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Project Based Learning Applied to Teaching Mechatronics

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Abstract

The teaching of mechatronic engineering is presented as the appropriate space for the integration of knowledge related to mechanics, electronics, control and programming, in the search for knowledge and skills necessary for the development of projects that meet the main needs of the environment that increasingly show greater interest. This article presents the methodology of project-based learning focused on the teaching of the engineering foundations in mechatronics through the methodology of the Mechatronic Workshop which is a strategy applied in the formative research at the Piloto University of Colombia, with this methodology Emphasis is placed on the importance of the construction of prototypes, to gauge the differences between the development of a conceptual design and the actual performance of a product that solves problems that are currently evident in society.

Keywords: Project based learning, product development, mechatronics workshop methodology.

INTRODUCTION

Project-based learning (PBL) has been a methodology in applied education in order to improve the deficiencies generated by the classical form of teaching (teacher-students). The PBL seeks to create study groups among students with different strengths and abilities, in order to generate an exchange and / or acquisition of knowledge to solve a problem. This learning model allows students to plan, implement and evaluate projects that are applicable in the real world beyond the classroom [1] [2].

Learning by projects should not be confused with learning by problems, since in learning by problems directs attention to a specific problem [3]. While the PBL can also cover other areas that do not directly relate to the problem to be solved. In addition, the project involves different topics and aspects related to what is already known, so that it is easier to understand. One of the consequences that the PBL brings, is that in one way or another it makes the students responsible for their own initiatives; Another important advantage is the collective work among the members of the group, because they learn to know the working environment that is handled in the industry (companies), it also allows students to open their minds to new possibilities and new ways of seeing the objectives, post who know different points of view from their peers; that is, they learn to learn from each other [4]. It is important to highlight the benefits that have been reported by some of the authors who work with this model considering the following findings:

- "Students develop skills and competencies such as collaboration, project planning, communication, decision making and time management" [5-6].
- "Increase motivation. There is an increase in attendance at school, greater participation in class and better disposition to perform tasks" [7-9].
- "Increase self-esteem. Students take pride in achieving something that has value outside of the classroom and making contributions to the school or community"[10].

On the other hand, there are disadvantages seen by students that later become limiting factors for the realization of a project; One of these limitations is the cost that is generated in the physical production of the project, it also requires a lot of time for the realization of the corresponding designs, because you have to do a research process that is summarized in: design, implementation and finally carrying out the tests and corrections of possible errors. However, the research process facilitates learning in the engineer's training, but does not necessarily motivate it, this allows to establish questions such as:

1. Is the knowledge acquired sufficient to address and solve an engineering problem in the real sector?
2. How is the knowledge acquired in subjects developed separately related?
3. How important is the experience at the time of applying the theoretical knowledge to solve a practical engineering problem?

Thus, this article shows the work done by the Mechatronic Engineering program of the Universidad Piloto de Colombia that seeks to solve these questions, where extracurricular activities have been developed in which the students with the guidance of the teachers, design , they elaborate and test research or practice projects applying the knowledge acquired in the subjects of the semester they are studying; evidencing a consolidation on the part of the students who later participate in the research seedbeds in order to strengthen their thematic of study, since the mechatronic engineering program tends for the research in five fundamental lines as a pillar of deepening according to the needs of the country, these lines are presented in figure 1.

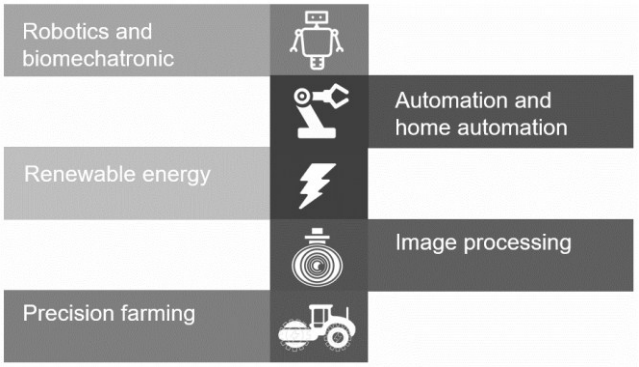

Fig. 1. Research lines of the mechatronics engineering program.

The present work starts from the methodological description of the implementation of project-based teaching, followed by the focus of the mechatronic workshop as formative research, allowing later to show how it is developed and what results have been obtained in recent years.

Methodology of Implementation of Teaching Based on Projects

Currently, technology is linking different fields of knowledge that allows professionals in any field of application to be constantly updated, this being the main motivation for teachers of the program to link new methodologies that allow students to be linked in the processes of teaching and learning [11-14], generating new proposals that link the use of information technologies (Tics) [15-16], practices that are developed in the classroom of class and laboratories will serve as an element of deepening in the search of the solution before a raised problem. However, during the realization of this search, some critical factors can be evidenced based on the evaluation of student knowledge, given that it is not known exactly if the knowledge acquired is sufficient to be able to pose and solve a real engineering problem. and how to link their knowledge of the subjects studied, in order to determine the degree of importance of the experience of their theoretical knowledge for the solution of a practical engineering problem.

Based on the previously mentioned parameters, an analysis is made from the conception of the rationale of mechatronic engineering to establish the methodology that the student of the program must develop in his training, where the student can establish solutions to the problem posed with the which can measure their skills according to their engineering proposals; It is essential to involve practical development so that the student has the ability to evaluate theoretical concepts in order to propose solutions that can be consolidated with the construction of a prototype. Finally, future engineers explore practical aspects that are related to design, construction and implementation in order to size the solution to the engineering problem posed.

It is important that during the learning process the theoretical and practical aspects are related to establish a clear methodology for the implementation of the mechatronic workshop, which will allow future engineers from their first year of training to establish design parameters, concurrent engineering concepts, processes of manufacturing, robust and parametric design. With this methodology, the student is expected to evaluate the trends of high technology products in the development of products that are focused on undergraduate training.

Mechatronic Workshop Description

The mechatronic engineering program of the Universidad Piloto de Colombia has as tool of extracurricular learning and formative research the mechatronic workshop, which consists of a workshop type exhibition at the end of each semester on which its research lines are based; to show the developments raised before a problem that is proposed at the beginning of each semester so that it can be developed and worked on throughout the semester by the students with guidance from the professors of each training area. The "Mechatronic Workshop" for students, allows you to find a process of professional training that provides them with investigative skills. This type of methodology is very useful, essentially because it complements and reinforces what has been learned in the classes, besides encouraging and promoting the realization of projects that may seem unattainable.

With the focus of problem-based learning, the mechatronic engineer generates the ability to propose solutions based on knowledge of mechanics, electronics, systems and control, which must be integrated for the development of applicable and competitive products, in a rapidly changing environment. as a result of the continuous technological advance

The correct implementation of the knowledge acquired in their training allows the resolution of problems and / or needs as the fundamental work of the engineers; However, practical experience allows us to gauge the close relationship that exists between knowledge and know-how [24], which is why the need to establish the skills that must be considered when part of a mechatronic development is generated.

With the development of the mechatronic workshop, the future engineer is expected to possess oral and written communication skills that allow him to interact appropriately with his clients and work team. Generating teamwork in which you can interact properly with a work team facilitating the implementation of concurrent engineering [17]. This

allows us to have the ability to conceptualize starting from the understanding of the problem according to the conceptualization for the development of mechanical, electronic and control models, which will allow you to establish solutions that are in line with the needs and are viable technologically and economically. For this it is important that there is a criterion to make decisions, that is, to establish the technologies of design support, such as computer aided design (CAD), computer assisted analysis (CAE, for initials in English), computer-aided manufacturing (CAM) and rapid prototyping, which allow to speed up the development process, emphasizing that this criterion should not replace the analytical capacity and the criterion that the engineer must have when the solution approach to engineering requirements is required. Subsequently, the recognition of technological resources that are easy and inexpensive access to reduce development times and costs. Finally, with the ability to plan, execute and monitor the development of projects as a solution to a problem raised.

Projects Carried out Using the PBL methodology in the Mechatronic Workshop

The mechatronic workshop is conceived as a strategy of formative research transverse to the curriculum in which the methodology of project-based learning is involved, allowing the students of the mechatronic engineering program of the Pilot University to apply the knowledge acquired during every semester. This knowledge is applied to a project articulated with the proficiencies of the different subjects which the student learns throughout the semester. In this part, teachers play the fundamental role in guiding the students along the path of developing proficiencies for the proper approach and execution of a research project, based on a theoretical support which allows them to generate alternative solutions for the problem posed.

The projects of the mechatronic workshop will integrate the subjects of the engineering component of the semester studied by the student in a project that allows the solving of a technological problem or failing with the sole purpose of reinforcing their knowledge from the practice. The themes of the projects will be presented in union by the professors of the program, seeking to impact the realities or problems of the environment where mechatronics can provide solutions. The above mentioned, seeks to motivate the students so they can offer solutions in accordance to the level of their acquired proficiencies in the course of their studies and where it should portray the most relevant proficiencies of the subjects considered to incorporate to the mechatronic workshop. The projects must have a high flexibility component which allows the student to generate multiple solutions to the proposed problem, thereby fostering competition and achieving better solutions among the participating groups.

Since the beginning of the mechatronic engineering program of the Pilot University, students have been involved in participating with their ideas and proposals to solve established problems ranging from home automation systems, precision agriculture, smart cities, animatronics, robots, among others.

Figure 2 shows the development of first-semester students, which consisted of a bipedal dinosaur-type robot, with the characteristic that its locomotion system was based on a bar mechanism, allowing it to move in a straight line. From this project the synergies of knowledge of the subjects can guarantee the contribution of teamwork.

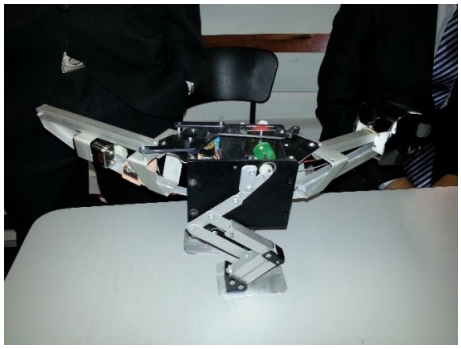

Fig. 2. Robot Dinosaur.

Likewise, topics on autonomous vehicles were set out where students developed a 1:10 scale vehicle with similar characteristics to a conventional vehicle, this application is focused to assist at the time of driving in order to safeguard the life of pedestrians and the driver, the application identifies pedestrians and encloses them in a contour. According to this contour a direct speed control is implemented to the point of stopping the vehicle completely when the pedestrian is very near to the vehicle with the risk of generating accidents, figure 3.

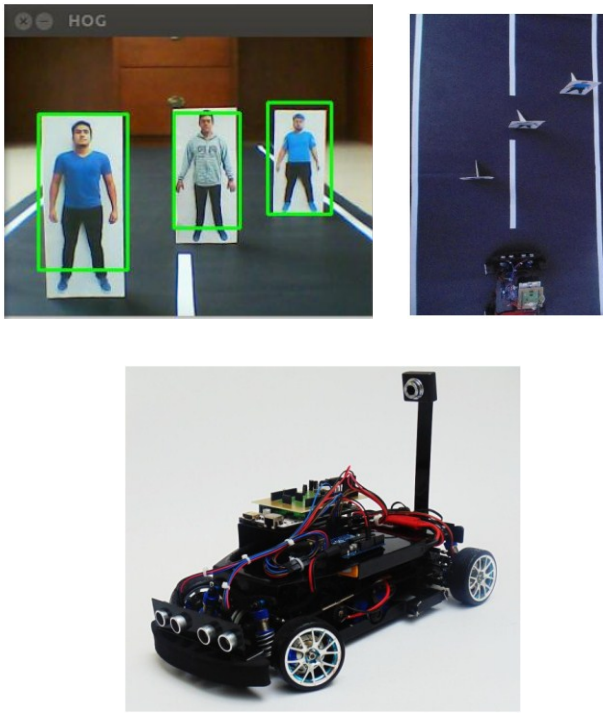

Fig. 3. Autonomous scaled vehicle with pedestrian detection..

Figure 4 presents the project entitled Circle type Leds of revolution, developed by students in seventh semester. It consists in generating informative notices that provide tourist information, guaranteeing user's interaction with the environment where it is found.

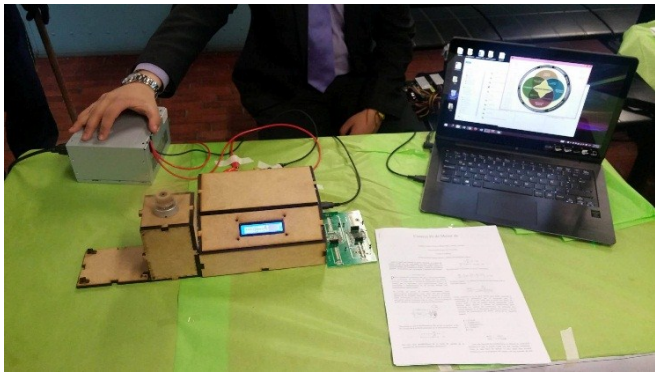

Fig. 4. Project circle type leds of revolution.

Finally, Figure 5 shows the application of a mechatronic proposal from fourth semester for the controlling of public lightning in an intelligent city, in addition to the control of traffic through the use statistics, it is possible to simulate how the behavior in the city will be through a scale.

RESULTS

The formative research process that students obtain with the mechatronic workshop demonstrates the creativity and the possibility of obtaining different solutions to a problem, where it is not affected by the monitoring of the proposed methodology, which can be evidenced in the four prototypes illustrated above. The problems raised show the search for solutions according to the knowledge acquired during each semester, where the future engineer reflects the acquired competences and guarantees the synergy of knowledge with the working group in which he / she is.

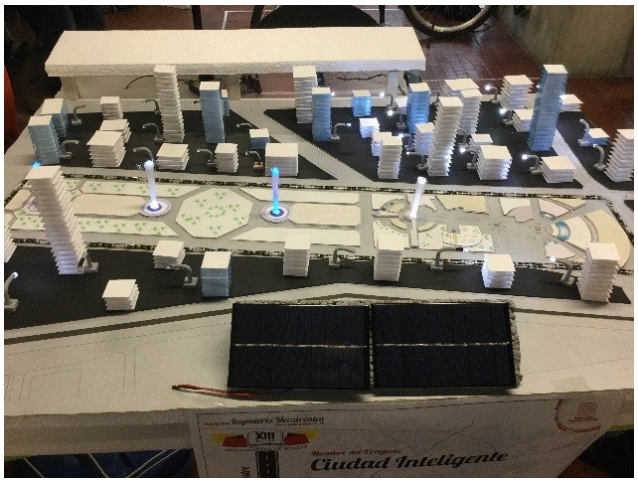

Fig. 5. Project circle type leds of revolution.

Figure 6 shows the participation of students and the number of projects throughout the implementation of this methodology, an average of 90 projects and 243 students that provide solutions to the problems raised with fields of action of engineering mechatronics, where the participation fluence is seen, since in 2012-2 there was the participation of 136 students divided into work groups of 3 to 4 people with about 46 projects compared to the participation in 2018-1 that It was 287 students with the presentation of 123 projects. This statistic shows that training in research through project-based learning is a complementary tool to classroom training that strengthens the training skills of future engineers in mechatronics.

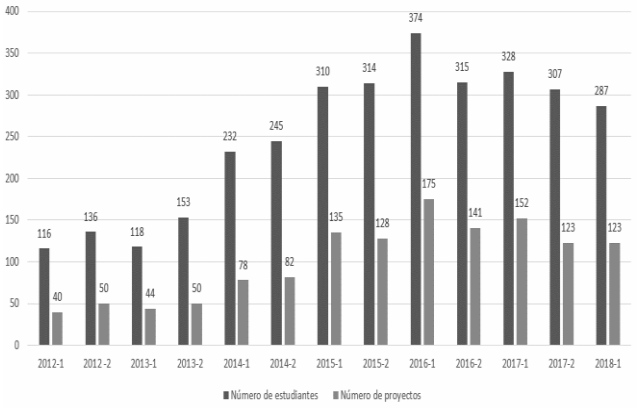

Fig. 6. Student and projects participation stadistic per year.

CONCLUSIONS

The engineer in mechatronics has the ability to integrate modern technologies to establish a development process from the initial idea to the construction and evaluation of prototypes developed by a conceptual design, based on the knowledge acquired throughout his training and supported by the correct use of modern tools for mathematical modeling, analysis, simulation and prototype manufacturing. The transition from design to construction and operation of the prototype, requires an indispensable orientation of the teachers according to the training of each of these to achieve good results in the manufacturing processes and design of the prototype assembly, despite the advance of the tools of analysis and modeling, you can still evidence large quantities of factors that can vary the desired result such as precision of construction and assembly, surface finishes, acquisition and signal processing, among many, which are practically impossible to determine and Take into account during the project development.

The ability to work in a team is a need that is currently reflected at a professional level, where the proposal and development of mechatronic projects allows to develop competences related to these, which can be validated in the follow-up to the distribution of responsibilities that are established At the beginning of the project they allow a first approach to the methodologies associated with problem-based learning, through planning, execution and verification, which are indispensable in the formation of the research of future engineers.

The high cost of the projects in the development posed by the working groups generates the need that in some aspects recognized development companies related to mechatronics can sponsor with elements that can be incorporated into the prototypes, allowing the developments to be high impact products. for the real sector, with low-cost skilled labor that promotes University-Business synergy and a sustainable economic development for the country.

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