PRODUCT DESIGN & 3D PRINTING: INTEGRATING NEW TECHNOLOGIES INTO THE CURRICULUM. CASE STUDY.

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ABSTRACT

The start of the 21st century takes us to the study of a new paradigm in knowledge, which has led different theorists to question and suggest a new education system. The rise of new information and communication technologies has not only evolved our lifestyles but also redesigned new methodologies for knowledge. Educational content is done for the curricular implementation in the subject of technology, and a scenario where students develop and experiment projects based on the regulated abilities by the Spanish education. A qualitative assessment that can be a guide for the teacher to improve the establishment of these named technologies in education and future proposals and investigations.

Learning methodology based on projects (PBL) and 3D printing as an experimentation tool is applied, constituting it as of the most important emerging technologies to face the new education of the digital era.

KEYWORDS

New technologies, Product Design, 3D Print, PBL, ICT, Education, Curriculum

1. INTRODUCTION

The start of the 21st century takes us to the study of a new paradigm in knowledge, which has led different theorists to question and suggest a new education system from different points of view, mainly based on the historical distinction between Arts and Science. Currently, new educational methodologies suggest a change so that both can be unified.

Development on Information and Communication Technologies (ICT) and the rise of the Internet have not only evolved our lifestyles but have also altered our way of being in contact and interact with others.

From the educational point of view, the implementation of new technologies in the classrooms has promoted a change on the use of the tools by the faculty making it easier for students to develop their digital abilities and guaranteeing an extra learning during their educational process. It should be recalled that these ICT are not prepared to create knowledge, in order to solve this problem technologies for Learning and Knowledge (TLK) are created [1].

These technologies, applied from an educational point of view, with proper resources and an expert teacher, can become excellent tools for the student to develop new knowledge.

But basing the learning on the use of one or some specific tools is not enough anymore, because these are increasing and are constantly changing and being updated. According to Lozano [2] & Enríquez [3], "[…] it is not enough to teach ICTs anymore, this must go together with methodological knowledge to learn or build with them significant learning".

To give an educational response to the evolutionary rhythm of the technological society, numerous schools have reconsidered their traditional education structure on behalf of new methods such as Project Based Learning (PBL).

Vygotsky [4] outlined a learning model where the students conceive, develop and experiment projects that are applied to daily life and at the same time creates a process where students acquire dexterities, processes and abilities to learn on an autonomous way.

Dewey [5] and later Bruner [6] outlined the basis of knowledge acquisition through constructivism, focusing on the student and his or her goals, building knowledge by communicating with their schoolmates and the achieved experience [7].

To accomplish this teaching-learning process based on the foundations of the PBL, it is necessary to delimit it to the TLKs inside educational field. For Canales, Carrillo, & Redondo said [8] "technologies have become a tool of undeniable value and efficacy at the management of information with educational purposes, acquiring significance on the teaching-learning process, being the PBL the appropriate methodological approach".

But the inclusion of these practices into the educational field means that the teacher needs to have a huge knowledge of the different technical abilities while having the endless number of tools with multiple possibilities that are offered by the manufacturers.

Facing that situation, in a lot of cases, according to Reig [9], "[…] the teacher will have to use a digital methodology and the required tools to give the learned things meaning, or learn how to adapt to the enormous amount of knowledge that we have created".

This way, it is investigated the way to pass on the knowledge about technology inside the educational field so that the teachers can keep using those tools outside that environment and, in general, adapted to society.

2. OBJECT OF STUDY

The main objective of this investigation is to make a qualitative assessment through the observation of the use of new technologies applied to the educational field.

To that effect a didactic model is done inside the framework of educational technological abilities where the students can learn and test using 3D printers.

This study is done at Txikitech company, based in Bilbao, and around 100 children aged between 10 and 14 took part during the school year 2017.

Through this project we will study, from both point of views of the student and the teacher, the interest generated by the addition of activities with 3D printers during the subject of Technology for the development and improvement of future activities.

2.1. SPECIFIC OBJECTIVES

To develop the object of study we define the project inside the general objectives established inside the legal basic education curriculum known in Spain as "Educación Secundaria Obligatoria (ESO)", published in the "Boletín Oficial del País Vasco (BOVP)" on January 15th 2016, Friday (pp. 237-279).

To develop a teaching subject named "Design and 3D printing", we place it inside the 7th unit in the bulletin: "Control, robotics and programming technology".

According to the 236/2015 decree, issued on December 22nd, where it is established the curriculum for the basic education and it is implemented to the autonomous community of the Basque Country in Spain, the basic objectives that must be developed during that stage of the technology have to be the following ones:

- "To detect a technological problem and design and plan a solution for it, searching and selecting the information from different sources, […] encouraging an enterprising behavior from the context itself".
- "Analyze objects and systems of the technological field in a methodical way".
- "Represent and simulate through appropriate channels and tools the expected or accomplished technical solutions".
- "Manage freely and responsibly technological elements from the environment, suggesting options to improve, checking different sources if needed, to solve habitual situations in different contexts".
- "Obtain, on the virtual or the physical field, the solution for a technological problem, preparing the required control program".
- "Assess the process on the followed work, as well as the obtained product, […] to guarantee that the technological problem has been solved and to be able to plan a new improvement cycle".

2.2. KEY COMPETENCES

To achieve a quality examination, the student will have to pass all the objectives through the abilities for a formal education that are underlined in the 2nd article of the Royal Decree 1105/2014 issued on December 26th, p. 7 of Spanish Education:

- Linguistic Communication.
- Mathematical competence and basic science and technology competences.
- Digital competence.
- Learning to learn.
- Social and civic competence.
- Sense of leadership and entrepreneurship.
- Conscience and cultural expressions.

3. AN EDUCATIONAL AND TECHNOLOGICAL NEED

In 2015 the company Txikitech is created to develop the project "Engineering for children" in Bilbao, where the integration of new technologies into the curriculum is carried out. A high percentage of the students identified the need and interest of a technological education, added to the one given at school.

In the same way it was analyzed the possibility of how to make the most of this interest and encourage an education from a playful point of view and outside the school hours and to be part on the educational and academic fields.

At the same time, López & Ponce [10] considered that experimenting with practical processes in education that permit to see the performance of a tridimensional object in the virtual environment of a computer and later a real representation through a 3D printer, provides inside the educational context an experience that improves the education-learning process.

Beltran & Rodríguez [11] consider 3D printers are a resource that is slowly finding its place among schools through teachers themselves and professional help from the outside. Generally,

these are people who teach computing and technological subjects, who want to use the design of components and their later printing to achieve the learning objectives.

The use of software for the following 3D printing inside the educational context has been possible due to the price decrease and the technological improvements that have caused new low cost or free applications so that both teachers and students can work in a tridimensional environment [12]. But not all the schools are able to buy one or some 3D printers to be used but all or part of the students.

Canessa, Fonda & Zennaro [13] & Saorín [12], state that "it is necessary to have methodologies and educational resources that allow to take advantage of 3D printers in educational environments".

Facing this, attention is centered in different national and international projects that are not only focusing in education, but also in the development of technological projects and engineering that establish the day by day of our society.
Almost all of these technologies are related to the information and communication technologies, and they permit us to establish some short-term objectives to investigate, analyze, experiment and later implement them.

Jones et al. [14] consider that among the best-known projects RepRap can be highlighted, which created a model of a 3D printer that could be manufactured at home using parts that could easily be found and even be manufactured with other printers, the maker movement, FabLab, SPC-MakerBot, opensource movement, BQ education, etc.

In Spain, the project Clone Wars must be underlined, created and directed by the engineer and Doctor of Robotics Juan González Gómez [15].

Txikitech states that the new learning of technological subjects should not only and exclusively use the technological product but also new and renewed ICTs.

To achieve this union between the different products provided by manufacturers for the academic education and, at the same time, encourage children towards science and technologies, it is developed following a series of activities delimited by a worldwide educational trend known as STEAM (Science, Technology, Engineering, Art and Math) defined by the designer John Maeda [16], and encouraged by the Rhode Island School of Design [17].

This education model is characterized by the integration and development of scientific-technical and artistic subjects inside an only multidisciplinary guide, allowing the settlement of nexus between students, education centers, teachers and teaching units using a learning based in projects.

3.1. METHODOLOGY

Integration of new technologies into education, in this case 3D printing as a tool for knowledge has meant some changes in planning and development of the activities. In Spain, from a general point of view, we could say that the most used methodology in an educational environment in the relations between teacher and student is the personalized teaching. This is distinguished by the achievement of goals of each student, but without affecting the rest of the goal achievements of each of them. This way the teacher is the broadcaster and the student the recipient of knowledge.
According to Cabero & Marín [18], the entrance of the ICT and TLK into the classrooms has meant an evolution in education and learning so he will have to execute new functions and new roles as teacher at the new digital schools. This implies that the teacher becomes a designer of education situations that will have to spin around the student. This way the teacher goes from being an expert in content to a facilitator of learning.

López & Ponce [10] proposed the development of a new educational area inside an educational frame where these new TLKs and 3D printing as a tool take part we will focus on a PBL type learning based on constructivist theories typified by a collaborative learning.
This way, González & Del Valle [19] said the PBL makes the student become the leader of his own learning:

- Learning happens in small groups.
- Student-centered learning.
- Teachers work as learning guides.
- Abilities are constructed achieved through solution searching.
- New information is acquired throughout independent learning.
- Leaner starts a motivation-based process that generates the "How to make" and finds solutions based on problems.

3.2. STRUCTURE OF THE COURSE

For the structure of this case of study, an exercise by Núñez [20] is taken as model. He accomplished an educational unit to introduce concepts and the use of 3D printing, known as "3D printing" into the subject Technology for students in school years higher than the case that has been studied.

For this investigation a new educational unit named "Design and 3D printing" is developed, introducing new technological tools using the product design methodology.

A didactics educational unit is developed in Txikitech and named "Design and 3D printing" in order to develop and test the procedure of an educational topic inside the curricular frame of the Technology subject and slowly adjust to the objectives set by the BOPV.

This experiment needs to be developed during extracurricular time. The student spends a lot of hours at school under a theoretical learning, so it is considered that it must be adjusted to a more playful scenario from a pedagogical approach to make the most of the child.

As can be seen in Figure 1, Txikitech approaches the unit from two perspectives connected to each other: playful and pedagogical.

Pedagogical approach: refers to developing of educational material to adjust and achieve the targets set by the BOPV. For that matter it is developed under a PBL structure based on the basic principles of Design Engineering (Figure 2).

Playful approach: through the constructivist methods applied to TLKs and in this case using 3D printing tools, the student immerses himself in a learning environment through experimentation.
This lets us address a scenario where we can imagine, conceive, plan, experiment and solve problems, facing all the deep changes that are happening and how they can be introduced as tools and/or teaching units for curricular development.

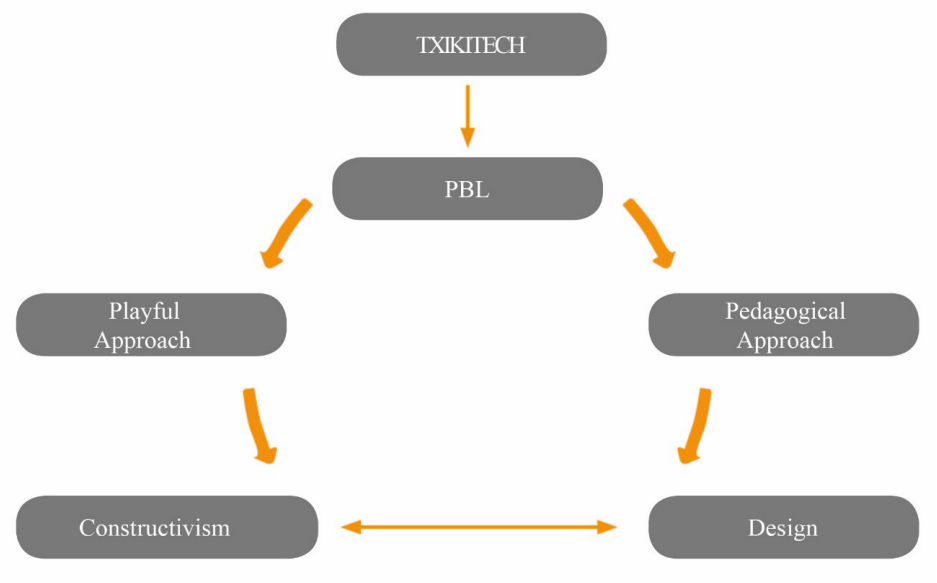

Figure 1. Approach for a learning based on design project

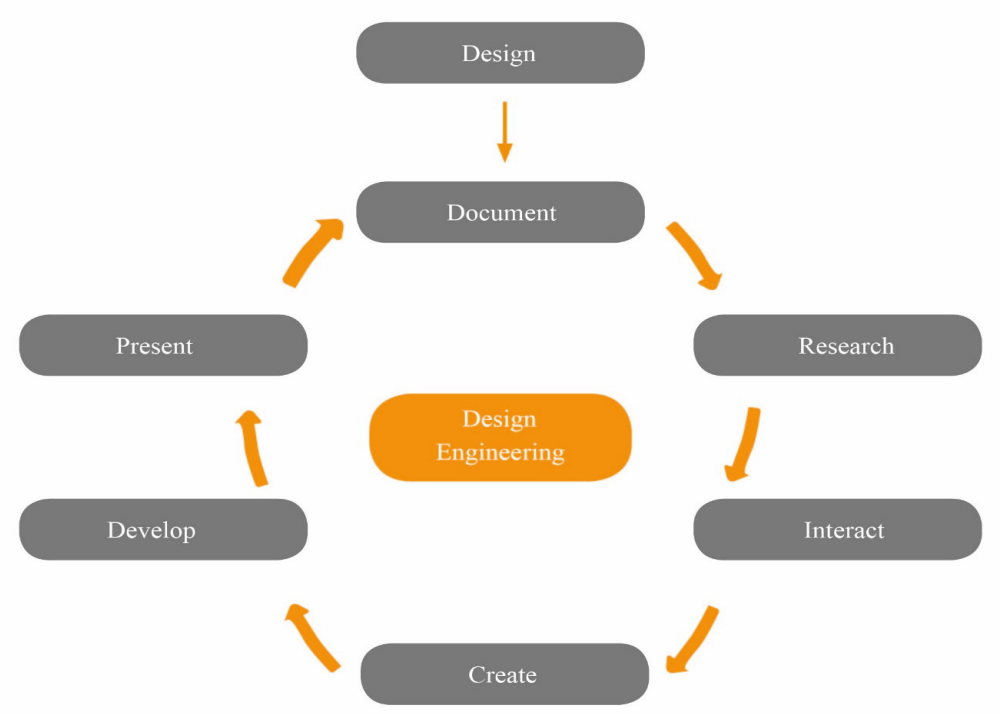

Figure 2. PBL structure based on the basic principles of Design Engineering

3.3. UNIT DEVELOPMENT

To accomplish the goals set by the BOPV and the basic abilities that a student should acquire inside a curricular program in education, the subject of Design and 3D printing has been divided in the two approaches previously mentioned.

A pedagogical approach that matches the knowledge acquisition through learning based on design projects and a playful and constructivist approach where the students will experiment their learning is suggested.

It is conceived for a trimester with the contents of the subject for students from 7th grade, 1st year of high school in Spain. The length will be a total of 12 sessions, one hour each.
Exercise that will be done – Brief "Dinosaur Exercise":

The student will develop a project that will investigate, conceive, create and manufacture a "dinosaur" using ICT tools and new technologies inside the subject of Technology related to the educational unit "design and 3D printing".

Concepts such as natural sciences, computing, creative and technical drawing and mathematics are included. The methodology used will correspond a product design PBL.

New resources and tools that are included in the curriculum are digital manufacturing, PBL, new digital manufacturing software and 3D printer.

3.3.1. Educational subject of Design and 3D printing

The educational subject of Design and 3D printing will be divided as follows:

Pedagogical approach:

- Product design and 3D printing: History and evolution – 1 session
- Design software assisted by a computer – 1 session
- Concepts for 3D printing – 1 session

Constructivist approach:

Conception – 2 sessions:

- Documenting and proposal that is going to be developed – 1 session
- Investigation and group interaction – 1 session (Figure 3)

Figure 3. Team paper for idea development

Creation – 3 sessions:

- Freehand and digital drawing – 1 session
- Computer assisted drawing – 2 sessions (Figure 4)

Figure 4. 3D Product design using computers and digital manufacturing

Manufacturing – 3 sessions

- Printer tuning – 1 session
- Preparation of the digital prototype – 1 session
- Prototype printing – 1 session (Figure 5)

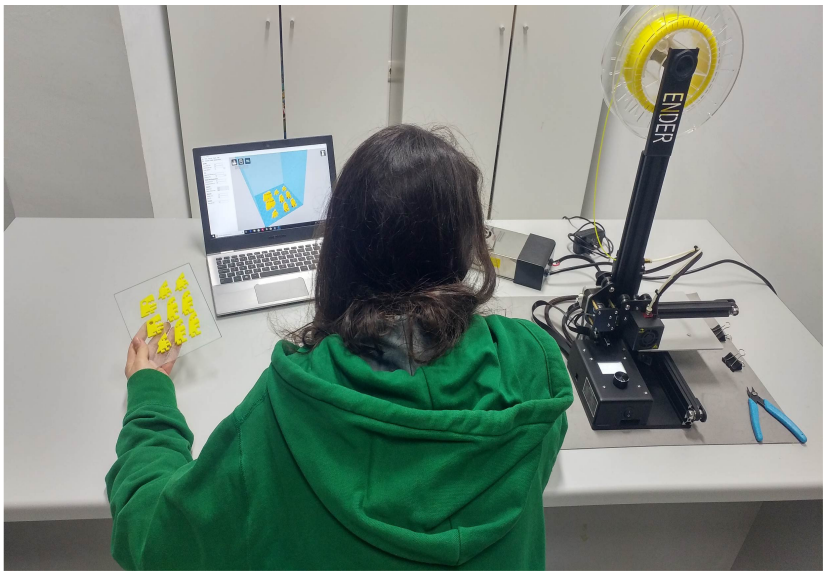

Figure 5. Product printing using 3D printers

- Presentation of the accomplished project (Figure 6)

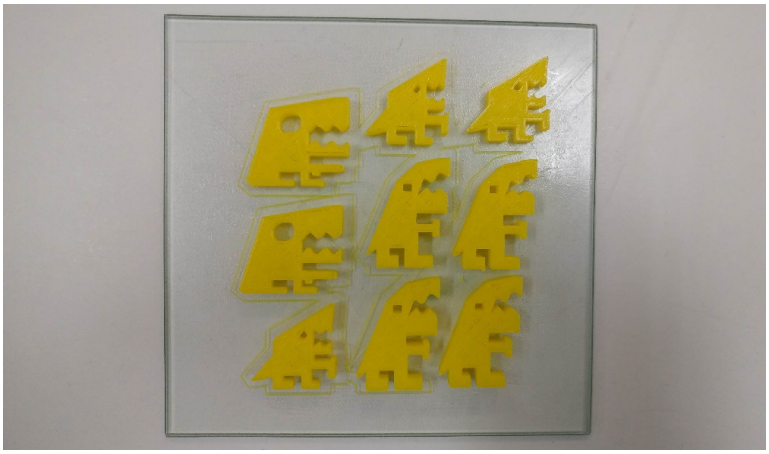

Figure 6. Final product that will be submitted

4. RESULTS

The objective of this paper is a qualitative evaluation through the observation of the students for the development and improvement of the subject Design and 3D printing inside the subject Technology in the curricular educational frame.

Considering the exercise done during the trimester, a qualitative evaluation is done based on the abilities that the student should achieve according to the 2nd article of the Royal Decree 1105/2014 from December 26th p. 7 of the Spanish education.

- Linguistic communication: a correct technical vocabulary is used to understand and communicate among students the elements related to technology, manufacturing methods and parts that form 3D printing: this means new and technical terminology that the student must learn for the correct use of the material and software. This communication is done both orally and written.
- Mathematical competence and basic competences in science and technology: a practical exercise is don base in the new educational trend STEAM. At the same time the "A" (Art) from STEAM is highlighted, this part being the creative supplementary one to the abilities mentioned in the title. Martínez Torán [17] said "the importance of the study of the subject and their application to real life is stressed". Due to the 3D printer we can make exercises where the students observe and experiment mathematics, science and technology from a practical view.
- Digital competence: all the abilities taken from the ICTs are used for a case study. At the same time these are complemented by new design and 3D printing software where they apply and develop simulations done in real life. Knowledge beyond playful software or text editors is acquired, this way managing new and different digital formats.
- Learning to learn: development through PBL from a design exercise distinctive of design engineering lets the student build knowledge in an autonomous way. The student has sensed phases and has conceived strategies to solve problems. The function of the teacher as a guide in the process of education-learning and not just as a knowledge broadcaster is introduced as key in this process.
- Social and civic competence: during the phase of the project the student has developed the ability of communicating with his classmates. From an individualistic point of view, each of the children has shared ideas and has contributed with solutions in every phase.

This way a supportive behavior and team work for the individualistic development of the exercise is strengthened.

- Sense of leadership and entrepreneurship: the application of mathematics, computing, science and technology from the practical point of view where the students can experiment practically in all the phases of the product design, transforms into personal initiative at the moment of facing with much more enthusiasm the urge to learn. The incorporation of these new ICT and TLK tools, in this case 3D printing as a tool for experimentation and manufacturing and new software for the development of a new design PBL methodology, has created cognitive changes and new behaviors on the student. According with Rivas Navarro [21], "this entrepreneurship ability from the point of view of building knowledge in an autonomous way makes them rethink that I used to do it this way; but now I do it this other way".
- Conscience and cultural expressions: analyzing the documents and studying the different proposals lets the student acquire new knowledge inside the ICT frame, in an almost unlimited and questioning way to achieve the solution of their problems.

5. CONCLUSIONS

From the point of view of investigation of how to introduce a 3D printer as a tool in the subject of Technology both at a curricular and extracurricular level, it means an evolution on the way to add science and technology to a society that is constantly changing. Both children and adults, students and teachers in this case, transform into a way to create the first steps of a communication between real life problems and exercises solved at school.

As done in previous studies, just like in robotics, 3D printing as an educational tool for the development of new information, communication, knowledge and learning technologies for an education based in design projects, proves that facing the changes in the educational field, the technological development and the digital break between native and immigrant digitals, a new discipline as opened the way in the development of new learning scenarios for the evolution of knowledge.

The 3D printer as a tool to experiment knowledge has been a motivation for students, where they have been able to strengthen their creativity and improved their multitasking ability applied to the different curricular areas.

Learning based on design projects has allowed the student to work in a more active and autonomous way, offering himself and leaning on his classmate.

The 3D printer as an educational tool has encourage team work. The continuous development of problem solving in a process where the teacher acts like a guide and not as a solution provider makes the students lean to each other giving their maximum cooperation. This cooperative learning increases the social and communication skills that let the student share ideas to overcome challenges.

"How to make" has led the student to the curiosity of a continuous learning where not only has he experimented the ability of performing his idea, but he has also made the most of capacity of the ICTs as an information source, receiving encouragement that cannot be achieved with a traditional or individualistic education.

The programs used for the project have been "open source". Free use in most cases typify these. Their development means progress as in that all the students can use these technologies not only in the classrooms but also at home for free. Against it, we can see that these are not always updated or are constantly being renewed, appearing changes that mean a lot of time to prepare the material.

From the teaching point of view, continuous and guided learning is required inside the new educational model. A lot of time is needed to prepare and develop contents and to maintain all the prepared and adjusted material for the student to use it.

Beyond any political, economic and social questions, we find factors that make it difficult or even impossible to admit these practices inside the curricular educational environment and that is why is offered in an extracurricular schedule. Among others we can underline training the teachers for ICT and TLKs, the introductions of the pedagogical practices, the lack of economic resources for the acquisition of technological tools, an oriented educational program, etc.

6. FUTURE LINES FOR DEVELOPMENT

Investigating the new possibilities that are offered by new technologies for their educational use. For that it would be convenient to study them from a non-instrumental or productive point of view. Analyzing new meanings and functions to create a new educational or school model that answers to the new society whose technology is constantly changing.

As this is a new educational scenario, the introduction of new technologies both as curricular methodologies and/or tools, it suggests a change in the idea of classroom formation or positioning. An investigation of the formation of the new laboratory is required, where we can make the most of this new education for the integration of the new technologies in our curriculum.

We take as a reference already existing projects from scenarios where an education around new technologies is applied. A good example would be the FabLab (Fabrication Laboratory) and all the spaces linked to the digital manufacturing that are becoming a powerful tool for our society in a short period of time. These spaces are distinguished by the development of projects connected to the production of physical objects through machines capable of manufacturing anything. Their mission is to favor any person's creativity through manufacturing and project development through a worldwide collaborative learning.

Studying a new vision of the model of teacher. New practices and methodologies that are constantly changing are required. The teacher will have to assume new roles to build the knowledge through technological tools.

The development of an educational program that allows to have a learning program for a non-prepared faculty is investigated, and this, along with their pedagogical abilities in educational subjects is the base for the proposal of new technologies based in the new ICT and TLKs.
A new line of investigation in the concept of STEAM is opened under a PBL approach. New proposals for the integration of technology as learning tools for students and as educational resources for the teachers are researched.

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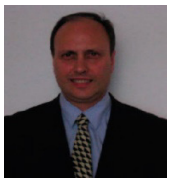

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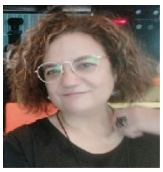

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