy). 2015 pp. 33-43
[6] Wiens, A. "An Investigation into Careless Errors Made by 7th Grade Mathematics Students". https://digitalcommons.unl.edu/mathmidsummative/32. 2007, pp. 1-46.
[7] Radatz, H. "Error Analysis in mathematics education". Journal for Research in Mathematics Education, 10(3), 1979, pp. 163-172.
[8] Movshovitz-Hadar, N., Zaslavsky, O., & Inbar, S. "An empirical classification model for errors in high school mathematics". Journal for Research in Mathematics Education, 18(1), 1987, pp. 3-14.

Developing Primary Teachers' STEM Knowledge for Teaching through Signature Pedagogies

Mairead Holden[1]
University of Lincoln, United Kingdom[1]

Abstract

The National Council for Curriculum and Assessment (NCCA) in Ireland is currently in the process of working with teachers and early childhood practitioners, school leaders, parents and children, to redevelop the Primary Curriculum. Amongst the objectives of the redevelopment is for Ireland to become internationally recognised as providing the highest quality STEM education for all learners across all levels of education. Despite challenges in enacting the existing mathematics and science curricula effectively in classrooms, this redevelopment poses further challenges to primary teachers who are now expected to take an increasingly integrated approach to teaching and learning with the knowledge and skills needed not always being evident. This paper reports on a Continuing Professional Development (CPD) programme the aim of which was the development of primary teachers' STEM Knowledge for Teaching, which describes the pedagogical and content knowledge needed to carry out the work of teaching STEM effectively in the primary classroom. The CPD programme was based on the distinctive signature pedagogies approach, involving critical dialogue, public sharing of work and communities of learners, each of which aims to enable teachers to engage in specific ways of thinking about their own practice in STEM, with the aim of enhancing their pupil's educational experiences and outcomes in STEM. Three groups of Irish primary teachers (N=12), each within their own unique school context, took part in the CPD programme over the course of six months. A self-reflection of the researcher, and deliverer of the CPD, on their ongoing professional experience as a teacher educator is reported here in terms of the participating primary teachers' development of STEM Knowledge for Teaching. The findings showed that while teachers participating in the CPD programme enhanced aspects of their STEM Knowledge for Teaching, it was noted that further opportunities to extend and consolidate this learning may be beneficial.

Keywords: STEM Education, Science Capital, Teacher Continuous Professional Development, STEM Knowledge for Teaching

Introduction

STEM Knowledge for Teaching

STEM education has been described as "not simply Science, Technology, Engineering and Maths, but a cross-curricular approach focusing on activities relevant to all four areas" [1]. The purported goal of STEM education is STEM literacy. The concept of STEM literacy relates to the knowledge, skills, and dispositions that are acquired and developed as a result of participating in STEM education [2]. An integrated approach to STEM education enables learners to develop STEM literacy thus building and applying knowledge, deepening their understanding and developing creative and critical thinking skills within authentic contexts [2], [3]. While the concept of STEM literacy generally pertains to pupil learning, in relation to the unique and specific knowledge, skills and dispositions required to teach in and about STEM [2], [3], [4], this project proposes that the concept of STEM Knowledge for Teaching (STEMKT) may be more appropriate. The proposed STEMKT conceptual framework (See Figure 1) has its roots in the foundation concepts of subject matter knowledge and pedagogical content knowledge [5], [6], [7]. Subject matter knowledge is considered to comprise two subdomains [9], [10]:

1. Common content knowledge, which describes general subject content not unique to primary school
2. Specialised content knowledge, which pertains to more sophisticated concepts in each subject. These demand a deeper knowledge of these concepts on the part of teachers in order to effectively enable pupils to develop an understanding of these concepts.

Pedagogical content knowledge comprises the expertise required by a teacher to enable their pupils to develop the requisite concepts and skills pertaining to each subject [7], [8]. This expertise includes knowledge of curricula, knowledge of pupils and knowledge of teaching. The proposed STEMKT framework recognises the complexities of teachers' acquisition of STEM subject matter knowledge and the subsequent translation of this into powerful integrated STEM pedagogical experiences for pupils.

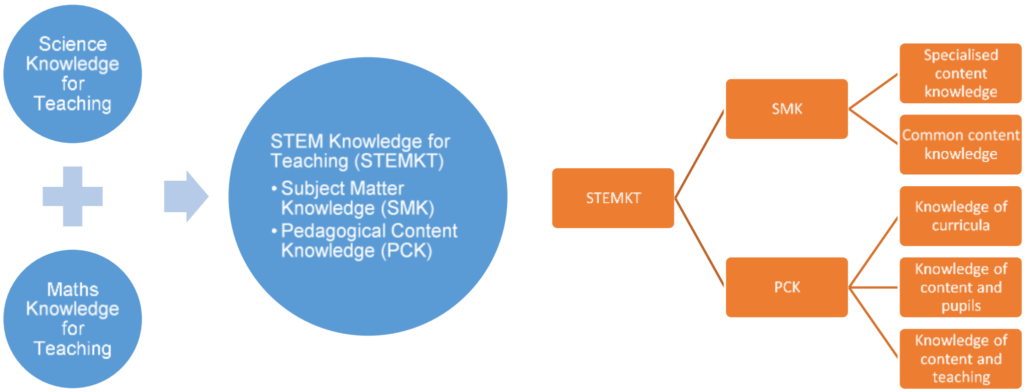


Fig. 1. *Overview of proposed STEMKT conceptual framework*

STEMKT in Irish primary classrooms

Within the current Irish Primary Curriculum, STEM does not exist as a standalone subject. This presents a challenge for generalist primary teachers, who are expected to deliver effective integrated STEM teaching and learning experiences within mathematics and science [3]. Preparations are underway for a redeveloped primary curriculum, which aims to support a more authentic integrated approach to teaching and learning in all subjects, including the STEM disciplines [9], [10]. These proposed curriculum changes risk exacerbating existing difficulties faced by teachers in the enactment of the current primary mathematics and science curricula [11], [12], [13]. It has been suggested that professional development interventions focusing on the development of primary teachers STEMKT may ameliorate to these difficulties [11], [12], [13].

Signature pedagogies

In order to explore primary teachers' development of STEMKT, this project draws on the theoretical framework of signature pedagogies [14]. The continuing professional development (CPD) intervention programme designed by the researcher utilised the signature pedagogies of

1. **1.** Critical dialogue (the process of acquiring knowledge through communicative interactions)
2. **2.** Public sharing of work (testing out practices in classrooms and sharing ideas with larger audiences, for example, a TeachMeet or through the sharing of artefacts)
3. **3.** Communities of learners (collective learning around a shared concern or a passion).

These pedagogies were noted as being particularly effective in the enhancement of teacher practices [14].

Methodology

This project draws from the methodological framework of self-study action research (SSAR) [15] which places its roots within the paradigm of critical theory [16] The SSAR approach involves the researcher engaging in critical reflection, where data is drawn through four lenses [17]:

1. **1.** Autobiographical or the "Self" lens, through the use of a reflective diary
2. **2.** Colleagues' experiences or the "Peer" lens (including ongoing dialogue with a Critical friend)
3. **3.** Theoretical Literature lens (Reflection using literature pertaining to the subject focus, STEM and teacher professional learning in this case)
4. **4.** Learners' eyes lens (the perspective of participating teachers)

Reflection through these lenses allows the researcher to interrogate and critically analyse their practice as a teacher educator, while enhancing rigour through triangulation of data [18].

Data gathering and analysis approach

Convenience sampling was used to recruit three primary schools, with four teachers in each school invited to take part in a CPD intervention programme. A mixed methods approach has been adopted which focuses on qualitative analysis of data. In order to track participants' progress, data was gathered prior to the intervention using an individual anonymised questionnaire instrument. This instrument comprised a combination of likert-style items and open-ended questions, which focused on teachers' perception of their own current STEMKT, current classroom practices and current pupil attainment and experiences in STEM. Further qualitative data is being gathered throughout the intervention using field notes and the researcher's reflective diary. Each school has also been invited to bring visual artefacts (photographs of pupil work samples, lesson plans, teaching resources) with an accompanying rationale for a national shared learning day, where each school will have the opportunity to engage with the other participating schools. Following the CPD intervention, data is to be gathered through semi-structured group interviews with each group of participants within their own school.

Post-intervention, individual questionnaires will be read ministered to ascertain if there has been any perceived enhancement in participants' STEMKT, classroom practice, pupil attainment and experiences as a result of engaging in the CPD intervention.

Professional development intervention programme design

In response to data gathered through the pre-intervention questionnaire instrument, the researcher's reflective diary, in which the researcher documented accounts and reflections based on critical dialogue with each group, three bespoke CPD programmes have been designed. These are being delivered by the researcher over the course of six months. While programmes were designed to address areas of need identified by each group, each programme features the use of signature pedagogies to support teachers' development of STEMKT. All participating schools are taking part in a Lesson Study cycle pertaining to their subject focus. All participating schools have also been invited to attend a national shared learning day, as earlier described. An overview of the programme devised for and delivered to each school is shown in Table 1.

School Name (pseudonyms)	**Subject focus & self-identified priority need**	**CPD approaches used** / **Signature pedagogies**	**Critical dialogue**	**Public sharing of work**	**Communities of learners**
Oakleaf	Mathematics: Inquiry based learning pedagogies to develop pupils' concept of measurement in mathematics	Demonstration lessons	◎		
		Lesson Study	◎	◎	◎
		Group meeting with school leaders	◎		◎
		Shared learning day	◎	◎	◎
Damson	Science: Developing pupils' science skills	Demonstration lessons	◎		
		Lesson Study	◎	◎	◎
		Shared learning day	◎	◎	◎
Figtree	Mathematics: Developing pupils' strategic competence in number calculations	Individual meetings with teachers	◎		
		Lesson Study	◎	◎	◎
		Shared learning day	◎	◎	◎

Table 1. *Overview of STEMKT CPD programme design using signature pedagogies*

Initial findings

Analysis of data from pre-questionnaires suggests that prior to engaging in the CPD programme, participants perceived their STEMKT to be relatively low, with only 40% of all participating teachers reporting having high or very high STEMKT. While each school's curriculum subject focus was on aspects of either mathematics or science, a majority of individual participants identified "opportunities for collaboration with colleagues", "gaining new ideas for innovative teaching and learning approaches" and "Inquiry based learning pedagogies" as priorities.

Initial analysis of data from the researcher's reflective diary and field notes suggests that the participating teachers' STEMKT is showing signs of enhancement. However, further analysis of data following conclusion of the CPD programme will ascertain if this enhancement has been sustained.

Limitations and future work

The relatively small-scale nature of this project, the self-reported nature of data from participants and its focus on the researcher's personal experience mean that findings cannot be generalized. However, this work does offer a tentative and potentially useful framework, STEMKT. This framework, in conjunction with the use of signature pedagogies, may act as potential springboard for the researcher and others to engage in further exploration of effective approaches to developing teacher practices for the benefit of pupils' learning outcomes and experiences in STEM.

REFERENCES

[1] Rosicka, C. "Translating STEM Education Research into Practice", ACER, Retrieved from https://research.acer.edu.au/professional_dev/10/, 2016.
[2] Liston, M. "Unravelling STEM: Beyond the acronym of Science, Technology, Engineering, and Mathematics", Science 53 (3), 2018, pp. 28-29.
[3] Department of Education and Skills (DES). "STEM Education Policy Statement 2017-2026", Retrieved from https://www.education.ie/en/The-Education-System/STEM-Education-Policy/stem-education-policy-statement-2017-2026-.pdf, 2016.
[4] Shulman, L. S. "Those who understand: Knowledge growth in teaching", Educational Researcher, 15(2), 1986, pp. 4-14.
[5] Parker, J. & Heywood, D. "Exploring the relationship between subject matter knowledge and pedagogic content knowledge in primary teachers' learning about forces", International Journal of Science Education, 22(1), 2000, pp. 89-111.
[6] Loughran, J., Mulhall, P., & Berry, A. "Exploring pedagogical content knowledge in science teacher education", International Journal of Science Education, 30(10), 2008, pp. 1301-1320.
[7] Shulman, L.S. "Knowledge and teaching. Foundations of a new reform", Harvard Educational Review, 57(1), 1987, pp. 1-22.
[8] Ball, D. "The mathematical understandings that prospective teachers bring to teacher education", Elementary School Journal, (90), 1990, pp. 449-446.
[9] Bacon, K. "Curriculum integration", Dublin, NCCA, Retrieved from https://www.ncca.ie/media/3499/seminar-two_bacon-paper.pdf, 2018.
[10] National Council for Curriculum and Assessment (NCCA). "Primary Developments: Consultation on Curriculum Structure and Time", NCCA, Retrieved from: https://www.ncca.ie/media/3242/primary-developments_consultaionon-curriculum-structure-and-time_final-report.pdf, 2018.
[11] Dooley, T. "Learning and teaching primary mathematics. An addendum to NCCA research reports 17 and 18". Dublin City University (DCU) Institute of Education. DCU, 2019.
[12] Varley, J., Murphy, C., & Veale, O. "Science in primary schools: Phase 1 final report", Dublin, NCCA, 2008.
[13] Gardner, M. "Understanding integrated STEM science instruction through the experiences of teachers and students", unpublished Ph.D. thesis, Syracuse

University, Retrieved from: https://surface.syr.edu/cgi/viewcontent.cgi?article=1686&context=etd, 2017.
[14] Parker, M., Patton, K. & O'Sullivan, M. "Signature pedagogies in support of teachers' professional learning", Irish Educational Studies, 35(2), 2016, pp. 137-153.
[15] Pithouse, K., Mitchell, C. & Weber, S. "Self-study in teaching and teacher development: A call to action", Educational Action Research, 17(1), 2009, pp. 43-62.
[16] Kemmis, S. "Exploring the relevance of critical theory for action research: Emancipatory action research in the footsteps of Jurgen Habermas", Handbook of action research, (4), 2006, pp. 94-105.
[17] Brookfield, S. D. "Becoming a critically reflective teacher", London, John Wiley & Sons, 2017.
[18] McNiff, J. "Action research: Principles and practice", London, Routledge, 2013.

Hands on or Hands off? A Look into Undergraduate Life Sciences Practical Work

Marina Constantinou[1], Nikolaos Fotou[1]
University of Lincoln, United Kingdom[1]

Abstract

Practical work has been long associated with the effective teaching of sciences and has been deemed as one of the most enjoyable aspects in a science curriculum. The science education literature, however, has mainly focused on practical work in secondary schools whilst the effectiveness and affective value of practical work in tertiary education remain unexplored. Although one of the most expensive parts in science teaching very few studies have reflected on what the reality is in a laboratory classroom in terms of effective learning and any interest and/or motivation in sciences. Taking into consideration that undergraduates at a tertiary institution have chosen to pursue studies life sciences, it can be presumed that practical work, as an integral part of their degree, is something that triggers their intrinsic interest and motivation. The present paper reports on a case study currently being conducted at a British university to examine the effectiveness of practical work in promoting conceptual understanding in sciences and its affective value. Preliminary findings suggest that…

Keywords: Practical work in tertiary education, Undergraduate practical work, Practical work in life sciences, Practical work

1. Introduction

Working in the laboratory and doing practical work has been long associated with the teaching of Biology both in secondary and tertiary education with academic staff unquestionably appreciating it as part of a university's curriculum. Whilst a considerable amount of the science education literature has identified the purpose of practical work and its pedagogical effectiveness in secondary education [1], [2], there has been limited research in tertiary education. These have been unable to present a realistic representation of a science lesson in the laboratory in terms of conceptual understanding and feelings towards the activity [3] but instead they have been presenting a rhetoric solely formed by subjective opinions rather than factual empirical knowledge on what the purpose and the specific aims of practical work should be. Provided that, as an activity, is deemed as one of the costliest and time consuming aspects of science teaching, its advantageousness over alternative, and perhaps more traditional, methods of teaching [4] should be supported by evidence, especially when there are descending voices as per its effectiveness in promoting conceptual understanding [5].

With regards to the affective value of practical work, it would have been expected that the choice of undergraduates to pursue studies in a science-related degree would triggers their intrinsic interest and motivation for practical work which, as already outlined, is in an integral part of such studies. Although there are studies that have looked at the affective value practical work can have on chemistry undergraduates [6] there has been no research looking at the motivation and intrinsic interest in such practical work activities in biology.

The present paper presents preliminary findings of a study which focuses on the effectiveness and affective value of practical work in tertiary biology education. The study is guided, amongst others, by the following two research questions:

1. Is practical work effective in helping students build conceptual understanding in life sciences?
2. Does life sciences' practical work have an affective value?

2. Methodology

This is an in-depth case study that is being undertaken at a British university in England in the school of Life Sciences. The study adopts a mixed methods approach in which both quantitative and qualitative data are collected so as to ascertain the effectiveness of practical work in terms of conceptual understanding and its affective value for life sciences undergraduates. The sampling of the study was opportunistic with students and academic staff from all eight programmes of the school recruited. All academic staff involved in teaching practical work was interviewed and administered a questionnaire on practical work and its effectiveness in promoting conceptual understanding. This approach was adopted with the intention not to approach the effectiveness of practical work in general terms but in terms of how effective a task is relatively to the aims of the academic who designs and delivers the practical work session. Their responses in both the interviews and questionnaires were compared with observations of what the reality of practical work in the laboratory was. A representative sample of Year 1 and Year 2 undergraduate students was also asked to complete a questionnaire on the affective value practical work might have and took part in interviews during the observations in order to assess their conceptual understanding of the practical work they were undertaking.

For the analysis of the data, a framework which examines the effectiveness of practical work in terms of the intention and objectives of the academic staff delivering the practical work session and those achieved by the students is adopted [7]. The framework is presented in Figure 1 below with the present study examining effectiveness in level one and two.

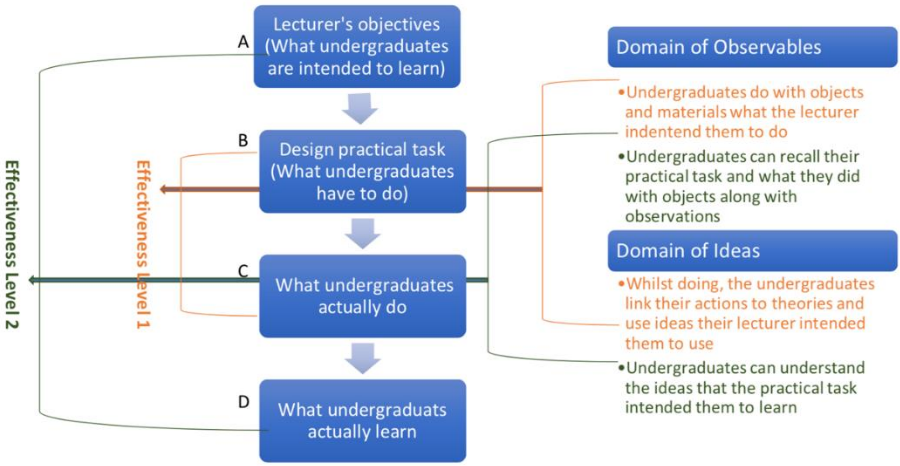


Fig. 1. *Theoretical model for the effectiveness of practical work. Adaptation from Millar et al., (1999) and Tiberghien (2000)*

3. Preliminary Study Findings

The preliminary findings reported here only include observation data from six different practical work lessons with Year 1 and Year 2 undergraduates. The two different types of classes emerged are as follows:

Type A practical work sessions	Type B practical work sessions
Students were not given any instruction in the beginning of the lesson and they were asked to read the protocol and draw possible conclusions	The lecturer started the session by discussing the main theories and ideas behind the experiment, the main objectives and what the undergraduates were expected to observe along with explanations of these observations.

Table 1. *Two types of instruction (A, B) during practical work sessions*

From the observations in the laboratory and interviews with the students, it was also found that in Type A practical work sessions, students were mainly focusing on the domain of objects and observables – hands-on learning – than the domain of ideas – minds-on learning. Although there were some students who could recall some background theory of the experiment they were conducting, they were unable to relate it to their observations when questioned. They were even unable to make that connection when being prompted by the academic staff or the interviewer. This was only achieved when the academic staff was helping them in explicitly relating that theory to what they were doing.

- Researcher: How was DNA amplified? Why do we have more DNA strands now?
- Student: No idea, I just read the protocol. Let me ask the demonstrator.
- Researcher: Let us think about this together. What Polymerase Chain Reaction does? Why do we heat the DNA?
- Student: We do PCR to make ‘more’ DNA. Heat ‘destroys’ it and then makes ‘more’ of it.
- Researcher: In a sense, yes. It denatures DNA, to separate it into two pieces of single-strands so that it can get synthesized by an enzyme later.
- Student: Oh, I do not know. The machine does it anyway.

In contrast to Type A practical work sessions, in Type B the lecturer introduced the main theories behind the experiment and the ideas students should use to link what they were about to observe. In this case, undergraduates actively engaged with their observations using the ideas that they were presented whilst their learning in the practical work being both minds and hands-on. It was in this type of sessions that students were able to make use of the theories, or part thereof, in order to explain practical work and develop conceptual understanding through it. The interview exchange from a similar with the above example practical work session further attests to this:

- Researcher: Why do we have cold and hot phases in PCR? What is the machine doing now?
- Student: It has to support transcription. At first the DNA is broken down into two pieces while denaturing, I think. Isn’t this the word Dr A used? Then when the temperature is cold it allows primers to stick and help in making a new DNA.

For the majority of academic staff questioned, practical work was deemed as very important for students in helping them develop those skills needed for a career in science. Their belief was that practical work contributes towards students' conceptual understanding and that it has a strong affective value to those who want to pursue such a career. The responses of two of the lecturers below serve as examples:

- Lecturer 1: Practical work motivates students because we are giving them sufficient training in practical work that can be applied in the industry and clinical sector later. That is why they are studying sciences.
- Lecturer 2: Practical work motivates students who already have an idea of what they want to do in the future so they take advantage of the practical sessions we offer.

Similar was the response of students who believed that practical work helps them understand the theory and develop conceptual understanding by linking the domain of the ideas with that of observables and objects. They also claimed that doing practical work is an experience they can draw on at any point in order link they observations with some relevant theory while their responses as per its affective value were mixed. Many students replied in a way similar to this:

Student: We see things and this helps reinforcing the theory. Theory makes sense when you see and do things on your own in the laboratory. It becomes more familiar.

Even if we do not learn things in detail now or sometimes do not know what we are doing, we will go home and we will recall what we saw in the lab and make sense of what we learned later.

4. Discussion

The preliminary findings show that while practical work in the life sciences laboratory offers important opportunities for students to link concepts and theories with their observations, thus working with both their minds and hands-on, Type B sessions were found to be more effective. Instead of being helped only to observe what the academic staff wants them to observe as in Type A, it is equally important to be helped to think about these observations and link them with the theory in a particular way.

REFERENCES

[1] Watts, A. "The assessment of practical science: A literature review", Cambridge. UK, Cambridge Assessment, 2013.

[2] Johnstone, A., & Al-Shuaili, A. "Learning in the laboratory; some thoughts from the literature". University Chemistry Education 5(2), 2001, pp. 42-51.

[3] Martindill, D., & Wilson, E. "Rhetoric or reality? A case study into how, if at all, practical work supports learning in the classroom", International Journal for Lesson and Learning Studies, 4(1), 2015, pp. 39-55.

[4] Reid, N., & Shah, I. "The role of laboratory work in university chemistry", Chemistry Education Research and Practice, 8(2), 2007, pp. 172-185.

[5] Abrahams, I. "Practical work in secondary science: A minds-on approach", London, UK Continuum International Publishing Group, 2011.

[6] Galloway, K. R., Malakpa, Z., & Bretz, S. L. Investigating affective experiences in the undergraduate chemistry laboratory: Students' perceptions of control and responsibility. Journal of Chemical Education, 93(2), 2016, pp. 227-238.

[7] Brownell, S. E., Kloser, M. J., Fukami, T., & Shavelson, R. "Undergraduate biology lab courses: Comparing the impact of traditionally based" cookbook "and

authentic research-based courses on student lab experiences", Journal of College Science Teaching, 41(4), 2012, pp. 36-45.
[8] Millar, R., Le Maréchal, J.-F., & Tiberghien, A. "'Mapping' the domain: Varieties of practical work", In J. Leach & A. Paulsen (Eds.), Practical work in science Education-Recent research studies, Roskilde/Dordrecht, The Netherlands: Roskilde University Press/Kluwer, 1999, pp. 33-59.
[9] Abrahams, I., & Millar, R. "Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science", International Journal of Science Education, 30(14), 2008, pp. 1945-1969.
[10] Tiberghien, A., Veillard, L., Le Maréchal, J. F., Buty, C., & Millar, R. "An analysis of lab work tasks used in science teaching at upper secondary school and university levels in several European countries", Science Education, 85(5), 2001, pp. 483-508.

Implementation of Workshops to Improve the Didactics of Technology in Teacher Training

Guadalupe Martínez-Borreguero[1], Milagros Mateos-Núñez[2], Francisco Luis Naranjo-Correa[3]
University of Extremadura, Department of Didactics of Experimental Sciences, Spain[1,2,3]

Abstract

Numerous studies have shown that teachers in training do not feel competent and show insecurity in teaching scientific-technological subjects to their students [1]. Considering that the STEM (Science, Technology, Engineering and Mathematics) literacy of the future teacher needs to be improved, several experts consider that university education should consider teaching based on inquiry and research methods in order to prepare the teacher as a designer of meaningful and student-centred learning experiences [2]. The aim of this research is to improve the didactics of STEM areas in teachers in training through the implementation of projects applied to the secondary and primary classroom. To this end, a quasi-experimental methodology has been followed. The sampling process carried out has been non probabilistic for convenience due to the easy access to the participating students. The sample collected was made up of 290 teachers in training, both at the primary and secondary levels, aged between 21 and 40. Two questionnaires were designed as measuring instruments based on previous research and implemented as pre-test and post-test in order to assess before and after the elaboration of the STEM workshops variables related to the cognitive domain and variables related to the affective domain and to teaching self-efficacy. The results obtained in the pre-test reveal a low frequency of positive emotions in STEM areas and very low initial levels of knowledge and competence. On the contrary, the results extracted from the post-test show a significant positive evolution (Sig. <0.05) in the participating students during the realization of these experiences, both from a didactic, competence and emotional point of view. On the other hand, the analysis of the different perceptions of the teacher in training reveals the need to carry out this type of experience in schools of different stages. Finally, it is concluded that the use of didactic strategies that use an integrated STEM approach can lead teachers in training towards positive attitudes regarding learning and scientific-technological teaching, as well as improving professional development and the quality of teaching in future actions [3].

Keywords: Teachers in training, STEM literacy, Workshops, Secondary education

1. Introduction

As several authors have pointed out, in recent decades the importance of science in everyday life and the concern of citizens for its social and technological consequences have been increasing. That is why in all science curricula of recent years, one of the purposes to which the teaching-learning process of science is oriented is to promote scientific literacy to all students, that is, to encourage adequate scientific and technological training [1].

Despite the efforts that have been made for decades to achieve a scientifically literate society, evidence shows that the situation is quite precarious and has significant shortcomings. Although teachers are the agents of curriculum change in science education, numerous studies show that primary school teachers have poor levels of competence in STEM (Science, Technology, Engineering and Mathematics) areas [2].

Specifically, studies from [3] have indicated that teachers in training show inadequate self-efficacy in class management and use of teaching strategies when teaching science and technology-related subjects, and that this influences the commitment and vocation of teachers. In this sense, it should be noted that teachers with low self-efficacy in class management may have difficulties in regulating stress in the classroom and are more likely to leave the profession [4]. Conversely, when teachers-in-training have higher levels of self-efficacy, they more often use effective teaching behaviours, leading to higher motivation of their students and higher levels of academic performance [5].

Although self-efficacy is enhanced through successful experiences, several studies indicate that the current reform of science education requires more than just a change in classroom practice [6]. From the perspective of content knowledge, teachers must master content on physical-natural systems, as well as understand basic scientific processes, and have pedagogical design skills in the area of science to facilitate student learning [7].

Taking into account this context, the present research has focused on the promotion of STEM competences of teachers in training, with the aim of strengthening the scientific, didactic and emotional component of this group in the teaching and learning processes.

2. Methodology

A quasi-experimental design has been followed. The aim of this research is to improve the didactics of STEM areas in teachers in training through the implementation of projects applied to the secondary and primary classroom.

The participating sample was selected by non-probability convenience sampling because of the ease of access. Specifically, 290 teachers in training, both at the primary and secondary level, participated.

A pre-test and a post-test were designed to measure variables related to the cognitive domain, to the affective domain and to the didactic training of this group. The opinions of those surveyed were also assessed in terms of the didactic effectiveness of the STEM workshops designed and implemented in the classroom.

Between the pre-test and the post-test, the participants, organized in groups of 4, had to design and develop a STEM workshop to promote scientific literacy and STEM vocations in the students. Each group had a working guide where the minimum criteria for the design of the workshop were specified. Likewise, the materials with which the STEM project was to be built had to be easily acquired, in order to facilitate their reproduction in the classroom of the different schools and to take into account the corresponding educational curriculum.

Eventually, the experience has led to more than 70 STEM workshops that could be implemented in the classroom from the age of 11 to 14.

3. Results

The analysis of the data extracted in the evaluation instruments has allowed us to contrast the evolution of the different variables (cognitive, effective and didactic) in the participating subjects. The results obtained in the pre-test determined that the future primary school teacher began with very low initial levels of knowledge since the average score obtained by this group in relation to the cognitive variable was 2.69 points out of 10, with a standard deviation of 1.01. They also had low levels of teacher self-efficacy, related to the low levels of knowledge shown. Specifically, about 80% feel either “Not at all competent” or “Not very competent” in items such as *“I3: Give a class on simple and compound machines with homemade materials”*, *“I4 Build some simple structure that fulfils a function or condition to solve a problem from modular parts”*.

With regard to the emotions initially expressed by this group towards the STEM areas, it should be noted that negative emotions such as Insecurity, Boredom, Stress, Anxiety or Worry took precedence. Likewise, they expressed very low frequency of positive emotions such as Joy, Confidence, Fun, Interest or Tranquillity towards STEM subjects.

These unfavourable results may be due to the fact that the great majority of this group, more than 80%, come from humanities and/or social science studies, and very few have had higher scientific training, as they did not like these subjects.

On the other hand, the future secondary school teachers in training initially presented high levels of knowledge in STEM areas and medium levels of teacher self-efficacy when faced with the teaching of these contents in the classroom, finding statistically significant differences (Sig. <0.05) in these variables with respect to the future primary school teachers. Likewise, this group showed initial positive emotions and attitudes towards these areas. These results may be related to the previous training received by future secondary school teachers, closely related to science and/or technology, with their degrees coming from the branches of engineering or architecture.

With regard to the results obtained in the post-test carried out after the STEM Workshops, it should be noted that the group of primary school teachers in training showed a positive evolution in relation to the emotional variable. Specifically, the STEM workshops produced in this group a significant increase (Sig. <0.05) in positive emotions and a significant decrease (Sig. <0.05) in negative emotions previously experienced.

On the other hand, the participants’ opinion was evaluated with respect to the usefulness of the STEM workshops carried out to improve their levels of teaching self-efficacy using a Likert scale that went from 1 (Not useful at all) to 5 (Totally useful).

With regard to the usefulness of the STEM workshops carried out to improve the learning of primary students in STEM areas, 71.2% of the participating sample catalogued them as very useful. In reference to the assessment they made regarding the usefulness of the STEM workshops to improve their learning as teachers in STEM areas, it should be noted that 58.4% considered them very useful and 29.7% totally useful. Likewise, with regard to the usefulness of the STEM workshops carried out to improve their didactic training in STEM areas, 60.9% valued them as very useful and 39.1% as totally useful.

Figure 1 shows some of the reflections of the teachers-in-training in the work diaries during the STEM workshops.

The realization of these workshops has helped us to see the usefulness of the interdisciplinary nature of the contents. We believe that this type of project helps us to improve the teaching of these contents in the classroom. **Student 22**	*The experience has attracted our attention and we liked it. Thanks to it we have lost the fear of teaching science, which until now was a theoretical subject that produced many negative emotions that in turn limited our own learning.* **Student 39**
We, as future educators, need to be competent in this type of experience because it helps us to assimilate necessary concepts that we can transmit with greater enthusiasm to our students. In fact, if we do not assimilate them ourselves, we will not be able to transmit them correctly. **Student 6**	

Fig. 1. *Metacognitive reflections after the STEM workshops*

4. Conclusions

The results obtained reveal the need to develop practical interdisciplinary experiences that allow STEM skills to be worked on at all levels of the education system, including in the training of future teachers, in order to improve cognitive and emotional domain [8]. The data show that the main difficulty that teachers have in implementing active learning strategies is the lack of good knowledge of the subject. In this regard, we agree with [9] that many primary school teachers lack sufficient knowledge to teach science, so they resort to simple transmission, with which they feel more comfortable, and avoid inquiry strategies, which require a deeper understanding.

In light of the above, it is concluded that future teachers need to acquire adequate scientific and technological literacy in order to foster experiential, contextual, meaningful and exciting learning in their students, thus avoiding attitudinal decline towards these subjects and alleviating the lack of STEM vocations from the early school stages [10]. If teachers in training gain confidence and show positive attitudes, they will teach science better and be able to improve the quality of teaching [11]. However, for this to happen, it will be essential to include recreational experiences in educational programs because they improve the teaching and learning of STEM areas, foster meaningful and contextualized learning and also produce a consolidation of teaching self-efficacy [12].

In this line, we agree with [13] that the integration of scientific and technological areas can promote students and teachers to have unique, memorable and motivating learning experiences in environments that extend far beyond the classroom.

Acknowledgements

Grant GR18004 and Research Projects IB16068 (Junta de Extremadura/Fondo Europeo de Desarrollo Regional) & EDU2016-77007-R (Agencia Estatal de Investigación/Fondo Europeo de Desarrollo Regional).

REFERENCES

[1] Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walwerg-Henriksson, H. y Hemmo, V. "Science Education Now: A Renewed Pedagogy for the Future of Europe", Belgium: European Commission Community Research, 2007.
[2] van Aalderen-Smeets, S. I., Walma van der Molen, J. H., & Asma, L. J. "Primary teachers' attitudes toward science: A new theoretical framework", Science education, 2012, pp. 158-182.
[3] Klassen, R. M., & Chiu, M. M. "The occupational commitment and intention to quit of practicing and pre-service teachers: Influence of self-efficacy, job stress, and teaching context", Contemporary Educational Psychology, 2011, pp. 114-129.
[4] Jepson, E., & Forrest, S. "Individual contributory factors in teacher stress: The role of achievement striving and occupational commitment", British Journal of Educational Psychology, 2006, pp.183-197.
[5] Caprara, G. B., Barbaranelli, C., Steca, P., & Malone, P. S. "Teachers' selfefficacy beliefs as determinants of job satisfaction and students' academic achievement: A study at the school level", Journal of School Psychology, 2006, pp. 473-490.
[6] Levitt, K. E. "An analysis of elementary teachers' beliefs regarding the teaching and learning of science. Science Education, 2001, pp. 1-22.
[7] Alake-Tuenter, E., Biemans, H., Tobi, H., Wals, A., Oosterheert, I., y Mulder, M. "Inquiry based science education competencies of primary school teachers: A literature study and critical review of the American National Science Education Standards", International Journal of Science Education, 2012, pp. 2609-2640.
[8] G. Martínez, M. Mateos, & F.L. Naranjo, "Implementation and Didactic Validation of STEM Experiences in Primary Education: Analysis of the Cognitive and Affective Dimension" in Theorizing STEM Education in the 21st Century, 2019.
[9] Vilches, A., & Gil, D. "La necesaria renovación de la formación del profesorado para una educación cientifica de calidad", Tecné Episteme y Didaxis, 2007.
[10] Sanders, M. "STEM, STEM education, STEM mania," Technology Teacher, 2009, pp. 20-26.
[11] Osborne, J. y Dillon, J. "Science education in Europe: Critical reflections", London: The Nuffield Foundation, 2008.
[12] Martínez, G., Naranjo, F. L., Mateos, M. y Sánchez, J. "Recreational Experiences for Teaching Basic Scientific Concepts in Primary Education: The Case of Density and Pressure", EURASIA Journal of Mathematics, Science and Technology Education, 2018, pp. 1-16.
[13] Duran, E., Ballone-Duran, L., Haney, J., & Beltyukova, S. "The impact of a professional development program integrating informal science education on early childhood teachers' self-efficacy and beliefs about inquiry-based science teaching", Journal of elementary science education, 2009, pp. 53-70.

Specialty High Schools to Support STEM Teaching and Learning

Michael R.L. Odell[1], Teresa J. Kennedy[2]
University of Texas at Tyler, United States of America[1,2]

Abstract

In the report, Rising Above the Gathering Storm, a number of policy recommendations were outlined to increase U.S. competitiveness in the 21st century economy. One of the most interesting recommendations was the call to states to develop state-wide specialty STEM high schools (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2007, p. 6). Specialty high schools as described in the report would focus on preparing students in STEM disciplines, including the sciences. In addition to focusing on science for students, these schools could support the next generation of science teachers by providing a training venue for inquiry-based pedagogies needed to support more effective STEM teaching and learning. Project-/Problem-Based Learning (PBL) are pedagogies that provide effective teaching strategies to support science education reform initiatives when implemented with fidelity. In 2010, the state of Texas in the United States authorized the creation of STEM Academies. STEM Academies are specialty high schools similar to those described in Rising above the Gathering Storm. In an effort to improve STEM teaching and learning, it was recommended that the primary instructional strategies of the academies would be Problem- and Project-Based Learning. In the science context, PBL is well suited as a primary pedagogy for learning. PBL aligns well with the process of scientific inquiry. This research paper examines the role of PBL in supporting students in the science classroom in the context of STEM focused academies, including the results of a 7-year longitudinal study that examined student achievement as measured by state accountability exams.

Keywords: Problem-Based Learning, Project-Based Learning, fidelity, STEM, Evaluation

1. Introduction

In 2011, the University of Texas at Tyler developed the University Academy, a STEM Lab School district in response to concerns about the future competiveness of American students in the STEM disciplines. The academies would implement inquiry-based pedagogies as the primary instructional strategies to be utilized by teachers. Inquiry-based pedagogies are recommended as model pedagogical approaches for the teaching of Science, Technology, Engineering, and Mathematics (STEM). There is significant support for teaching science through inquiry in the research literature [1]. Inquiry approaches are also frequently cited in the research literature as a way to develop 21st century skills that are needed to be successful in the STEM workforce [2]. Initially, the academies experienced a number of challenges in implementing an inquiry-based school model. As a result, scores on state accountability tests were not at the desired level. As a result, the academy district implemented the Texas STEM Academy Blueprint Model funded by the Texas Education Agency to guide the school design for the future [3]. The blueprint aligns well to recommendations made in the report, Rising Above the

Gathering Storm (RAGS). One of the recommendations in the report was to create “specialty” STEM focused high schools as a strategy to improve STEM teaching and learning and increase the number of high school graduates entering STEM majors in higher education and the STEM workforce [4]. The opening of the new STEM academy district provided an opportunity to conduct longitudinal research on the implementation of the T-STEM Blueprint in an authentic setting from creation to present day and examine science achievement over time in a school designed specifically to address STEM though inquiry. It should be noted that the STEM Academy district is open enrolment and free of charge. Any student may enrol. There are no admission tests or requirements other than students must live in the attendance zone.

1.2 The Texas STEM Academy Blueprint

The Texas STEM Academy Blueprint was developed to guide school district in designing and opening new schools as STEM Academies or redesign existing schools to become STEM Academies. Academies use the blueprint to create schools that address seven benchmarks. The benchmarks include:

1. Mission driven leadership;
2. School culture and design;
3. Student outreach, recruitment, and retention;
4. Teacher selection, development, and retention;
5. Curriculum, instruction, and assessment;
6. Strategic Alliances; and
7. Advancement and sustainability.

For the purposes of this study, the researchers focused their attention to Benchmark 5: Curriculum, Instruction and Assessment. Benchmark 5 guides the development of the curriculum including teaching strategies and assessment requirements. Table 1, provides an outline of Benchmark 5 requirements.

Table 1. *Benchmark 5: Curriculum, Instruction and Assessment*

5.1	Rigor: Aligned Curriculum & Assessment, Endorsement, 12-30 college credits.
5.2	STEM-focused Curriculum: STEM electives, PBL, STEM Extracurricular, Portfolios, Internship/Capstone
5.3	Instructional Practices: Data-driven, PBL, Student choice/voice
5.4	STEM Education Integration: Innovate, Invent, STEM literacy, Technology
5.5	Literacy: 21st Century Skills, Read, Write, Speak, Present, STEM Vocabulary
5.6	Assessment: Standards, Diagnostic, Summative, Performance-based, Tracks

To meet the requirements of each sub-benchmark, the school implemented common planning times for all core teachers. As a result, all science teachers met daily as a team as part of a Professional Learning Community and were provided time during the school day to collaborate and design a curriculum that met the benchmark [5], [6]. Teacher were also trained in problem- and project-based learning to assure a common instructional approach. This is ongoing process.

2. Research Methodology

The research was conducted as part of a mixed-methods evaluation [8] that has been ongoing since the academy opened. The primary intervention that was examined was the introduction of problem- and project-based learning as the primary instructional strategy for the academy. The researchers utilized student achievement results in science as measured by the state accountability exam as the measure of impact.

Accountability exams are given to all public schools in the spring of each year. In addition to examining science achievement data, the researchers also utilized the T-STEM Blueprint Rubric to examine implementation fidelity for meeting Benchmark 5. The academy is rated annually on blueprint implementation. Each benchmark is given one of the following ratings based upon evidence that the academy provides to the evaluators.

Ratings include:

- Developing (D)
- Implementing (I)
- Mature (M)
- Role Model (R)

The goal is to become a Role Model academy over time.

3. Results

Table 2 shows the impact of pre- and post-intervention on science achievement and provides district and state average scores.

Table 2. *State assessment scores pre-and post-intervention*

Year	2013	2014	2015	2016	2017	2018	2019
Pre/Post	Pre	Pre	Post	Post	Post	Post	Post
District	54	67	78	88	85	88	93
State	79	78	78	80	79	76	81

Science scores on state accountability tests have improved annually since the implementation of the blueprint and the inquiry-based instructional strategies. Science achievement continues to be higher than the state average.

Table 3 shows fidelity to the blueprint over time as rated using the T-STEM Blueprint Rubric. This study focused on Benchmark 5: curriculum, instruction, and assessment.

Prior to the intervention, ratings defaulted to "Developing".

Table 3. *Benchmark 5 Rating over Time*

Indicator	2013	2014	2015	2016	2017	2018	2019
Pre/Post	Pre	Pre	Post	Post	Post	Post	Post
5.1	D	D	I	M	M	R	R
5.2	D	D	I	M	R	R	R
5.3	D	D	I	I	M	M	R
5.4	D	D	I	I	I	M	M
5.5	D	D	I	I	M	M	R
5.6	D	D	I	M	R	R	R

Note: D =Developing; I = Implementing; M = Mature; R = Role Model.

4. Conclusions

Tables 2 and 3 in the previous section show continuous improvement. These data suggest that implementing Benchmark 5 with fidelity is correlated to increased science achievement as measured by the state accountability exam in science. These data provide evidence that the implementation of problem- and project-based instruction as outlined in the Blueprint may be an effective strategy for improving science teaching and learning.

REFERENCES

[1] Bransford, J., Brown, A. L., Cocking, R. R., & U.S. National Research Council. (1999). How people learn: Brain, mind, experience, and school. Washington, DC: National Academy Press.
[2] Bybee, R. W., & Fuchs, B. (2006). Preparing the 21st century workforce: A new reform in science and technology education. Journal of Research in Science Teaching, 43(4), pp. 349-352. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/tea.20147/epdf
[3] Educate Texas. (2015). T-STEM academy design blueprint. Retrieved from http://www.ndisd.net/hs/2015-blueprint.pdf
[4] National Academy of Sciences, National Academy of Engineering, & Institute of Medicine. (2007). Washington, DC: The National Academic Press.
[5] National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: National Academies Press.
[6] National Science Teachers Association. (2011). Quality science education and 21st century skills.
[7] Odell, M.R.L. and Kennedy, T.J. (2019). The Impact of PBL as a STEM School Reform Model. Interdisciplinary Journal of Problem-Based Learning, 13 (2). www.ijpbl.org (ISSN 1541-5015).
[8] U.S. Department of Education, Office of Elementary and Secondary Education, & School Support and Rural Programs. (2014). Evaluation matters: Getting the information you need from your evaluation, Washington, DC.

Training of Science Teachers

Active Learning of Plants Biology – Report on an Effort to Educate Science Teachers in Brazil

Diego Tavares Vasques[1], Suzana Ursi[2]
The University of Tokyo, Department of Arts and Sciences, Japan[1]
University of São Paulo, Department of Botany, Brazil[2]

Abstract

There is no question that plants are an important part of ecosystems. Knowledge on the more than 300,000 species of Embryophytes known today is available through different sources and scopes, as systematics, taxonomy, morphology and ecology. However, studies point to the lack of enough contextualization and engagement of students in basic education when exposed to plants biology subjects at school. Reasons are many, going from motivational factors on the students' side, to lack of preparation of instructors to teach about plants, a phenomenon referred by many authors as "plant blindness". This paper will describe an effort to educate Brazilian Biology educators towards more effective ways to teach plants biology. Between 2017 and 2019, we held workshops and activities with teachers and grad students at the University of Sao Paulo (Brazil). These workshops focused on describing systematic ways of organizing classes and activities on topics related to plants biology. Based on this experience, we report the planning of project-based classes on topics like plants life cycle, plants anatomy and physiology and plants evolution and taxonomy systematics. Activities developed during the workshops, as well the responses from the teachers taking the discipline will be discussed, and with this we present a paper providing examples on how to tackle "plant blindness" and achieve more effective outcomes when teaching plants biology.

Keywords: Plant Science, Active Learning, Science Education, Teachers' Training, Basic Education

1. Background

The LDB law from 1996 [1] had an important impact on national curriculum development in Brazil, acting as a scaffold for many other actions. The BNCC (National Curricular Common Base) was one of these actions, guiding teachers and school administrators on what and how to teach [2]. For the Science curriculum in particular, the thematic unities are suggested for each of the nine years of the basic education, and three years of high school. Although the BNCC is successful in suggesting abilities and competences that must be fostered during the school life, it does not bring many concrete examples of activities that can be used in class to reach these goals.

This can be a potential problem when the contents being taught are of difficult engagement. Within natural sciences, plants sciences classes are frequently reported as a difficult and less engaging topic, both by students and teachers [3], [4]. The main challenges teachers face when designing botany classes include plant blindness [5] and *zoocentrism* [6], difficulties in engaging an evolutionary context to the teaching approach and lack of access methods and activities designed for an effective teaching and learning [7]. This paper describes an effort to educate Brazilian Biology educators towards more effective ways to teach plants biology, hoping to cover the lack of access to teaching methodologies reported in the literature.

2. The Workshop

2.1 Workshop organization and implementation

The workshop was held at the University of São Paulo (Brazil), in August 2017. The discussions were recorded with consent of the participants and transcribed through 2018. Fourteen students from the department and teachers working at public schools in São Paulo joined the discussions. Prior to the beginning of the workshop, participants were inquired about their expectations through Google Forms. Also, participants were asked to suggest one topic in Plants Biology they would like to develop into a class activity. The workshop was 4 hours long, and divided in two main parts: a lecture and discussion on Active Learning and classes design methods; followed by a group activity applying the concepts discussed on the first half of the workshop.

On the first half of the workshop, participants were exposed to the concept of Active Learning and some studies discussing the effectiveness of the methods. After this, a system for designing classes was introduced, and participants were informed that they would follow this system on the second half of the workshop. The system provided to participants suggested: (1) deciding a theme or topic accordingly to the time and resources limit; (2) listing goals for the activity to be designed; (3) stablishing the required skills for the effectiveness of the activity (including cognitive, practical and attitudinal skills); (4) setting the expected outcomes of the activity; and (5) planning the materials, methods and chronogram for the activity. Finally, participants were exposed to four examples of activities designed using the five steps described before. Participants were, then, divided in groups for the second part of the workshop.

2.2 Activities design

On the second half of the day, participants were divided in three groups and asked to design an activity on a common topic: plants life cycle. To support the activities design and to facilitate the implementation of the methods exposed on the first part of the workshop, participants received a framework with the five design steps explained above, and a supplementary table with a series of suggested active learning methods (Table 1).

The supplementary table included methods organized by (1) name, (2) time for implementation, (3) target group size, (4) goals, and (5) a brief description of the method.

The methods included in table 1 were adapted from the "+15 minutes" booklet [8].

The requirement was for participants to implement at least one of the methods described on table 1.

2.3 Feedback

Participants worksheets, including the activities developed during the workshop, were shared and discussed between groups at the end of the day. Finally, the worksheets were collected and compared to the initial expectations reported in the pre-workshop questionnaire. Transcriptions of the discussions, the pre-workshop questionnaire answers and the two final worksheets were used for discussion in the following section.

3. Outcomes

3.1 Pre-workshop questionnaire

When inquired about the expectations towards the workshop, participants replied with both conceptual and practical reasons. The most common answers (9 respondents) showed intentions towards the praxis: i.e., intentions to "learn new methods", to "learn how to plan active learning classes", and to "learn how to apply AL methods to classes".

Additionally, half of the entries (i.e., 7 respondents) mentioned an intention to learn about the concept of active learning, and only 3 respondents (2 PhD students, and 1 undergrad student) showed an academic interest on the research supporting these strategies.

The second question of the pre-workshop questionnaire asked participants to suggest one topic in Plants Biology that they would like to use as a basis for the development of a class activity. Within the obtained answers, "Evolution and Plants Diversity" was the most common topic, present in 8 of the responses. "Ecology of plants" (2 entries), "plants reproduction" (1 entry) and "plants cytology" (1 entry) were also responses obtained. This evidences a need within the participants for an approach based on critical thinking and process skills that can be used to explain concepts in Botany [9].

3.2 Work sheets

3.2.1 Group 1: Mosses (and allies) life cycles

School year: 5th-9th grades, basic education.

Goals: To learn the concepts of spores and gametophytes; to learn how to formulate hypotheses; and to develop skills for abstraction through reading of visual models of the life cycle.

Chosen Methods: Buzz-groups, Snowball.

Methodology: Students are exposed to images of life cycles in plants, without any labels describing the different generations and structures observed. In groups of five, students are given 15 minutes to think on a description of the figure ("Buzz-groups" method). After this, the instructor brings "trigger questions" to guide students' descriptions ("Snowball" method). Groups receive 10 minutes to discuss on the trigger questions, and then additional 15 minutes to label the life cycle figure with concepts provided by the teacher. In the final 10 minutes, each group gives a small presentation on the completed life cycle figure.

Table 1. *Model table provided for the activity design. The original table (in Portuguese) also included a description of each method. Participants were asked to refer to this table and use at least one of the suggested methods in their original activities*

Method	*Time*	*Target*	*Goals*
Think-pair-share	5-20 min	Pairs	▪ To discuss and fix concepts ▪ Projects ▪ Problem solving
Buzz groups	5-20 min	Groups	
Snowball	10+min	Groups → whole class	▪ Projects ▪ Problem solving ▪ Development of complex ideas
Corner exercise	20 min	Pairs or groups	
Peer-Review	15-30 min	2-3 students	▪ Revision ▪ Development of academic skills
Mutual-class method	20-40 min	Pairs	▪ Discuss and fix concepts ▪ Challenges

Minutes paper Revision table Worksheet	5-15 min 5-15 min 5+min	1-2 students 1-2 students 1-2 students	▪ Feedback activities
Brainstorming	10-20 min	1-2 students	▪ To apply concepts ▪ Develop academic skills
Word webs	20-30 min	Groups	▪ To review/Fix concepts ▪ To connect concepts
Jigsaw	30+min	Groups → whole class	▪ To solve questions ▪ Hypothesis design ▪ Teaching skills development
Case study	30+min	Pairs → groups	▪ To solve questions ▪ Development of academic skills ▪ To recognize/understand concepts
Problem Based Learning	1 hour	Groups	▪ Development of academic skills ▪ To recognize/understand concepts ▪ Hypothesis design ▪ Research project
Poster section	30+min	Free	▪ Communication skills ▪ Discussion skills

3.2.2 Group 2: Embryophytes life cycle

School year: 1-year University.

Goals: To discuss evolutionary trends in embryophytes' life cycles; to make evident the diplobiont condition of embryophytes' life cycle; to understand and interpret visual representations of life cycles.

Chosen Methods: Word Webs, Jigsaw or Corner Exercise, Case Study.

Methodology: Using the "Word Webs" method, students first discuss and review the concept of "diplobiont life cycle", and then are divided in six groups. Each group receives a set of examples of life cycles and have some time to study it. After this, students are shuffled between groups in a "Jigsaw" or "Corner Exercise" model, and have to explain the life cycles to other groups' members. In the sequence, the instructor brings some case studies, and open space for discussion.

4. Reflections and Conclusion

Both activities designed by the groups start with an exposition of the student to the problem to be discussed (Introduction), move to one of more activities that bring additional layers to the topic (Development), and finish with a summary or reflection of the activity (Conclusion). During the initial 10 minutes of workshop, both groups focused on deciding a topic and setting goals and requirements for the activity to be designed.

The analysis of the transcripts shows that the group working with high education struggled when narrowing down topics for activities. Concerned with the idea that in high education classes need to cover broad topics in a deep approach, participants of this groups spent the first 10 minutes diverging in opinions of what topic to decide for. The table with suggestions of activities provided by the workshop (table 1) proved useful for this group: the table aided participants on focusing their ideas towards the educational goals they had in mind. As the workshop facilitator, it was interesting to observe participants of this group scooping activities from the table based on their needs. This is another evidence that systematic ways to teach sciences (like the resources presented here) can be very useful to teachers.

REFERENCES

[1] BRASIL. Lei de Diretrizes e Bases da Educação Nacional. Lei número 9394, Dec. 20, (1996).
[2] ______________. Base Nacional Comum Curricular (BNCC). Brasília: MEC. (2017). Available in: http://basenacionalcomum.mec.gov.br/images/BNCC_20dez_site.pdf Last access: Sep. 1, 2018.
[3] Wandersee J.H. (1986). Plants or animals — which do junior high school students prefer to study? *Journal of Research in Science Teaching*, *23*(5), pp. 415-426.
[4] Ursi S., Barbosa P.P., Sano P.T., & Berchez F.A.S. (2018) Ensino de Botânica: conhecimento e encantamento na educação científica. *Estudos Avançados*, *32*(94), pp. 7-24.
[5] Colli-Silva M., Florentino J.J., Teixeira L.A., Corsi A.C.S., & Ursi S. (2019) Quali-quantitative evidences of plant blindness in a Brazilian urban green space with plaqued trees. *Paisagem e Ambiente: Ensaios*, 30 (43), pp. 1-18.
[6] Balas B., & Momsen J. L. (2014) Attention "blinks" differently for plants and animals. *CBE – Life Sciences Education*, 13(3), pp. 437-443.
[7] Copetti C., & Canto-Dorow T.S. (2019) Botany Teaching: An Overview of Academic Research in Brazil from 2002 to 2017. *Acta Scientiae*, 21(3), pp. 155-169.
[8] Yamaguchi K., Ohara Y., Fukuyama Y., & Yoshida L. (2017) Plus fifteen minutes. *The University of Tokyo, Komaba Organization for Educational Excellence*, p. 52. [In Japanese]
[9] Uno, G.E. (2009) Botanical literacy: What and how should students learn about plants? *American Journal of Botany*, 96(10), pp. 1753-1759.

Analysing Plans of Localizing Professional Development of the Ministry of Education in Kuwait Based on TPACK Model for the Rolling Out Competency Based Curriculum for Math and Science Teachers

Fatima Alhashem[1]
Gulf University for Science and Technology (GUST), Kuwait[1]

Abstract

In current thinking the professional development of teachers is viewed as a continuum process that needs to contain content, pedagogical and technological knowledge. While shifting the national curriculum of Kuwait to competency-based curriculum starting in year 2016 (Kuwait review of Professional Development, 2016), the education field needed incentive amount of induction and training for teachers to adopt to the new curriculum. The training is delivered either through one-week courses in one of the training centers or through one-off workshops in district centers or in schools. This training is largely subject or pedagogical-related. It is determined in a top-down manner by the Supervisors with little or no consultation with teachers as to their need (Kuwait review of Professional Development, 2016).
Also, The lack of adequate of training programs, and the continuous follow-up in terms of professional development. The evidence from a broad range of interviewees from both math and science teachers strongly suggested that the mode of training delivery was formal, lecture-oriented, and did not normally entail much hands-on involvement of the participating teachers. Descriptive analysis as well as qualitative approach were used to analyse the process of localizing training in public schools of Kuwait based on TPACK model specially for science and math teachers as in-depth case study.
It is acceptable to set up the plan to localize the training and enrich the educational field with new curriculum techniques and provide them with ongoing training, however, the critical part remains in being innovative and provide the teacher with their needs rather than top down- or uncategorized type of training. It was noticeable from the results that there was no clear vision on how to determine the training for teachers. This is normal during a radical change in the national curriculum, but in the near future, and with the application of self-evaluation of the teacher, training programs should be a combination of a vision for development by guidance and an actual need of teachers through surveying or any other methods. Training requires high competencies in the transfer of experience and a thorough understanding of the training materials. This research, with its analyses and recommendations, can be used as a first step towards the provision of a roadmap for the career-long professional development of teachers in Kuwait and a basis for the formulation of policies on which a Teacher Education Strategy and a National Teacher Framework can be built.

Keywords: TPACK model – Competency Based Curriculum – Science teachers – Reform curriculum – localizing training

Teachers share a significant responsibility in preparing young people to lead successful and productive lives. There is a broad consensus that teacher quality is the single most important in-school factor influencing student achievement[1]. Sustained professional development for teachers is associated with more positive and stimulating teacher behaviour and positive student outcomes. When designed well, these opportunities help teachers master content, improve teaching skills, and address challenges faced in the classroom. However, the professional development in Kuwait still in need of development to fulfil the teachers' requirement. Technical Supervisors in Kuwait have the formal responsibility for the provision of professional development for teachers. There are 18 General Supervisors each of whom is responsible for one of the 18 subjects. While shifting the national curriculum of Kuwait to competency-based curriculum starting in year 2016 (Kuwait review of Professional Development, 2016), the education field needed incentive amount of induction and training for teachers to adopt to the new curriculum. The training is delivered either through one-week courses in one of the training centers or through one-off workshops in district centers or in schools. This training is largely subject or pedagogical-related. It is determined in a top-down manner by the *Supervisors* with little or no consultation with teachers as to their need (Kuwait review of Professional Development, 2016). Also, The lack of adequate of training programs, and the continuous follow-up in terms of professional development. The evidence from a broad range of interviewees strongly suggested that the mode of training delivery was formal, lecture-oriented, and did not normally entail much hands-on involvement of the participating teachers. Thus, in this research, the plans of localizing training provided by the public education sector was examined to answer the following:

- What is the number of training courses prepared by each supervisory for each subject?
- What are the elements included in the training based on TPACK? (Educational/technological/specialized/administrative/administrative)
- What is the duration of the localization plan? Who is involved in training? What are the stages covered by the training resettlement plan? And why the fixed schedule of the plan to localize training?
- What was included in the training material for the training resettlement plan?

The Training Models:

TPACK Model

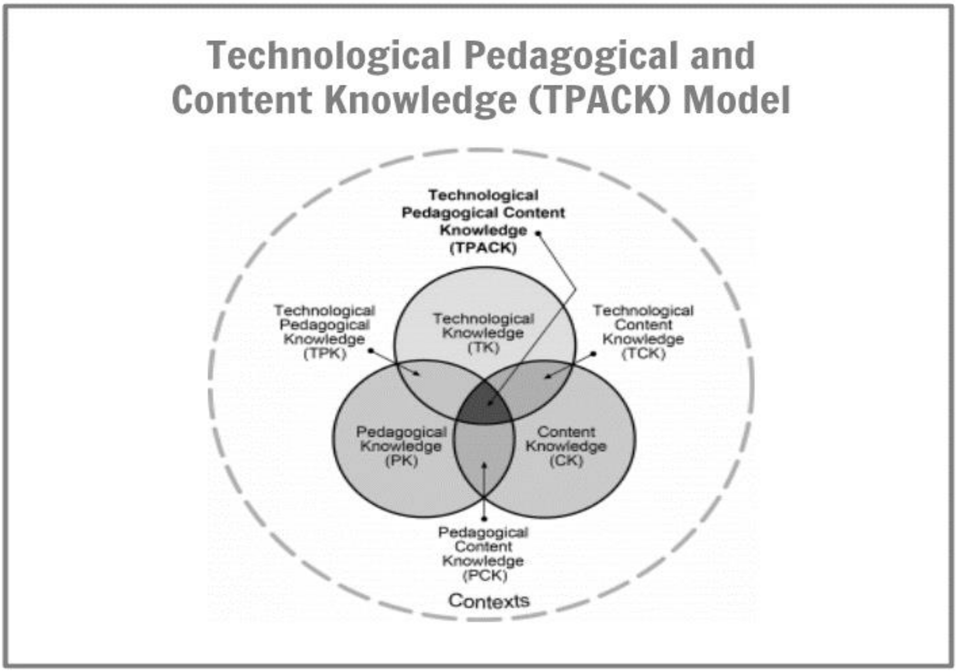
The professional development that was conducted during the years 2016-2017 was explored based on number of trainings in terms of pedagogical, content, and technological knowledge among teachers in both elementary and middle school level.

The design was based on TPACK model. The acronym TPACK refers to "Technology Pedagogy and Content Knowledge," and these three elements (technology, pedagogy, and content) are presumed to be familiar to teachers and to be continually applied in their classrooms. Not only are teachers required to understand relevant content knowledge, they also need to know how to convey this content to their students; at the same time, they need to adapt and update their technological knowledge to keep up with technical and lifestyle developments.

Thomas, Herring, Redmond, & Smaldino, (2013) stated that educational leaders must establish a clear vision for how their programs will develop candidates who are TPACK

[1] Organization for Economic Co-Operation and Development (OECD), Teachers matter: Attracting, Developing and retaining effective teachers, Paris, OECD Publishing, 2005.

competent and who can become models/change agents at their schools. Technology, pedagogy, and content knowledge (TPACK) model is extensively used to scaffold teacher's integration knowledge and skills into their practices. Thus, it is essential that teachers understand the concept of TPACK, which will help them connect their skills with content via technological means to produce integrated lesson plans. More broadly, it is very important that teachers know how to wisely and purposefully add technology into their practice and to use different methods to deliver content.



Method

Statistical Methodology

Descriptive analysis of the number and quality of training programs in each supervisory were counted and categorized using TPACK model as a guide. The analyses took into consideration the fact that there were some training courses related to school administration.

Qualitative Approach

In order to have a complete image of the whole situation about the training. In depth analytical reading to the training program, focus groups, visits for training sessions and interviews were conducted to know the sources, backgrounds and rationales behind each training course.

Results: Include the Results of the Study

The descriptive analysis results

The focus of the training was more on the educational aspect, especially on the issue of strengthening the educational aspect is important and its presence was noted in all plans.

There was a marked discrepancy between the number of training sessions on the material level and this is due to the nature of each subject. But there was a difference in the level of one article (physical education of girls/boys) which may raise a big question: “what are the bases of building the training model?” The training programs were not described except for the science. The science supervisory described the preparations for the training programs and the development of general guidelines only. Most of the training were missing the technology side.

It was also noted that there was no clear methodology for laying the groundwork for training.

The qualitative results

In terms of school visits: we have attended a sixth-grade lesson in based on the competency curriculum. Then, it was followed by a meeting to discuss applications, compare it with other regions, and the extent of application for other school districts. After that, it was followed by a training session. Discussion was held between the supervisors of the various educational districts about the pros and cons in the lesson. We have been provided with visual presentations on the plan for localization of training, which includes an explanation of the lessons and applications according to the competency curriculum.

Discussion and Implications for Practice

The focus on the educational aspect, especially on the issue of strengthening the educational aspect is important and its presence was noted in all plans for the resettlement of training and this is positive. There was a marked discrepancy between the number of training sessions on the material level.

It is fine to set up the plan to localize the training and enrich the educational field with new curriculum techniques and provide them with ongoing training, however, the critical part remains in being innovative and provide the teacher with their needs rather than top down- or uncategorized type of training. It was noticeable from the results that there was no clear vision on how to determine the training for teachers. This is normal if there is a radical change in the national curriculum, but in the near future, and with the application of self-evaluation of the teacher, the training programs should be a combination of a vision for development by guidance and an actual need of teachers through surveying or any other methods. Training requires high competencies in the transfer of experience and a thorough understanding of the training material. The training of heads of departments for a week to transfer knowledge, is not enough, and affected negatively in the transferring the actual material, and thus affect the teacher’s understanding of the curriculum competencies.

Recommendations

On Planning for Training Localization:

- Prepare training plans based on two things (vision guidance and teacher needs).
- The development of exercises that integrate the actual needs in the field and the latest educational innovations that the ministry seeks to continue.
- Increase the integration of teachers with outstanding experience in planning and implementing training programs in accordance with the frameworks and controls.
- Establish clear criteria for training to be in equal proportions.
- Activate the teacher self-assessment, adapt the needs of the teachers and plan

the localization of training.
- Blogging, documentation and compliance are among the most important factors that will help the field improve training and develop it.

On the training material and methods:
- Develop specific frameworks to help guide the development of training without neglecting one aspect (educational/specialized/administrative/technological).
- To find the balance between the three training components of the educational, cognitive and technological head, while not neglecting any of the other components needed by the field (administrative)
- Increase technology topics and employ them in the competency curriculum.
- For active learning, training must be active, and it should increase the number of workshops and practices and reduce the lecture style.
- Use of the centers available to develop and support the guidance towards upgrading the training as well as the head of the department.
- Archive of plans and educational programs and the use of the curriculum sector on the work of publications in the training programs or lessons annotated and uploaded electronically on the website of the Ministry of Education.
- Link professional development and training as an integral part of supervisory functions.

REFERENCES

[1] Kuwait review of Professional Development (2015) – Andrew Burke, World Bank.

[2] Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teacher knowledge. *Teachers College Record, 108*(6), pp. 1017-1054.

[3] National ICT in Education Strategy. (2008, Feb). Paper presented in the national conference for

[4] Schleicher, A. (2012). Preparing teachers and developing school leaders for the 21st century: Lessons from around the world. OECD publishing.

[5] Thomas, T., Herring, M., Redmond, P., & Smaldino, S. (2013). Leading change and innovation in teacher preparation: A blueprint for developing TPACK ready teacher candidates. *Tech-Trends*, *57*(5), pp. 55-6.

[6] Thompson, A., & Mishra, P. (2008). Breaking news: TPCK becomes TPACK! *Journal of Computing in Teacher Education*, *24*(2). Pp. 38-64.

[7] Wiseman, A. W., Alromi, N. H., & Alshumrani, S. (2014). Challenges to creating an Arabian Gulf knowledge economy. *Education for a Knowledge Society in Arabian Gulf Countries*, 24, pp. 1-33.

Shifting from a Traditional Evaluation to a Competence-Based Assessment in the Degree of Primary Education

Cristina Sánchez-Cruzado[1], Teresa Sánchez-Compaña[2], Juan Antonio Macías-García[3]
University of Málaga, Spain[1,2,3]

Abstract

In this communication, we show a part of the results of an action research carried out throughout four years in a subject within the Didactics of Mathematics area, in the Primary Education degree in the University of Málaga, based on the flipped classroom methodology. In this experience we took into consideration one of the suggestions given by students to improve the assessment of the subject during the first year and applied it during the next two years. This evaluation transitioned from a traditional standpoint in which the greater weight (70%) was a content-based exam, to an assessment based almost completely (90%) in the development of competences demonstrated through projects done about the subject. Students can choose to elaborate a group project with absolute creative freedom that encapsulates the contents of the subject. In most cases, these projects transcend the mathematical scope and transform into truly interdisciplinary projects, which include topics such as history, gender studies or science. The flipped classroom methodology enabled to move the theoretical content outside the classroom letting the group work to be done in class and having the professor as a guide. Due to this, the quality of the projects has increased exponentially, to the point of considering a book for future Primary Education teachers in which each group can share their work and how can they be done. Lastly, this evaluation is done through several rubrics, a self-assessment and a peer assessment rubric, which each item is a competence translated into learning results.

Keywords: Student assessment, competences, mathematics

1. Introduction

The general and specific competences of the subject of the Primary Mathematics Education area from the Faculty of Education Sciences of the University of Malaga, address the need to boost different skills in students and future teachers. In many cases, these skills are difficult to acquire simply with the traditional lecture approach. Some of these competences insist on collaboration, group work and respect for diversity. They are involved in the modelling, planning and evaluation of the teaching and learning processes, both individually and in collaboration with other teachers (minimum competences of RD 1393/2007, Annex I, section 3 [1]). It is essential to use methodological strategies in the classroom such as Flipped Learning, which favour the acquisition of these skills [2]. During the first academic school years of this research (2015-2016 and 2016-2017) the participating students assessed the improvements implied in the methodological shift [4]. This methodology has provided significant improvements in the teaching-learning process, and yielded very satisfactory results.

Group work was developed at a much higher level than in previous academic years [3]. There was also an increase in motivation and adaptation to special needs and different paces of learning. Lastly there was an overall progress in the learning experience [4].

There was an overall need for a methodology that favoured skill acquisition and an improved teaching-learning process. In the same way, the students also demanded that the evaluation be consistent with the proposed improvement. A newer methodological strategy was being developed throughout the class sessions. Therefore, it would have been highly unreasonable to maintain a traditional evaluation, in which the final result would hold more importance than the actual learning process, and a written exam is 70% of the final grade. After a consensus with the rest of the teachers, the teaching guide was modified so that the workshops and group work, which were carried out by the students, would hold a greater weight: up to 90% of the final grade. In this way, the grading and evaluation method is reconsidered in order to deliver a more effective evaluation of competences. This in turn makes group work more prominent in the evaluation processes. The initial research followed this procedure, as well as the modification and improvement of the evaluation process, while attempting to achieve and put into practice a formative evaluation [5] during the academic years of 2017-2018 and 2018-2019.

2. Evaluation Proposal

Among the tasks and workshops presented in the course, special emphasis was given to group work. In this teaching proposal, the students laid out the contextualized mathematical contents in such a way that not just instrumental dimension of mathematics were worked on, also the functional and formative ones. In order to evaluate this work, the presentation and explanation of the document was also assessed. Each group had between 60 and 90 minutes, depending on the number of members, to develop an exposition of their teaching proposal in the most original way possible. They had the opportunity to show in detail the work and skills gathered from the Primary Education Degree and the Mathematics Teaching Field [1], [9]. The students brought their own structured and unstructured teaching material, including recorded video and props.

The evaluation of students with a rubric system was proposed, one for teachers, and the other for the students who answered both for the evaluation of their group mates, and their own self-evaluation.

2.1 Teacher Rubric

By using this rubric, the teacher was able to assess the acquisition of skills, very similar to the student rubric. On the other hand, it was used to assess the characteristic details of group work, such as clarity, order and content writing, original modelling, and proper sequence of activities [3]. Moreover, as it is a subject in the area of Mathematics Education, they also assessed the design of activities associated with mathematical skills: thinking and reasoning, communicating, representing and symbolizing, arguing, modelling, outlining and solving problems [6].

2.2 Student Rubric: Peer & Self-Evaluation

In order to directly involve students in their own evaluation, a second rubric was designed jointly with the students. This rubric was based on the main competences needed to acquire, according to the Primary Education Degree. Therefore, the

"CoRubric-Rubrics Collaborative" platform was used as an appropriate evaluation instrument [8]. Students could register on the platform, simply by entering his or her email address and password. He or she could then access the evaluation rubric using the link provided through the virtual campus, or by scanning the following QR code:

Fig. 1. *QR code to access the peer and self-evaluation rubrics*

Once inside the platform, each of the students had to evaluate themselves, selecting the degree to which they considered that they have acquired a certain skill or competence. They were requested to be honest and responsible when selecting the most appropriate option for each case. They also had to justify their answers as much as possible in the "Observations" section.

Figure 2 shows the format in which the evaluation of competencies rubric was laid out. Each of the items is an adaptation of some of the general and basic skills in the Primary Education Degree and the specific skills found in the teaching and learning of mathematics [1], [9].

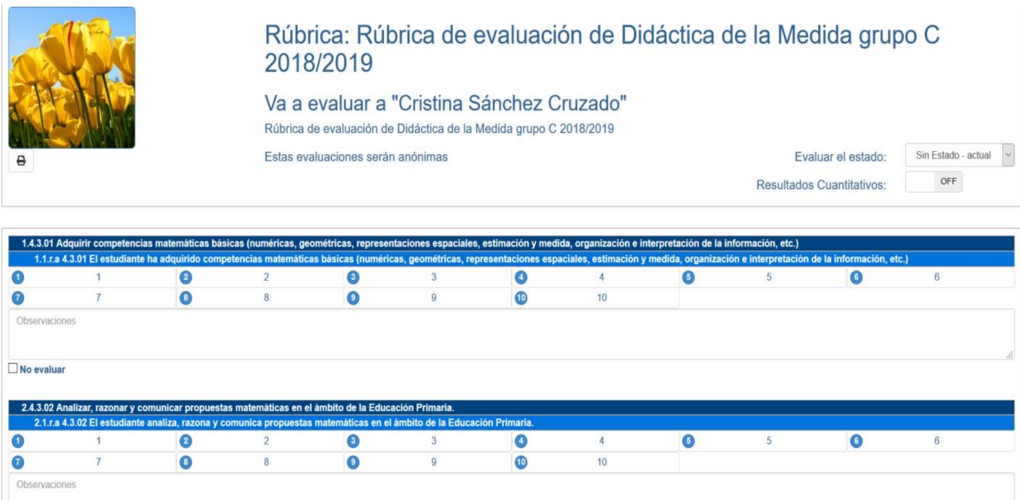


Fig. 2. *Evaluation Rubric Format*

Once the self-evaluation was completed, the student had to do the same with some of the classmates, choosing each member of his or her group, and selecting the degree to which that student had acquired one or another skill or competence. Again, it was requested that they be sincere with their evaluations and that they avoided exaggerated praise.

In the event of a perfect score, they were asked to give detailed justification as to why they, or a certain classmate, deserved the highest evaluation level.

3. Results

As a result of this experience, a formative evaluation was achieved, in which the students were much more aware of their learning, and accepted responsibility. They actively participated in their evaluation process, even in the design of the rubrics [10].

Moreover, thanks to Flipped Learning, much more time was allotted to be able to focus on points that were presented as possible weaknesses, or areas in which the teacher wanted to further explore [2].

The final grade included, on the one hand, the evaluation that the teacher carried out in the individual and group work, and on the other hand, the peer and self-evaluation, which was done by each student. The students felt that they played an active role in their learning and evaluation process. The evaluation did not seem to be an isolated item at the end of the educational process. Instead they valued those necessary and ideal competencies, which every future teacher should possess.

Regarding the peer and self-evaluation, note that in general, students behaved in a responsible way. At first, the teachers expected to find extremely biased evaluations based on the positive or negative relationships that they had with one another. However, there were mostly notes which were in accordance with the evaluation made by the professor, with coherent explanations and justifications for each case. Colleagues who did not work at the same level as the rest also stood out and received lower scores.

4. Conclusions

The conclusion reached from the results obtained in the two academic years in which the experience was carried out, is that this type of evaluation is much more impartial and logical than the traditional methods. It truly highlights the advantages of the formative evaluation [5], [10], in accordance with a teaching method that aims to put the main focus on the student and in the development of his or her skills. It has also shown that students can become much more motivated, once they are aware of their role in the teaching-learning process. Ultimately, it grants the student much more autonomy and responsibility in his or her education.

Acknowledgments

This work is part of the Reference Research Project PGC2018-094114-A-I00, "Didactic Analysis of Teaching and Learning Units in Math and Science Textbooks from a Gender Perspective", funded by the MINECO/MICIU, Ministry of Science, Innovation and Universities.

REFERENCES

[1] Real Decreto 1393/2007, de 29 de octubre, por el que se establecen las enseñanzas mínimas de la Educación primaria. *Boletín Oficial del Estado*, España, 2007, 293, pp. 53-93.

[2] Santiago, R., & Bergmann, J. "Aprender al revés. Flipped Classroom 3.0 y Metodologías activas en el aula". España, 2018, Paidós Educación.

[3] Sánchez-Cruzado, C., Sánchez-Compaña, T. & Macías-García, J. A. "Flipped classroom como estrategia metodológica para mejorar la competencia en trabajo

grupal en didáctica de la matemática", *Matemáticas, educación y sociedad*, Córdoba, 2018, 1(3), pp. 31-43.
[4] Sánchez-Cruzado, C., Sánchez-Compaña, M. T. & Ruíz Palmero, J. "Experiencias reales de aula invertida como estrategia Metodológica en la Educación Universitaria Española". *PUBLICACIONES*, Granada, 2019, 49(2), pp. 39-58.
[5] López-Pastor, V. & Sicilia-Camacho, A. "Formative and Shared Assessment in Higher Education. Lessons learned and challenges for the future", *Assessment & Evaluation in Higher Education*, 2017, 42, núm. 1, pp. 77-97.
[6] Niss, M. "Quantitative Literacy and Mathematics Competencies. En Quantitative Literacy: Why Numeracy Matters for Schools and Colleges", *National Council on Education Disciplines*, 2003, pp. 215-220.
[7] Sánchez-Cruzado, C., Sánchez-Compaña, T., & Macías-García, J. A. "Flipped classroom como estrategia metodológica para mejorar la competencia en trabajo grupal en didáctica de la matemática", *Matemáticas, educación y sociedad*, Córdoba, 2018, 1(3), pp. 31-43.
[8] Martínez Romera, D., Cebrián Robles, D., & Cebrián de la Serna, M. (2016). "Evaluación de competencias docentes con e-Rúbricas en Máster de Profesorado", *Journal for Educators, Teachers and Trainers*, Granada, 2016, 7(2), pp. 120-141.
[9] Orden ECI/3857, de 27 de diciembre de 2007, por la que se establecen los requisitos para la verificación de los títulos universitarios oficiales que habiliten para el ejercicio de la profesión de Maestro en Educación Primaria. *Boletín Oficial del Estado*, España, 2018, 312, pp. 53747-53750
[10] Romero, I., Gómez, P., & Pinzón, A. "Compartir metas de aprendizaje como estrategia de evaluación formativa. Un caso con profesores de matemáticas". *Perfiles educativos*, 2018, 40(162), pp. 117-137.

Authors

T

V

Y

Scientific Committee of the Ninth Edition of the International Conference
New Perpectives in Science Education

International Conference New Perspectives in Science Education

CONFERENCE SECRETARIAT:
PIXEL
Via Luigi Lanzi, 12 - 50134 Firenze (Italy)
Tel. +39-055-48 97 00 - E-mail: science@pixel-online.net
Web site: http://www.pixel-online.net/
Conference Web Site: http://www.pixel-online.net/NPSE

PIXEL