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A CONTEXT VISION

Project- based learning as an alternative methodology in technological education

Aprendizaje basado en proyectos como metodología alternativa en la educación tecnológica

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ABSTRACT

This article presents an analysis of current university teaching practices, and Project-Based Learning is introduced as an alternative methodology to improve said practices. In addition, this document includes examples of how this methodology was applied in four Electronics-related courses from different universities, to guide those willing to apply it.

Palabras clave:
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RESUMEN

En el presente artículo se hace un diagnóstico de la práctica docente universitaria y se presenta el Aprendizaje Basado en Proyectos como una metodología alternativa con el fin de mejorar dicha práctica, además se muestra cómo se aplicó esta metodología en cuatro cursos relacionados con la Electrónica en diferentes universidades, con el fin de orientar a quienes estén dispuestos a aplicarla.

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1. Introduction

Today's society, shaped by technological advances, requires capable and competent professionals who adapt easily to changes, who can work as a team and provide solutions to problems related to their field of action. The training of these professionals is responsibility of universities and also of their professors, who mostly lack pedagogical training, and therefore teach in a traditional way, that is, following a model where the professor own the knowledge and their students act passively as receivers of that knowledge.

Teaching methodologies must adapt to the requirements of a changing society. In this document, an analysis of university teaching practice is made, for which different related documents were consulted [1-3], in addition, Project-Based Learning is described and proposed as a methodological alternative in the teaching-learning process. This methodology has been adopted by some university professors in order to improve their teaching practice and develop in their students' competences such as critical thinking, collaborative work and autonomous learning, allowing them as professionals, to adapt to a society with all its demands [4-5]. To illustrate how this methodology has been applied in some Electronics-related courses, some specific examples in different universities are shown [6-9].

2. Analysis of University Teaching in Colombia

Today's society is partly result of achievements in different branches of science and engineering, we can say that these achievements were obtained thanks to the way we have been educated, we have all gone through the higher education system for some period of time and our current living conditions are largely due to the training we have received. Although education in our environment receives various criticisms, we owe these achievements to the people who have been trained in this system, there are existing qualities in our higher education system worth highlighting and improving upon. Nevertheless, that that does not work must change.

Regarding higher education, universities have a fundamental role in Society's development thanks to their contributions in the training of new professionals, research on topics of interest and the search for solutions to problems in their environment. One of the various factors taken into account to determine the quality of education imparted by universities is that of their professors [1, 3], since they are responsible for guiding and developing all those tasks that are the essence of university. Their performance depends on several aspects such as their professional experience, their pedagogical experience and, of course, their training [3].

Traditionally, more importance has been given to the professor's knowledge about the content addressed, than the way in which he develops it in his classes, that is, to the pedagogical part [1,2] . It is believed that whoever knows how to do something automatically knows how to teach it, and therefore pedagogical knowledge is not necessary. Except for education programs oriented to pedagogy, there is little to no pedagogical training for university professors before and after they are hired. Additionally, those who have had training in pedagogy have had it mostly oriented to school-level students than college-level ones. [1, 3].

In Colombia, teaching at a public university has as a minimum requirement to have a professional degree, or to have made a significant contribution in a technique, arts or humanities [10], training in pedagogy is not required, and once is appointed as a professor, the National Political Constitution grants the fundamental right of academic freedom [11], which means he or she has the autonomy to choose the teaching method and the way in which he or she will evaluate his or her students, as long as those align with the contents and schedules established by the university [12-14].

When the role of university professor is assumed, even if there is no formal training in pedagogy, one intuitively possesses a "pedagogical knowledge", acquired through one's own experience as a student, as a professional, and as a person, and it continues to develop through interaction with its students [1-3]. Being graduates of the traditional educational process, some of these professors tend to reproduce it, repeating with their students the same strategies developed by their former professors, without reflecting on whether they are appropriate or not, forming what is called "traditional education" which is characterized by being centered around the professor, who has the authority, owns the knowledge and transmits it; students in turn, either due to fear or lack of motivation, become simple receivers who rarely question them.

However, other professors assume their responsibility differently and try to improve their work by applying

strategies that make their students more motivated and increase their participation, thus improving their learning. Pedagogical and didactic knowledge should be part of the training of university professors, but they rarely show interest in pedagogy as a resource that can improve their activity, they give more importance to scientific production than to that related to teaching, despite being their main activity at the university, and when universities promote postgraduate training, the majority show much more interest in the specifics of their profession than in the pedagogical aspect, a fact that is corroborated by observing the degrees of those who complete said training [1 ,3].

One of the reasons for this phenomenon is that research and projection to the community activities are incentivized more than teaching activities, and although it is not verbalized or made explicit, there is a certain underestimation for pedagogical knowledge and didactic. Another factor comprises the other activities that university professors must devote their time to, such as publishing papers, organizing events, and managing institutional procedures before the corresponding authorities. [1-3].

Today's society, with globalization and the vertiginous development of technology, imposes new challenges in the training of new professionals, the methodology applied by professors in universities must also evolve, new skills must be developed in students that allow them to adapt successfully in today's world, not only the transmission of knowledge is required, but also its generation, the promotion of autonomous learning, facilitating their own training, critical thinking and the promotion of teamwork in the search for solutions to real situations [1-3]. A methodological shift is necessary, one oriented toward active methodologies and continuous evaluation systems, instead of teaching models based on lectures and evaluation through one or a few exams [3]. Project-Based Learning as a teaching methodology promises to achieve that improvement that higher education requires.

3. Project-Based Learning.

This methodology is based on the idea that what interests us, what has meaning for us and is supported by our own experience is best learned, initially this idea was promoted by the renowned educational theorist John Dewey, who proposed to present students with real-life situations in which a problem had to be addressed and solved by using resources provided by their teachers, based on the idea that school should be useful for life [4,15]. The word "project" being related to education was proposed by William Heard Kilpatrick in his article "The Project Method", according to him, a project is any action with a purpose and through its execution learning is achieved effectively [16]. In the late 1960s this approach was applied on formal education in medicine, business, education, architecture, and engineering schools and today in many other disciplines.

Not all projects are valid in this methodology, an activity can technically be a project and still not be significant from an educational point of view, therefore, in its application the following criteria must be considered:

- The projects to be carried out respond to real-world challenges.
- There should be questions related to the contents of interest, which students must investigate and solve.
- The projects are aimed at the students; therefore, they have much of the control and must plan their realization.
- The role of professors is not to impose but to propose the situation to be resolved and advise students in achieving the different proposed solutions.
- The project must be carried out in groups to develop in the students a collaborative but not competitive spirit.
- The evaluation is carried out based on the result (product) obtained [5].

One of the essential elements in the application of this method is the initial planning phase that students must complete before starting the project. It makes them responsible for the project's implementation. However, this does not mean that all the responsibility for their education is delegated to them, since the professor is permanently orienting all the activities [5].

In a nutshell, this methodology consists of proposing a challenging but viable project to students, providing them with the necessary tools for its realization through collaborative work in small groups. The teaching and learning process is then organized according to the needs of the teams to carry it out, and it is demanding for both students and professors; students must actively participate in the development of the project and professors must have the ability to plan and manage it, becoming no longer experts but facilitators for students [9,17].

4. Some Application Cases of Project-Based Learning.

In order to make an approximation to the implementation of this methodology in different university courses, four cases related to Electronics area training are briefly presented. Tables 1 to 4 summarize the main aspects of courses in which it was applied.

4.1. Case 1

Tabla1. Main aspects of case 1. [6]

Course name	Introduction to Electrical Circuits
University	University of Oklahoma
Project to be carried out	Implement different circuits using in each case some of the following elements: DC sources, Switches, Resistors, Coils, Capacitors, diodes, LED diodes, and light and temperature sensors.
Topics to cover	Ohm's Law, Kirchhoff's Laws, Multimesh Circuit Solution, Thévenin Equivalent Circuit, Superposition Principle, Transient and Steady State Analysis of Circuits Including Capacitors and Inductors.
Methodology	The general project consists of carrying out several activities where different circuits are implemented, and the theoretical results are compared with the measurements made.
Evaluation	Reports of the practices are qualified in which answers to proposed questions are given, including their respective calculations and verifications in the implemented circuit, in addition a final exam is carried out.
Students feedback	Survey on the impact of the methodology used in learning the basic concepts of circuits.

4.2. Case 2

Table 2: Main aspects of case 2. [7]

Course name	Introduction to Digital Signal Processing
University	Princess Sumaya University for Technology (PSUT)
Project to be carried out	Measure the duration of heartbeats from the signal obtained by means of a stethoscope connected to a PC through a microphone.
Topics to cover	Sampling Theory, Analog Digital Conversion, Frequency Analysis of Signals applying the Discrete Fourier Transform, Design of digital filters.
Methodology	Apply different techniques of Digital Signal Processing learned in class using MATLAB, in order to adapt the signal for the measurement of the duration of the heartbeats.
Evaluación	No information found.
Students feedback	Survey on the impact of carrying out the project on learning the concepts of Digital Signal Processing.

4.3. Case 3

Table 3. Main aspects of case 3. [8]

Course name	Power Electronics
University	Technical University of Denmark (DTU)
Project to be carried out	From a catalog of projects that are mostly switched sources for different applications and LED drivers, one is chosen for its realization.
Topics to cover	Switched Sources and DC-DC Converters.
Methodology	The classes cover the main topics and once the project is chosen, it is about solving four technical problems; select the topology of the converter, design the magnetic elements, design the filters and perform the closed- loop control.
Evaluation	Each group develops a final report describing the theoretical analysis and design results of which an oral evaluation is made by several instructors.
Students feedback	A survey is carried out on the methodology, the level of knowledge achieved and the advice given by the professor.

4.4. Case 4

Table 4. Main aspects of case 4. [9]

Course name	Robotics
University	Universidad Europea de Madrid
Project to be carried out	Develop an application that allows a robot to play checkers against a person.
Topics to cover	The theoretical part of the course is handled separately so the project corresponds to the practical part and covers various topics from different disciplines such as Artificial Intelligence, Computer Vision, Software Engineering and Programming.
Methodology	The project was presented to the students and proposals and suggestions were heard regarding it, from there 4 groups were formed to develop 4 subprojects, each group elaborates a preliminary project where the tasks to be carried out and the results to be achieved are defined, in the end they disclose the results orally and in writing with all the information that can be reused.
Evaluation	The document delivered, the oral presentation and the performance of each student are evaluated.
Students feedback	The opinions of professors and students involved in the project were valued.

In courses such as "Introduction to Telecommunications" this methodology can be applied by adapting a project like the one shown in [18], similarly, in courses related to Robotics, the one shown in [19] could be adapted. Each professor can use some of the projects developed by students as a degree project and adapt it for the orientation of their subjects.

5. Conclusions.

It is necessary that university professors receive training in pedagogy to improve the quality of higher education.

Application of knowledge to solution real problems, teamwork, autonomous learning, and critical thinking are essential skills for professionals today.

Project-Based Learning is one of several methodological strategies that professors can apply, within their academic freedom, to develop skills and competencies in their students that are required today.

Project-Based Learning does not simply consist of carrying out a project, it requires very careful planning and the active participation of professors and students to achieve an improvement in educational practice.

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