Arts and STEM for Social Inclusion

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Abstract

According to the report of the European Agency for Development in the Special Needs Education (2012) "Profile of inclusive teachers", the inclusive teaching approaches are relevant for supporting better the students with special learning needs. In education, inclusive teaching and learning means that everyone is supposed to possess the same opportunity, without boundaries such as ethnicity, gender or disability. All students should feel valued, be able to mix and participate with all members of the group, and be in a safe and positive environment.
Currently, different pedagogical approaches are recognized as enhancers of social inclusion into the classroom, such as participated and collaborative methodology focused on the motivation improvement and emotional cognitive development through the use of different intelligences.
In this context, this paper describes two inclusive teaching and learning approaches which exploit the creativity and potentiality of use of the Arts for the STEM skill development.
The first one aims to introduce the art-works in a defined pedagogical approach which follow the Singapore's method structured into three phases (concrete, pictorial and abstract) for studying mathematics. It starts from a concrete phase in which students are called to make experience through the object manipulation up to reaching the abstract concept by recognizing and re-producing the mathematical formula studied through an art-work.
In the second teaching approach the use of the art-works by the students is made through the development of mini-games settings and scenario. This last is a part of the project co-funded by European Commission under Erasmus Plus programme.

Keywords: *STEM, Learning by doing, Arts, Inclusive teaching.*

1. Introduction

Regarding the teacher figure, Gravells [1] states: "You are not teaching your subject to a group of learners who are all the same, but to a group of individuals with different experiences, abilities and needs, which should be recognized and respected".
In education, the word "inclusion" means that everyone has the same opportunity; no boundaries such as ethnicity, gender or disability. Therefore, everyone has an opportunity to fully participate in learning activities carried out every day in the classroom [2].
The inclusive education is the teaching of all, which is addressed to personalized and individualized approach through active, participatory, constructive and affective methodologies.
This will allow the constructing of a safe and positive environment for all students who should feel valued, being able to mix and participate with all members of the class group.
An inclusive education implies a participated and collaborative methodology to promote students motivation; dealing with students emotional cognitive aspects; setting as the goal not "leaving anyone behind"; showing the relationship with knowledge by giving meaning to the school work; developing self-learning capacity and negotiating different types of rules and contracts and using the multiple intelligences. [2]
The quality of inclusive teaching is determined by the capacity to put in practice all these features with a certain reflexivity and educational intentionality, by the search for motivations and alternative hypotheses, by the ability to change the meaning perspectives and produce transformative learning following students' real needs.
The initial assumption of the "inclusive teaching" approach is based on the "valorization" in terms of what is necessary to valorize the students and what they can do. This means, first of all, giving meaning to the students work by contextualizing and staring from their already acquired knowledge to construct new ones.
Secondly, this means motivating considering both cognitive and learning aspects and the subject who learns.
"Inclusion" is something different from "integration", because it is a process and not a situation. It refers to the whole of educational, social and political spheres. It indistinctly and differently looks at the

students and at their potential. It intervenes first on the context and then on the subject by transforming the specialized response into ordinary.
According to the report of the European Agency for Development in the Special Needs Education "Profile of inclusive teachers" in 2012 [3], the class is a learning community characterized by the possibility to combine the diversity of the members, to establish a continuous advancement goal shared by the group and to use new learning strategies and teach how to learn them.
Although, “inclusive teaching” approach includes an intervention at multi-level environment in one organization by stimulating more interactive and synergistic sets, the paper presents two teaching and learning approaches aiming to exploit the potentiality to use different learning style and languages, such as visual, sensory, verbal and non-verbal [4].
The multi-sensoriality derives, in both of them, by the use of the Arts where creativity and problem solving skills are enhanced in students during the whole learning and teaching process in STEM education.
The first method aims to introduce the art-works through a specific pedagogical approach, inspired to the three phases (concrete, pictorial and abstract) of the Singapore’s method for mathematics study.
The second teaching approach is the result of a combination between the use of art-works and mini-games settings and scenario development [5].

2. Using arts: from the object manipulation to the abstract representation

In the first example, the introduction of the “art-works” with the support of technology, in particular for the mathematics study, has favored the whole learning process by reinforcing the student understanding and motivation [6].
The supposed teaching and learning method is based on the three phases (Concrete, Pictorial and Abstract), as defined in Singapore’s method applied to mathematics study that can guide students to the discovery of the challenging connections between math and reality.
The concrete phase is the first step of the pathway focused on the object manipulation, passing through the visual representation of the topic studied (the second phase - pictorial), students will reach its abstract representation (the third phase – abstract) [7].
Students learn mathematical subjects by discovering that different relationships exist among things or math concepts and by developing, accordingly, problem solving skills yet avoiding just memorizing the solution procedure (adidactical situation, as defined by Brousseau) [8].
They are supported by the worksheets providing instructions to lead the student from the concrete phase to the pictorial, and up to the abstract one (didactical situation).
Non-didactical, because the teacher will have the function to mediate and support the learning process through the creativity and the imagination of their students.
According to Didactics Hexagon Model proposed by Guy Brousseau, the art-work has the function of “milieu” to reach knowledge which is “constructed” by students through a concrete phase (object manipulation) to pictorial up to reach the abstract representation of a scientific concept.
The use of the modeling program, like Geogebra, in the concrete phase, has allowed students to explore and understand mathematical concepts through the help of visualization and virtual object manipulation (Fig. 1). Therefore, students learn and familiarize themselves with the specific objects’ construction, e.g. a dodecahedron [8].
This helped students to reinforce their visualization skills, modeling the real world problems and making connections between the real world and mathematics.

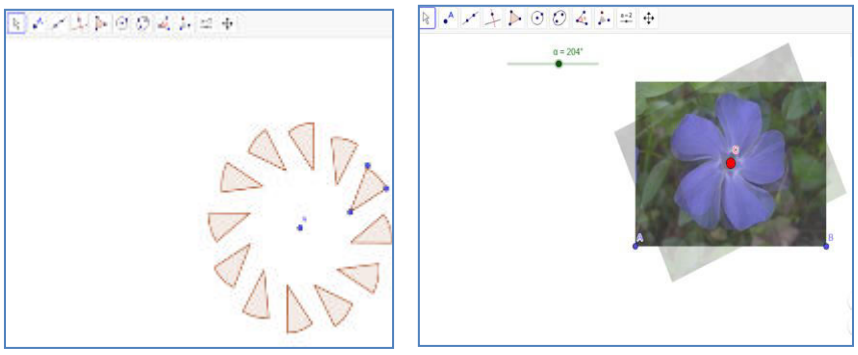

Fig.1: Visual Modelling Programming – Examples of symmetry study – Geogebra

The aim is to reinforce student knowledge in mathematics through the use of specific art-works which support the development of systems thinking based on applicable knowledge, imagination, creativity and problem-solving skills.
Secondly, during the pictorial phase, students learn to recognize mathematics in the art-works, working in groups and individually. For instance, they are asked to find the art works containing dodecahedron shape, such as “The Portrait of Luca Pacioli” of Jacopo de' Barbari (around 1500 A.D.) as shown in the Fig. 2.

Fig. 2: Dodecahedron contained in “The Portrait of Luca Pacioli” of Jacopo de' Barbari.

Finally, they create their art-work starting from the math formula studied. The use of the creativity from students is unconstrained; especially when they produce their own artworks on the basis of the math concepts studied learning experiences and meaningful context.
At the final stage, students transfer their artworks into a digital form by using modeling programs for the objects creation and, then, the artifacts will be uploaded in a 3D Virtual Museum produced by Institute for Computer Science and Control, Hungarian Academy of Science in collaboration with Institute of Mathematics and Informatics - Bulgarian Academy of Sciences [9] [10].

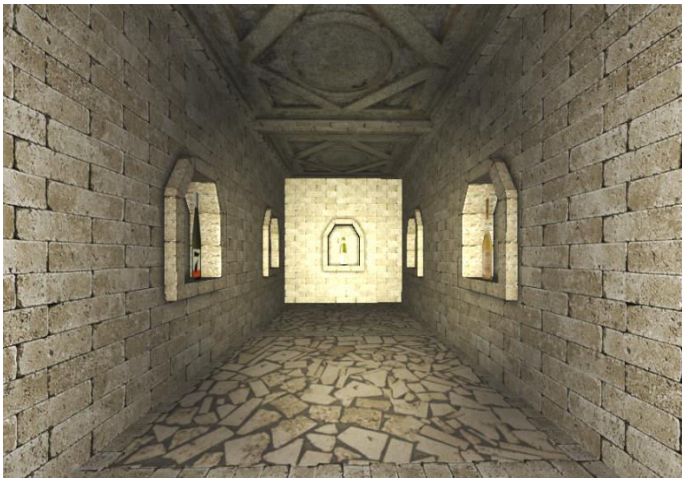

Fig. 3: An example of 3D virtual environment.

The proposed approach stimulates students to draw a pictorial model to represent mathematics concepts (known and unknown) and to catch their relationships (part-whole and comparison) emerged in a specific problem, and to help them visualize and solve the problem itself. This favours students to make their connections and draw generalizations about the concepts learnt by leaving out the simply memorization of disconnected and isolated facts.

3. Enhancing STEM skills through Arts and mini-games: G.A STEM project

The other example of an effective combination between STEM, arts and mini-games is a part of an on-going project, co-funded by European Commission under Erasmus+ Programme. It is coordinated by a partnership constituted of no. 8 organisations (two universities, one research center, four secondary schools and one international education and training institution) from Finland, Estonia, Italy and Belgium.

This project, titled G.A STEM, intends, with the introduction of Arts in Mathematics and Science study, to empower STEM education teaching and learning processes in young students, by showing them the real applications of STEM studies through the creativity, problem solving development and inquiry based learning.

The main objective is to favour a relational reasoning connected to the concrete STEM concept and to develop skills for the recognition of real relationships to be able to work on them dynamically through a cognitive association between theoretical and real life problems.

The proposed approach, thanks to the teacher mediation and facilitation, can reinforce in the student such recognition.

Therefore, the application of the proposed teaching and learning approaches improves not only student performances but ensures the development of those transversal skills, such as problem solving and creativity, which might be even more useful for their future professional career.

In this direction, G.A. STEM supports teachers and students to become co-creators and co-constructors of their personalized learning and teaching process and tools to be used in a multidisciplinary and interdisciplinary approach referred to both scientific and humanistic subjects.

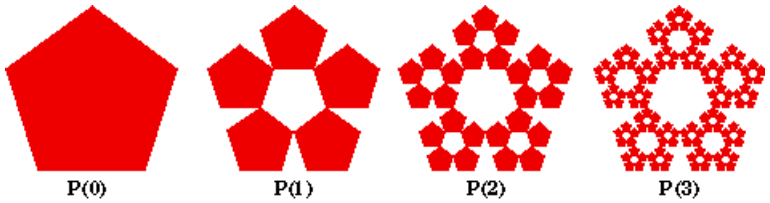

Fig. 4: Example of the combination between mathematics, art and game: Sierpinski Pentagon transformation

The innovation is in the combination between the introduction of Art to develop STEM skills and the design and development of mini-game and game setting to promote digital skills [11]. A perfect combination between creativity and technology generates, as a result, a specific form of digital art.

In particular, G.A.STEM project aims at:

1. improving motivation in scientific study through the use of “Art-works” as a supporter in student creativity development and an enhanced awareness of their applications in everyday life;
2. utilizing the attractiveness of the art and technology (in terms of mini-games design and game assets) to improve social inclusion and gender equality;
3. supporting STEM skills (vertical and horizontal skills) useful for professional careers for both teachers and students;
4. improving the collaborative sense among teachers and schools through the exchanging of experience, best practices focusing on the interdisciplinary and multidisciplinary approach;
5. increasing the community sense and citizenship awareness through the discovery of European Cultural heritage constituted of (past and present) art-works produced in the partner project countries [12].

This proposed innovative combination helps, on one hand, students with some study and learning difficulties to learn the discovering through a more personalized and creative learning process in order to study what they would not learn following the traditional approach.

From the other hand, the discovery of existing relations between science and arts in teaching makes science or scientific subjects more interesting and attractive by facilitating the development of creative and complex ideas in students and an outstanding reasoning process.

The project foresees three phases: the first is related to the analysis of the mathematics and science exercises including the referred art-works to be used in all partner countries; the second one aims to develop the teaching and learning materials to be shared with secondary school teachers on how to integrate arts in the STEM subjects through the mini-games design and game scenario development and, finally, these learning tools will be tested with the students in their classrooms.

Currently, the partnership is finalizing the first phase with the selection of the mathematics and science exercises and their corresponding art-works to be submitted during the piloting activity.

4. Conclusions

The proposed teaching and learning methods and tools can favour the creation and the development of a more effective learning environment which benefits both cognitive and emotional dimensions in students.

These approaches can reinforce the learning process and amplify the quality of student performance based on problem solving skills. Both of them use the cooperative learning because students, working in small groups, use different social and cognitive aspects. This allows the synthesis between knowing and doing in learning and teaching context.

In addition, these favor the use of multisensory teaching in terms of a use of multiple perspective channels (visual, auditory, tactile, etc.) [13] and the use of technology, such as modeling applications or mini-games, by increasing learning thanks to the potentiality exploitation of different learning styles [14].

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