Maths, Art and Technology: a Combination for an Effective Study

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Abstract **– In this paper a novel learning and teaching approach for studying mathematics is presented. The method is the result of a combination between art and technology in order to stimulate and motivate secondary school students in mathematics often considered boring and difficult to understand.**

This helps students revive the art perception displaying its hidden science base and understand that artists' reasoning is reducible to mathematical concepts.

Currently, the research project is in the experimentation phase in which the students have the opportunity to test the model proposed.

In the article some preliminary results are presented and discussed.

Keywords **– Mathematics, Arts, Technology, Teaching, Learning.**

1. Introduction

Nowadays, understanding mathematics is crucial in terms of a personal development and people's life adjustment to a modern society. As well as it is important to see the interrelations between mathematics, technology and other aspects of the society including economic and social development for a high quality well-being life.

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This paper aims to describe an innovative methodological and pedagogical approach using a combination between art and technology to improve mathematics study in secondary school students from 14 to 16 years-old.

The proposed method foresees an appropriate application of Singapore's method to the mathematics study.

This is a part of a PhD research work to be completed by the end of this year.

2. Mathematics and students difficulties

About 79% of students define mathematics as a big obstacle for their learning process [1].

The difficulties often revealed are related to its being considered more abstract than the others. Actually, about 83% of students work using visual memory [1]. This means that if we can imagine a history lesson as a film or a cartoon, it is quite impossible to do the same with a mathematics lesson. For instance, a lesson on inequalities or on functions hardly can activate the visual memory as a literature subject does. At most, it can stimulate the photographic memory which is only 7% of the visual one [2].

In addition, it is very practical topic. This means that it is not enough to understand the concept and remember it, as for geography, literature, philosophy or history. The theory should be learnt through doing exercises to understand the solution process by activating the procedural memory. This allows students to get skills through learning by doing. Therefore, this process requires a lot of practice.

Students often do not perceive a practical utility in mathematics study unless they study specific subjects, such as economics where the utility is directly evident. However, the others don't have a stimulating overview for being interested in mathematics.

Mathematics is not complicated by itself, but must be studied differently from other disciplines. The suggested learning approaches usually are the following: full immersion, association between image and concept or using memory techniques [2].

Full immersion is when a student dedicates at least one hour and a half daily to do the exercises.

Association between image and concept: when students try to memorize the mathematics formula or concept, e.g. function, through a corresponding image. This is very useful to activate the visual memory.

Another method is to take advantage of memory techniques. For example, the use of mnemonics can help students remember formulas or demonstrations even in the long term by looking at them once. These techniques can work well because they stimulate the innate abilities of student's mind.

However, these learning methods can help students in short-term study but they don't seem effective if we think on a long-term learning [2].

Therefore, the model proposed in this paper is a combination between arts and technology to provide students with an effective approach and some tools to be used in mathematics study.

3. The theoretical approach

The proposed learning and teaching approach is based on the Singapore's' method for mathematics study. It is basically characterized by the use of visual and model-drawing strategies which underline mathematics and surrounding world problems and leave out the memorization occurring through repetitive exercises [3]. It is applied to the mathematics study through a process structured into three phases: concrete, pictorial and abstract. The process allows students to start from a symbolic representation through the concrete mathematical experience to reach an abstract concepts of what they are studying [4].

The use of this method in the research work is based on the theory of didactical situations occurred in mathematics study, as stated by Guy Brousseau [5]. This theoretical framework defines three types of situations: a-didactical, non-didactical and didactical, where a "student" is led to "do" mathematics, to learn how to use it and how to invent it.

First of all, in the "a-didactical" situation, students have all the conditions to establish the relationship with specific knowledge. Secondly, the non-didactical one is referred to a not organized learning environment where students learn specific knowledge. Finally, the didactical situation is, for example, the frontal face-to-face-lesson where teacher uses the traditional teaching approach based more on the teacher-centered than students-centered approach by delivering students precise instructions to carry out the tasks. This means that all the activities are well-organized and developed by teachers [6].

These three situations can interact with each other through a means or, using the words of Brousseau, a "*milieu*". In the proposed model this *milieu* is the art, as an effective representational element.

The variant in the application of the Singapore's method is represented by the introduction of the "art" as *milieu* in all the three phases foreseen. The choice of the "art", such as music, painting, dance, theatre, in the proposed method, is connected with its immediacy in catching and making visible better the interconnections between scientific subjects and reality.

This allows students to understand the application of scientific subjects in everyday life by co-constructing a new knowledge in "meaningful" context.

Actually, people often forget that mathematical principles could be found both implicitly and explicitly everywhere: in human beings, in architecture, plants and animals. So, the connections between arts, meant as representation of reality, and mathematics universal and pervasive as well. For example, you can meet one of the Italian traffic sign for stopping where a triangle is inscribed in a circle (Figure n.1.) or in the cathedral of Porto in Portugal, a column built using symmetry (Figure n.2.).

Figure 1. Italian Traffic Sign representing an inscribed triangle

Figure 2. Symmetry in the Cathedral of Porto (Portugal)

4. Technology as learning reinforcement

In this framework, meaningful learning environments, where knowledge is built, co-constructed and shared, can be supported by digital and e-learning technologies.

Information and Communication Technology (ICT) can become artefacts used as meaningful learning tools, if they provide students with opportunities to learn with technologies and not from technologies [7].

Students learn in a meaningful way if they can master the use of technologies creatively by organizing and representing what they know and learn, by creating products and solving problems anchored to real life, reflecting on contents and processes. The technologies or "collaboration tools", as defined by Jonassen, can promote collaboration, cooperation and distribution of knowledge in knowledge-building communities; make possible and support dialogic processes, then discussions, productive confrontations, meanings negotiation, consensus building through a critical reflection on a "progressive", improving of knowledge [7].

At the same time, the technologies contribute to the promotion of the affective-motivational sphere development by offering scaffolding in knowledge and skills (cognitive scaffolding) and in affective sphere (affective scaffolding).

The "areas of proximal development", in fact, include not only the people (teachers, experts), but also the technologies, both traditional and digital, which have the potential to motivate students in learning, in their interest, in participation and commitment [8] [9].

Technology can be an additional resource in the classroom beside teachers' job, because it supports and helps students in their learning process and teachers in their teaching approach. These tools can be useful also for students with specific learning disorders (DSA). For example, when software transforms a long text into an oral synthesis, or a traditional explanation of a teacher into a conceptual map or an evocative image.

The new technologies in the classroom allow carrying out simulations, to travel virtually, to retrieve information from different sources and to compare them, to write texts in several co-operative ways, to watch video tutorials and to do interactive exercises.

These experiences allow a more active involvement of students by using tools which are more familiar to them. The technology used in the study of some disciplines is, therefore, able to integrate better the learning experience at school by offering a solid starter to achieve a meaningful knowledge [6].

However, technology can improve learning only if effective teaching strategies are implemented. This is the case when the use of technology allows students to increase the time spent for learning and exercising, when it supports their collaboration or when it compensates for their specific learning difficulties.

5. A combined approach for mathematics study

As aforesaid, the model proposed is inspired from the Singapore's method applied to mathematics study structured into three phases: concrete, pictorial and abstract.

In the framework of these phases, the method foresees the use of the artworks and the technology as below described.

During the concrete phase students make experience and become familiar with specific mathematics objects or concepts through their manipulation using digital tools.

During the experimentation phase, students use Geogebra application for this first step (Figure 3.). The choice of this software is motivated by its suitability for the research model proposed, ease of use for people with low ICT skills, friendly-use on PC, Mobile and Tablet. In addition, it allows a manipulation of objects in 2D and 3D dimension and different type of animation.

Figure 3. Experimentation time - Concrete phase with students at Istituto Tecnico Superiore Bianchini in Terracina (Italy).

In the pictorial phase, students have learnt to recognize math in the art exploiting the potentialities to work both in group and individually. Students were expected to find in the habitual surrounding objects the mathematical concept studied, that, in this case, was the "symmetry". In this step, they used not only what is strictly known as the art-works but also they have found the mathematical concept in other contexts as in nature as shown in Figure 4, that is a picture of American linden leaf taken at Park of Minturno.

Figure 4. Experimentation time - Pictorial phase with students at Istituto Tecnico Superiore Bianchini in Terracina (Italy).

Finally, on the base of the mathematics concept studied, students have created their own art-works by using their creativity as shown in Figure 5.

Figure 5. Experimentation time - Abstract phase with students at Istituto Tecnico Superiore Bianchini in Terracina (Italy), 14-15 years-old students.

The final step features less use of technology compared to the first one, due to the often lack of students' practice in the use of creative and graphics software in secondary school causing their low ICT skills. Therefore, they preferred the traditional tools, as pencil and paper, to create their art-works.

The new model achieved allows students to develop and improve their mathematics knowledge through the use of the specific art-works, which help them, in turn, develop systems reasoning based on applicable knowledge, imagination, creativity and problem solving skills by dealing with mathematics problem with variations. This means that students learn to recognize the same mathematical concepts studied in different situations because the different art-works can provide them with changeable background and contexts related to the same concept studied.

Afterwards some of these art-works created by students will be uploaded in a specific 3D virtual museum [11] in order to make the learning experience more amazing and interesting [12]. An example of this 3D environment is shown in Figure 6., which represents a part of 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 from Bulgaria [10].

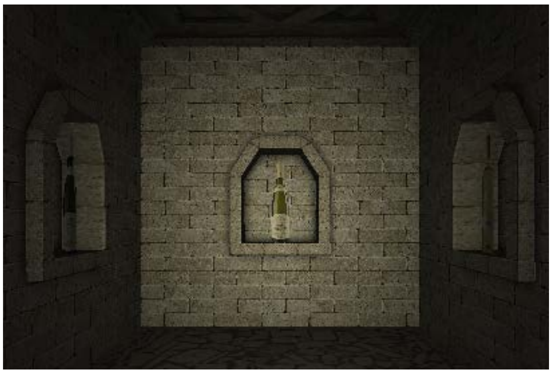

Figure 6. An example of 3D virtual environment

6. Conclusion

At preliminary analysis, this combination allows the creation and the development of interesting learning environment where teachers and students are actively involved by using different languages, visual, graphical, verbal and non-verbal, representational and pictorial.

The contemporary exploitation of these languages favours both cognitive and emotional dimension development in the students and shows them the real applications of mathematics concepts and formula in the everyday life.

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