Use of Robotics and A Learning Methodology Based on Engineering Design Projects

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Abstract - The start of the 21st century, the development and evolution of new information and communication technologies (ICT) opens a new paradigm in the area of knowledge, bringing a debate about new and renewed learning methodologies for their implementation in the educational system. A technological environment for children is designed based on the principles of design engineering for a project-based learning (PBL). Robotics constitute the tool to assemble different curricular subjects such as mathematics, technology or sciences, thus allowing the student to acquire new abilities and competences. The objective of this paper is the creation of a scenario for obtaining results and conclusions for future investigations, reconsidering new methodologies and learning units based on new technologies to face the new education in the digital era.

Keywords –Engineering, Design, Technology, Robotics, PBL, Education.

1. INTRODUCTION

From the pedagogical point of view, ICTs have favored the use of different information and communication media among the teaching staff, encouraging the student's curricular development in digital competences and guaranteeing a supplementary training in an educational process.

Since ICTs have been established in our society, it has to be highlighted the transformation of the way to access information and knowledge. This way it is being established that new technologies are favouring knowledge so that it can be managed, which is making society to start talking about new technologies for learning and knowledge (TLK).

According to Moya [1], these ICT and TLKs have opened a new paradigm where teachers and educational systems have to reconsider new formation spaces and new educational contents and therefore new methodologies that stress in the teaching-learning process.

In a pedagogical level, in Spain this need cannot be satisfied, due to the great lack of qualified teachers which affects the student directly. Most of the teachers hold that scientific disciplines are the ones that teach children about their environment. Science study plans are focused almost exclusively in nature, even if this only constitutes a small part of our everyday environment. Most of the products with which we coexist belong to an artificial world, designed by humans: telephones, houses, computers, clothes, fridges, pens, cars… All this technology created by humans as a result of an engineering design process is absent in children's curriculum, and the spend a great amount of learning time with things that are irrelevant for their lives. This study plan makes us technological illiterates [2]. Because of this, maintains that, "the educational model has to be changed and engineering has to be the master key to make the study of science more enjoyable and linked to the world around us."

In a pedagogical environment, robotics becomes a process to ease and develop educational abilities such as creativity, integration, socialization, critical thinking, problem development, etc. Allowing the student to obtain an answer to the continuous technological changes.

Ruiz-Velasco [3] defined educational robotics or pedagogical robotics as a subject whose purpose is the conception, creation and commissioning of robotics prototypes and specialized programs with pedagogical purposes. He states that the use of robotic tools not only favours the learning-knowledge process, the easy integration of the theoretical with the practical, the development of critical thinking and the acquisition of scientific notions, but it also contributes to the development of new abilities, new concepts and strengthens systematic, logic and structured thinking, solving specific topics and giving a prominent answer to a constantly changing society.

The teaching of robotics does not mean directly training students in this matter but taking advantage of its multidisciplinary characteristics and creating new learning spaces with the main objective of making classrooms the new experimentation laboratories where students can ask themselves and constantly question the developed work, directly influencing other subjects and awaking interest for knowledge [4].

2. EDUCATIONAL ROBOTICS

Nowadays the need to promote new interdisciplinary learning scenarios where students develop new abilities to investigate, conceive, solve problems and finally experiment to give a solution to new lifestyles has in-creased.

In the pedagogical curricular field, the union of various disciplines focused in engineering meant that robotics manufacturers turned to education. This integration is based on the educational trend that has been considered in different countries such as the US and Japan to include pedagogical robotics in the STEAM education, and acronym borrowed from English that makes a reference to the subjects of science, technology, engineering, art and mathematics, and thus adopt an integrating part in teaching and learning.

The US organizations United States National Researched Council, National Science Foundation and Society of Education of the IEEE, consider that these integrations to these disciplines are basic for technologically developed societies.

Vasquez [5] says that STEAM education is an interdisciplinary approach for learning, where complex academic concepts, together with real life lessons of how students apply science, technology, engineering, art and mathematics, is given in a context that gives connections between school, society, work and companies.

To address said proposals it is suggested as pedagogical material the use of new information, communication, learning and knowledge technologies through activities such as educational robotics with the aim of integrating knowledge in other educational areas related to curricular subjects that students have in their formal education.

Simultaneously it has to be highlighted that the aim of the investigation is to evaluate the qualitative form of the process to start a theoretical-practical educational mean that is available for first and secondary education teachers, that allows them to include in the teaching program elements and exercises compatible with a technological education related to our sociocultural environments.

At the same time, it is pursued to motivate using ludic concepts the interest for science and technology through investigation, conceiving, development and experimentation with real cases approaching knowledge in a more enjoyable way.

As has been described previously, educational robotics can be placed inside the activities that belong to STEAM. These activities have allowed the development between children, teachers of their regulated education and teachers.

Jacek [6], quoted by Pedro Antonio Ramírez and Hugo Andrade Sosa [7], makes an analysis about the use in education, classifying it in two types: robotics in education and robotics for education. The difference is in the use of the robots for the learning of robotics in the first case and the use of robotics for the learning of topics of different knowledge areas in the second case.

In this case the found experiences are studied to determine the role that computer science plays in the learning of and with robotics.

The process is centred on the study of both learnings inside the curricular activities of the STEAM environment. Computer technology gets to be a tool belonging to ICTs for the development of activities.

Pedro Antonio Ramírez and Hugo Andrade Sosa [7] describe that robotics belongs to the technological branch, thus constituting the “know and make” about the robot. This knowledge implies the learning or knowing of other branches such as design, building, assembling and launch of the robot.

It is considered that in this learning it is necessary that the student pays attention to other educational subjects such as mathematics, technology, drawing, electronics, programming, electricity, mechanics, etc., becoming a multidisciplinary theme. Azcaray et al. [8] contend that this multidisciplinary process can be achieved from a learning from design and a constructivist learning.

The student will be capable of conceiving, thinking, imagining, experimenting, deciding, investigating, developing, innovating, inventing in a collaborative environment and supported by teachers.

All this knowledge acquisition will be done in a technological environment based on ICTs and from an educational point of view based on new STEAM tendencies, thus preparing the student to the continuous changes and challenges of the society.

3. AN EDUCATIONAL AND TECHNOLOGICAL NEED

This research it is developed during the academic year 2017 at the site of Txikitech Bilbao with a sample of 99 boys and girls divided in groups into age groups between 11 and 12 years old as stablished by the study cycles in the regulated education valid in Spain (LOMCE).

The need and interest in robotics of a high percentage of students was identified from a playful point of view and outside the extracurricular timetable. At the same time, the possibility of how to take advantage of the concern to take part in the pedagogical and academic field and to be part of a curricular subject inside the regular education.

Eyes are focused in some national and international projects in education, technology and engineering, aiming to set some short-term objectives to be investigated, analysed, experimented and later on put into practice. A predesigned and commercialized educational robotics kit was taken as reference. Among the most well knowns Lego Midnstorms education, SPC-Makeblock, Vex

Robotics, Fishertechnik, Parallax Scribbler and Dynamixel have to be underlined.

But not all the study centres are able to buy one or more kits so that they can be used by all or part of the students.

The company establishes that new knowledge in technological matters should not come from the technological product but from new or renewed ICT methodologies.

To achieve this link between the different tools that the manufacturers provide us with and the educational environment of regulated education and at the same time encourage the youngest ones towards science and technology, a space for activities and work framed in a worldwide educational tendency known as STEAM is developed.

These activities have allowed the establishment of nexus between children, study centres, teachers and curricular educational subjects, always under a learning based on learning making and learning playing.

3.1 Approach to the problem of investigation

After identifying and analysing the educational needs of the company, a new study model is proposed, where all parts take part: student, school teacher, company teacher, school management and parents so that it is possible to integrate ICTs and TLKs in a continuous way inside the regulated education.

The educational basis of the company is focused in industrial design processes and project development to transfer and make it a reality in first and second education.

For that, it is developed a series of structured and level organized educational units according to age and previous knowledge of the students going around the basic principles of design engineering, PBL and STEAM educational methodologies (see Fig.1).

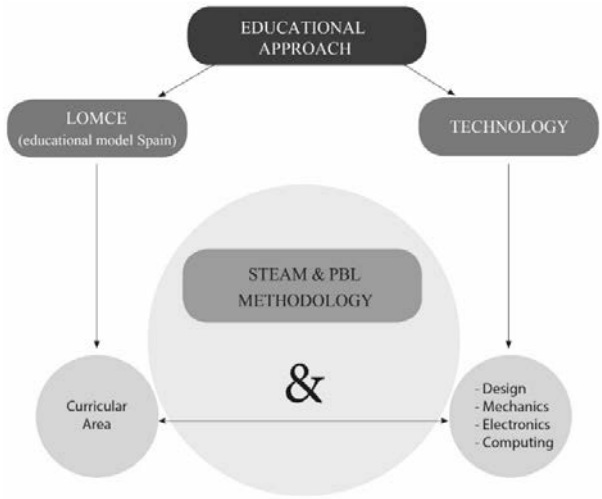

Fig.1. Approach for a learning based on design PBL and STEAM.

3.2.Methodological approach

It is understood as methodological proposal an educational scenario developed by the company framed in a theoretical-practical investigation case for the development of the robotics teaching and learning process from strategies typical of engineering design, PBL and STEAM models:

· Encourage children towards the importance of an education based on science, mathematics, computer science and engineering subjects.

· Create abilities in the students based on the new ICT and TLKs and make them a resource for the curricular development.

· Promote a technological education with easy use and valid comprehension both for the educational environment and for personal and life environment.

· Proposal of a methodology that integrates product design and design engineering and the use of robotics as a tool for creative and technological development.

· Development of pedagogical strategies and educational material for the orientation of curricular students and teachers in processes of technological learning in constant change and development.

· Create and collaborate environment where projects and proposed challenges solving can be done in a group dynamic and integrating way.

· Make all children aware of genre equality and integration for the interest of science and technology learning.

4. DESIGN OF A TECHNOLOGICAL SCENARIO

4.1.Structure of the workshop

It is developed from a pedagogical approach where the student feels in a playful scenario. The students spend too much time at school with theoretical learning. It is proposed a design and constructivist workshop (see Fig.2).

The student performs a process where curiosity, the making and how to solve problems is promoted.

This knowledge acquisition is characterized by the continuous questioning of how things work and how they can be done and it allows to create exercises where creativity elements take part in a science and technology environment.

This constructivist method where robotics as a tool and design as project structure will be used will allow the student to fulfil himself and answer questions at the same time, being leader of his own learning.

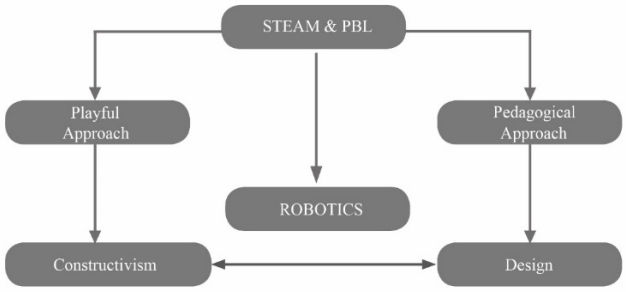

Fig.2. Approach for a learning based on engineering design projects

4.2.Design of the workshop

A scenario where the main objective is that the student feels like a little engineer (or designer in this case) is created.

This allows us to address a workshop where it is possible to imagine, conceive, plan, experiment and solve problems watching closely the deep technological changes that are happening and how to introduce them in the curricular development.

In Fig.3 it is shown the pedagogical approach based on a project-based learning using as reference the structure of an exercise of product development inside design engineering [8].

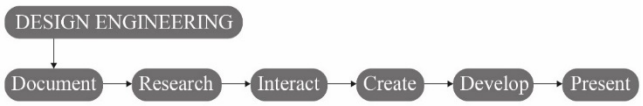

Fig.3. PBL structure based on the basic principles of Design Engineering

4.3. Development of the workshop

The development of the workshop has 6 main steps:

Documenting: the needed documents will be provided to acquire and complement the knowledge taken from school subjects. At the same time the students will be provided with scientific materials based on new technologies. The student will receive all the theoretical information from the new ICTs. As previously described, computer science will become a communication tool for learning.

Defining and investigating: a scenario, a problem or a challenge will be established in order to find its solution. Students will have to be able to search for new knowledges with the help of the teacher. In this phase the students start to be the leaders of their own learning. The use of searching tools (ICT), brainstorming sessions and participation so that students are involved in the development of the project are encouraged.

Conceiving: through the acquired knowledges, the conceiving phase of the project will start. The students will work in small groups in a collaborative way. This way they will be able to try and develop what they learnt feeding one to each other.

Creating and prototyping: the students acquire the specific knowledges of robotics, functioning of things and the implementation in real life. The student will start to experiment through the previously acquired knowledges.

Experimenting and developing: the student already knows how to solve problems through reasoning and knowledge to develop the product.

Projecting and presenting: once the project is done, the student will be ready for the divulgation of the exercise done sharing with his classmates the experience and knowledges.

5. RESULTS

Considering the previous exercise of the different challenges and projects carried by the students, the following results are deduced:

- Increase of the creative ability applied to the development of an objects used in everyday life. Development of a process based in projects starting from the general idea to the development of a product.
- Ability to develop exercises where different knowledge areas take part such as electronics, programming, computer science, robotics and design. Ability to integrate in join and individual exercises.
- Knowledge, management and use of different sensors and analysis of them in products used by society.
- Raise of interest of how things are done and their application in other sub-jects in the education environment such as mathematics, sciences and technology.
- Increase of the development and problem-solving ability. Through a constructivist methodology, it allows the student to find multiple versions for the development of an exercise.
- Greater ability to experiment and manage the tools for content analysis.
- Increase of confidence and self-esteem facing the possibility of finding solutions. This generates at the same time an increase of knowledge.
- Development of technical language associated to new technologies and its application to everyday life or the school environment.
- Control of the abilities related to challenges and projects worked through robotics with its application with examples of products in everyday life and subjects typical of the STEAMs.

- Greater group work capacity and group solidarity.
- Awareness of the integrity and respect for genre equality in the area of sciences, technology and engineering.

6. CONCLUSIONS AND FUTURE SCOPES

From the point of view of the investigation of the introduction of the educational robotics in classrooms both at a curricular level and extracurricular level it has supposed an evolution of the way to integrate science and technology in a society that is constantly changing. It develops to be the way to generate the first steps toward a direct communication between problems in everyday life and exercises done in the classroom.

Robotics as a tool inside new information, communication, knowledge and learning technologies for education in a methodology based in design engineering demonstrates that, facing the continuous changes in the education outlook and the technological development or the existing digital breach between students and teachers, it is starting to develop to be a disciplinary possibility in the creation of new learning spaces and knowledge evolution.

Nowadays it is identified that the principal source for learning in matter of science or technology is given in a university environment related to engineering. The challenge has been to take the first steps to address the new educational paradigm in constant changes based on new technologies and how it can influence in a close future if those knowledges have already been worked before getting to superior studies.

But this new paradigm collides with the possibility to integrate robotics and design in the curricular subjects in elementary and secondary school and A levels.

Beyond the political, economic and social questions there are a lot of elements that hinder the recognition of these exercises inside the curricular environment and thus it has to be offered as extracurricular subject. Among others we can highlight for example the learning of ICT and TLK sub-jects by teachers, new pedagogical practices, the lack of economic re-sources for the acquisition of technological tools, an oriented educational project, etc.

These knowledges and technics developed by Txikitech allow at the same time to have a learning platform for non-qualified teachers that, with their pedagogical competences in curricular matters, constitute the basis for the proposal of new methodologies based on new technologies.

REFERENCES

[1] M. Moya, "De las TICs a las TACs: la importancia de crear contenidos educativos digitales," DIM: Didáctica, Innovación y Multimedia, no. 27, pp. 1-15, 2013.

[2] I. M. "El reto de la alfabetización tecnológica," in Aprender hoy para solucionar el mañana, Barcelona, 2015.

[3] E. Ruiz-Velasco, Educatrónica. Innovación en el aprendizaje de las ciencias y la tecnología, Madrid: Ediciones Díaz de Santos S.A., 2007.

[4] F. O. D. C. Rica, "Robótica y aprendizaje por diseño," RICA, Fundación Omar Dengo-Costa, 2004.

[5] C. M. Vasquez, Aplicación del PLC en robótica dentro de la educación superior como metodología de enseñanza, Universidad Mayor de Santiago de Chile, 2007.

[6] M. Jacek, Some thoughts on robotics for education., Lund University, 2001.

[7] P. López Remírez and H. Andrade Sosa, "Aprendizaje con robótica, algunas experiencia," Educación, pp. 43-63, 2013.

[8] J. K. Azcaray, M. Martínez Torán, M. Leslabay Martínez and C. Esteve Sendra, "Product Design & 3D Printing : Integrating New Technologies into The Curriculam - Case Study," International Journal on Integrating Technology in Education, vol. 6, no. 4, pp. 11-23, 2017.

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Joseba Koldobika Azcaray Fernándezis a design, manufacturing and Projects engineering PhD student at the Polytechnic University of Valencia, Spain. He is currently the director and professor of Txikitech school and is investigating an educational program about how to implement new technologies in the educational process through different methodologies. As an industrial designer he excels in new product investigation and tools for education.

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