Reinforcing Learning Setting through the Use of Digital Tools

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Abstract. The tremendous digital revolution is generating, in our society, complex transformations in teaching and learning setting. This will conduct innovation in education towards a new quality.

This paper presents some possible examples on how digital tools can be introduced and used to make a learning setting more effective.

Keywords: Digital Tools, Learning/Teaching Settings, Learning Approach

1 Introduction

Nowadays society becomes more and more based on ICT and advanced technologies. As a consequence, the need for experts with a scientific and technology background is constantly increasing. Nevertheless, according to the latest studies (Osborne J., 2008) (Potvin P., 2014) the interest and motivation towards science is decreasing among students and consequently their interest in careers based on science and technology is decreasing as well. Mostly, it is caused by the fact that some teachers still use traditional teaching and learning methods even for an up-to-date curriculum for their science teaching. Moreover, observing the present avalanche development of information technologies and natural-scientific disciplines, their increasing organic connection becomes more and more evident.

The modern science is meaningless without widespread computer calculations and modeling. Moore's law underlying modern computer technologies, which in many respects has predetermined the development of economy of the second half of XX and the beginning of XXI century, requires the search of absolutely new decisions in view of a physical limit of current technology (Brock D.C., 2006). Without truly creative approach, the decision of the given problem is impossible.

Technological revolution in the world gradually leads to the displacement of human-workers by computerized systems in the routine and low-qualified areas. In turn, the trades involving the creativity, the analysis and common sense - become the key for placing in a job in the future.

In this context, thanks to the use and the application of digital tools, it is possible to create an innovative combination and implementation of different approaches in

STEAM (Science, Technology, Engineering, Mathematics combined with Arts) teaching and learning.

Thus, the paper intends to show how the introduction of digital tools into learning settings can reinforce the improvement and development of student's learning skills.

2 Digital Tools for Enhanced-learning

According to OECD (2013): "to mainstream ICT in classrooms and use technology as a catalyser of innovation in education, hopefully to conducing to new teaching practices, new models of school organisation and tools to support quality teaching" are required (Avvisati F., 2013).

In fact, the digital tools used in education emphasize the interactivity of learning process, the active testing of knowledge and the construction of a new knowledge allowing to simulate and understand complex phenomena (Jonassen D. et al., 2007). These are the solutions that can extend and enrich the potential offered by e-learning and other technological tools. For example, in Italian schools the following solutions to improve student learning are used very often: serious game, educational robotics, virtual reality and, its variation, the augmented reality.

– *Serious game:* they are digital games, interactive virtual simulations with educational purposes (Tsalapatas H., 2013) (Tramonti, 2014). They reproduce real situations difficult to reproduce, allowing the user (or player) to act in an environment very similar to the reality or in a fictitious scenario that serves as a training, deliberately decontextualized. For example, emergency surgery, natural disasters, but also daily situations related to the needs of people with various types of disabilities. The information and sensations experienced by the user, remaining strongly imprinted, allowing him/her to sharpen perception, attention and memory by promoting understanding of the context and behavioral changes through the so-called learning by doing. Unlike Gamification, which only contains some elements derived from the games, such as the allocation of points or achievement of levels, the Serious Game is completely a game (Arnab S. et al, 2012).

Fig. 1. Example of 3D Serious Game.

- *Educational Robotics*: the word “robotics” refers to a machine able to perform tasks autonomously. A robot consists of three main parts corresponding to some parts and functions in the human being: a) computers and software → brain; b) engines and chassis → muscles and skeleton; c) sensors → sense organs.
- The computer and software start from the sensory information to make decisions and to move motors. The sensors can be of various types (contact, sound, distance, color, gyro, etc.).
- The idea to let students manage computers, providing them with objects that they can easily manipulate and make experimentations, arises from the Massachusetts Institute of Technology (MIT) and from the revolutionary ideas of Seymour Papert (Papert S., 1994), with his programming language LOGO. The first experiment was a programmable mechanical turtle, then the turtle became virtual and finally with Mitchel Resnick[1] was built the first prototypes of LEGO / Logo.
- Educational robotics allows to work in small groups of teachers and students with the aim to learn in a fun and creative way.
- *Virtual reality (VR):* it indicates a simulation of the actual reality. With the advancement of technology, virtual environments become more and more realistic allowing also the interaction with the objects inside it (Zheleva M., 2015).

Even if, at a theoretical level, the virtual reality is constituted of a totally immersive environment in which all the human senses can be used (the so-called Immersive Virtual Reality), currently the term is usually applied to any type of virtual simulations created with the use of computers, from video games that they are viewed on a normal screen, to the applications that require the use of special equipment such as wired gloves (Biocca F., 1995) (Tramonti M., 2015).

A variation of virtual reality environment, currently existing, is the *Augmented reality*, that means the enrichment of human sensory perception by means of information, usually manipulated and conveyed electronically, that would not be perceived through the five senses. It is a web-based application that allows you to view streamed directly an overlap between real and virtual elements, such as 3D animations, videos, audio and multimedia elements (Behringer R., 1999).

The elements which "increase" the reality may be supported by a mobile device, such as a Smartphone, with the use of a PC equipped with a webcam or other sensors, with vision devices (e.g. protective glasses), of listening (e.g. headphone) and handling (e.g. gloves) that add multimedia information to reality already normally perceived. While in virtual reality, the information added or subtracted electronically are dominant, to the point that people are totally immersed in a virtual situation; in augmented reality (AR), instead, the person continues to live the common physical reality, but benefits from additional information or manipulation of reality itself. The distinction between VR and AR is, however, contrived: the mediated reality, in fact, can be considered as a continuum and are not simply two opposite concepts (Milgram P., 1994).

[1] http://www.lego.com/it it/mindstorms/?domainredir=www.legomindstorms.com

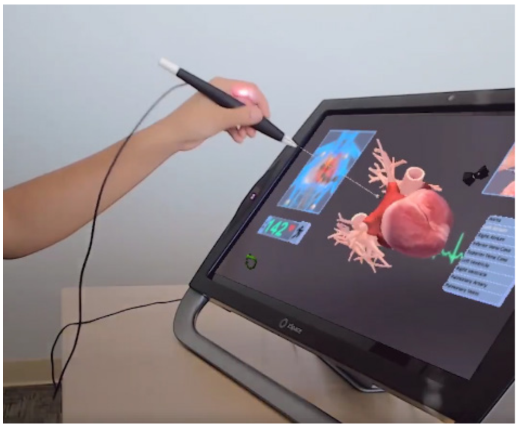

Fig. 2. Example of Augmented Reality

In the following paragraph, the Author presents one example on how the introduction of digital tools can reinforce a learning setting.

2.1 Digital Tools as Facilitator of STEAM Skills Improvement

The use of the technology combined with Inquiry-based Learning approach (Hutchings W., 2007) increases knowledge formation to be applied in different and wider fields.

In the current technological world the memorization of the facts and information is not the most important ability. Since the facts change and we can easily collect information, it is necessary to understand how to give meaning to all the data collected.

Therefore, teaching has to overshoot the simple data and information transmission in order to develop the production of useful and applicable knowledge. Teaching-learning process based on the Inquiry-based approach (Ontario Government, 2013) supports other didactic methodologies (e.g. problem-based, project-based, cooperative learning), since the research is a fundamental factor, not only for a constructivist approach, but also for cooperative and collaborative teaching. The teaching, based on inquiry approach, should conduct students towards knowledge of a real-world for a successful development of their future private and professional life. Thus, the students will be able to combine and relate the technology with the scientific inquiry method. This will allow them not only to understand the contents, but also to learn to apply the same method to different study fields.

This model is lined with Papertian theory (Stager G., 2005) based on which students already possess knowledge upon entering the classroom; the teacher acts as a facilitator that guides learners in scaffolding a new knowledge upon existing experience in a step-by-step manner. Learners are given the opportunity to act not only as information consumers but also as information producers by designing and modeling their virtual objects for building STEAM skills.

Therefore, the technological educational model is focused on “learner centered” and “situated” for the development and improvement of STEAM skills.

Another example on how digital tools can be introduced and used to reinforce the student learning process is described in the following approach.

2.1.1 From the manipulation to the creation of digital tools

The learning process considered comes from a new combination of Western and the Singapore's method approaches, and, in particular, between analytical methods and Eastern holistic approach for the mathematics teaching. The theoretical reference system under consideration from the Western researchers could be schematized by referring to Aristotle with the organization of bivalent logic characterizing the way of arguing in western culture. For example, Euclidean geometry, the first structured language in the math's history, is a model of Aristotelian bivalent logic (Leung, 2001).

In fact, Eastern researches prefer, in general, following a different approach from Aristotelian hypothetical deductive that is the continuous search of relationships among things, such as phenomena or objects (Spagnolo F., 2010). In other words, the aim is to favor a relational thought connected to a concrete arithmetic concept and to develop skills for the recognition of relationships among variables, to be able to work on them dynamically. This approach, mediated by teacher, can promote in the student a stronger recognition of the relationship between syntax and semantics of arithmetic writing. For example, the theory of the elements is defined on the base of their function in a situation. This is analogous to the method mostly used in mathematics, according to which an object is determined from the relationships established with the other objects.

Therefore, the mathematical reasoning results can be assimilated to a set of analysis and synthesis processes that evolve in the development of both abstraction and generalization phases through the so called "variations". In addition, the observation and recognition of invariant elements can give rise to generalizations through the search of algorithmic procedures unifying and contextualized in more fields (Gu L., 2004).

The Singapore approach is defined as the Concrete to Pictorial to Abstract approach (CPA) applying the so-called Concrete to Representational to Abstract (CRA) strategies (Witzel B.S., 2008). This approach aims to teach student how to visually represent math concepts before applying the abstract symbols like numbers and equations (Ginsburg a., 2005). This helps students make their connection and draw generalizations about the concepts learnt and not simply memorization of disconnected and isolated facts (Hazalton M., 2008). In this context, students experience different types of representations of the same concept by finding correspondences and relationships among them. This step conducts students to consolidate conceptual understanding (Clements, 1999). Thanks to this transition, starting from concrete objects to pictures arriving then to symbols, the Singapore approach offers many and various opportunities to learn maths concepts, especially for students with difficulties (Jordan L, 1998).

The result of the combination of Western and Eastern approaches (the Singapore's method) is that to overcome the gaps, which some researchers have identified in both eastern and Western teaching approach (Stigler J., 1999): while western teachers of mathematics focus on student understanding through concrete examples, eastern teachers on abstract thinking after the use of concrete examples. In additional, Eastern teachers are more concentrated on the mathematics content, process and student's learning when they plan their lessons teaching to their students through a “rote learning” or “repetition” (Leung, 2001).

Moreover, the combination proposed will be developed using “art” as unifying element and, to use Guy Brousseau’s word, as “milieu” (Brousseau G., 2002), that represents the context or means through which students can reach knowledge.

This will occur through the application of three phases of the Singapore’s method (concrete-pictorial-abstract). In the first phase, “concrete” students will do manipulative experience with objects to understand how do they work. During “pictorial” phase students learn how to transfer their knowledge through the real objects into a mind image, into a diagram or drawing. Finally, the abstract phase, they learn to use mathematics symbols.

In the application of this method a single system will be developed by the integration, as defined by Guy Brousseau (Brousseau G., 2002), of three situations (a-didactical, non-didactical and didactical) in which a “student” can learn how to do science, to use it and to invent it.

The context will be *A-didactical* because the students will learn mathematics topics by discovering that different relationships exist among things or maths concepts (even if they cannot be so explicit) and by developing, accordingly, problem solving skills avoiding to memorize just the solution procedure. It will be *Non-didactical* because several worksheets will be prepared for the students before starting the experimentation phase. These will contain instructions to lead the student from concrete phase to pictorial up to the abstract one. Finally, it will be *Didactical* because the teacher will have the function to mediate and support the learning process through the creativity and the imagination of their students. The use of the creativity from students will be let free, especially when they will produce their own art-works on the base of maths concepts studied.

Also in this application of the three phases through the art-works, the use of digital tools and the virtual environment can be introduced in order to make student learning more effective.

Since this combined learning approach is still at the beginning conceptual phase with no results available at the moment, an example related to a possible introduction of digital tools in this approach will be described here below to clarify the concept further.

Firstly, in the concrete phase, students will learn and familiarize with tools and modalities useful to construct specific objects to be studied such as a dodecahedron by using Visual Modeling Programming in 3D like Geogebra as in the following figure:

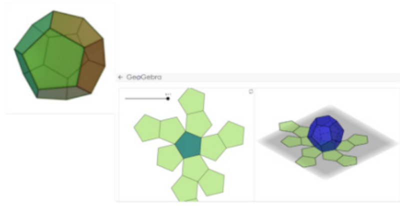

Fig. 3. – Dodecahedron representation using Geogebra application.

Secondly, in the pictorial phase, they will learn how to recognize math in the art exploiting the potentialities to work both in a group and individually. For example, they will be asked to find the art works containing dodecahedron shape, such as “The Portrait of Luca Pacioli” of Jacopo de' Barbari (around 1500).

Fig. 4. – Dodecahedron contained in “The Portrait of Luca Pacioli” of Jacopo de' Barbari.

Finally, in the abstract phase, they will create their artwork, using their creativity, started from the scientific formula studied. Students will be able to produce their artworks using modeling programs for the objects creation and, then, in order to make the learning process effective and attractive, these art-works will be uploaded in a 3D Virtual Museum (Tramonti M, 2017) realized with the support of Unity 3D software as shown in the figure below.

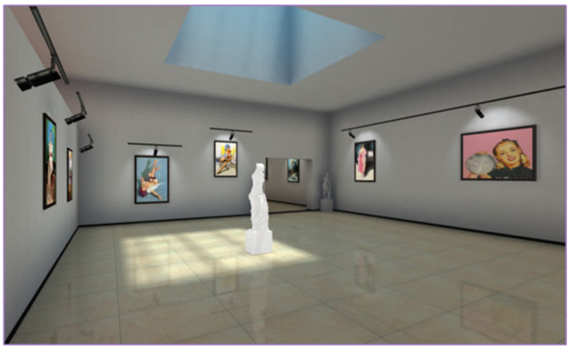

Fig. 5. – An example of 3D virtual environment using Unity 3D.

3 Conclusion

The use of digital tools in a specific learning setting can be an effective combination for the development and improvement of student skills, especially in STEAM field. These tools will ensure their engagement and interest thanks to the exploitation of different languages such as visual, sensory, verbal and nonverbal by favoring the development of both cognitive and emotional dimensions. As a result, the study of scientific subjects like mathematics, that usually is considered boring and difficult, can turn into attractive and funny. Currently, the research project is in the phase of the designing of educational tools which will be tested in the next experimental phase in order to check the validity and the effectiveness of the educational model proposed.

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