Quest Journals
Journal of Electronics and Communication Engineering Research
Volume 3 ~ Issue 8 (2017) pp: 01-05
ISSN(Online) : 2321-5941
www.questjournals.org

Research Paper

Didactic Modules to Improve Academic Performance in Programmable Logic Control

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Received 16 Jan, 2017; **A**ccepted 27 Jan, 2017 © The author(s) 2017. **P**ublished with open access at **www.questjournals.org**

ABSTRACT: *The development of practices is one of the pillars in professional realm, especially in technological areas. Unfortunately the equipment used in many Mexican schools often does not possess the adequate didactic characteristics that allow the student to obtain a better understanding of the phenomena that are wanted to study, or sometimes the material that is needed to perform some practice is constituted of several components and it is insufficient in the laboratories, in addition, a lot of time is frequently needed in the delivery of all the elements. The present paper presents a study where didactic modules for the teaching of Programmable Logic Control are implemented. Measurements of the academic performance of the students as well as the performance of the equipment are also presented. Control and experimental groups were established, both in order to research academic performance over a period of six months. At the end performance results characterized and based on the corresponding academic needs are compared and analyzed.*

Keywords: *Academic Performance, Didactic Modules, Programmable Logic Control, Delivery Time*

I. INTRODUCTION

Technology is fundamental in the development of society and it has been the basis of great progress in the modern era, it is has been for centuries the amount of theories and techniques which has allowed the practical development of scientific knowledge, and it can also be used for educational purposes to consolidate the training of students from basic to professional level [1]-[4]. In Mexico, the General Direction of High Technological Education recognizes the importance of the implementation of technology in education, as an agent for the economic development of a country, so it has used resources to provide the equipment and instruments to promote the acquisition of practical knowledge to the students of this system.

One of the branches of technological application in schools is Programmable Logic Control, however, understanding their fundamentals is often a difficult task for many of the students in the first experiences they have with this discipline field [5][6]; this problem has several factors involved, some of them are related to the processes of logic and the teaching of Mathematics, this has been studied in part by organizations such as the Latin American Committee on Educational Mathematics [7] , where areas of interest such as propositional language and linear algebra have been detected [8]. There are also other technological factors, where the equipment and materials used do not exist in sufficient quantity or do not have the appropriate didactic characteristics to motivate student learning. All these factors promoted the development of this research. The general objective of this project was to design and implement didactic modules of Programmable Logic Control that allow students improve their academic performance, which is justified since the development and application of didactic modules in the schools have been very important for academic development of students in Mexico, including organizations such as the National Program for the Improvement of Teachers (PROMEP), which recognizes and motivates the teacher who wishes to obtain the recognition of the Desirable Profile, to generate didactic material of quality. The technological application teaching modules can be generated at all levels, and they have been built with the aim of correcting some lack of simplicity and versatility that is not found in sophisticated equipment, as well as to reduce costs and operating times. In the short term, advantages

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related to student learning are obtained, which help to recognize the processes of logic and control for the programming of sequences and solution of real problems. By following a didactic method based on the correct training technology, the student might also be able to propose the solution of problems of energetic nature, besides that this will strengthen its vocational training and provide tools that would transform their mental maps to modify their meaningful learning and that will bear fruit when students are integrated into the productive forces of the country in the long run [9].

II. RESEARCH BACKGROUND

This research is related directly with academic performance, so intelligence is an important parameter to be considered. Gardner argues that intelligence is located in various areas of the brain, which are interconnected with each other and can be developed with amplitude if one has the proper environment for this purpose. According to his theory there are eight types of intelligences [10]. Linguistic-verbal intelligence is defined as the ability to use words effectively, manipulating syntax or structure of language, semantics, phonetics and their practical dimensions, which allows a capacity for expression and communication that stands out clearly. There are studies about how verbal and non-verbal intelligence changes in the youth brain. The students who have it are easy to learn languages [11].

Physical - kinesthetic intelligence is the ability to use one 's own body to express ideas and feelings, and its particularities of coordination, balance, dexterity, strength, flexibility and speed, as well as receptive and tactile, are closely related to educational psychomotricity [12].

Logic-mathematical intelligence is the ability to handle numbers, relationships and logical patterns effectively, as well as other functions and abstractions of this type. Students who have developed it easily analyze approaches, problems, numerical calculations, statistics, and estimations. Nowadays new findings in mathematical logic are being discovered and it is related with creativity and divergent thinking in some cases [13]. This is one of the most important intelligences to be considered in the development of this project.

Spatial intelligence is the ability to perceive the visual and spatial image with certainty, to represent ideas clearly, and to sensitize the line, color, shape, figure, space and their interrelations. It is present in students who study better with graphs, diagrams, pictures. In Programmable Logic Control it is very common to use graphic interfaces to develop application programs, there are even studies which deal with the relation of neurovision and logic control [14].

Musical intelligence is defined as the ability to perceive, distinguish, transform and express the rhythm, tone and timbre of musical sounds. Students who have developed this ability have the ability to play musical instruments. Interpersonal intelligence is the ability to perceive and distinguish emotional states and interpersonal signs from others, as well as to respond effectively to such actions in practice. It is special in sociable students, who like teamwork. There are even some studies which deal with music and artificial intelligence [15].

Intrapersonal intelligence is the ability of self-insight, and acting as a consequence on the basis of this knowledge, as well as having a correct self-image, and ability for self-discipline, understanding and self-esteem. It implies a very important degree of maturity. In this study workgroups were created to develop the practices, so is essential the interaction among team members.

Naturalistic intelligence is the ability to distinguish, classify and use elements of the environment as objects, animals or plants. Both in rural and urban environments. It includes the skills of observation, experimentation, reflection and questioning of our environment. At the present time it is very important to consider the impact of technology in the environment, so students must be educated under this way of thinking in order to preserve the world and society. It is clearly identified in students who like to investigate characteristics of the natural and man-made world, in their own context and in their proper dimensions [15].

It is also importan to consider Ausubel's cognitive theory of meaningful learning, which is a theoretical current. Ausubel uses information processing models and emphasizes the development of thinking skills and solving of problems to explain his theory. It is in this context, where the teacher is the promoter of such skills and learning, which are determined by knowledge and experience that the student has acquired in advance and which will allow him to move forward to build new knowledge[16].

III. METHODOLOGY

The main objective in this project was to design and construct didactic modules for teaching of Programmable Logic Control, to improve the academic performance of Mechatronics Engineering students of Technological University of Altamira as well as Electromechanical Engineering students of Technological Institute of Cerro Azul.

In Technological University of Altamira and Technological Institute of Cerro Azul, several subjects are taught in the areas of Mechatronics and Electromechanics which are related to the programming and

implementation of logic control circuits such as control of electrical machines, integration projects, systems automation and control engineering, among others. Data base of qualifications, as well as results obtained in diagnostic exams, revealed a low academic performance of the students, especially in the aspects related to the logic of sequences and the practical implementation of the theoretical foundations.

On the other hand, the delivery time of material and equipment to be used, as well as the time of its return to the end of the class and the number of connections to be made, does not allow to effectively carry out practices in short sessions, because it is consumed up to 30% of the total time allocated for the class. For all this, it would be pertinent to design didactic modules for the teaching of programmable logic control, that allow to reduce times for the implementation of practices, as well as for the understanding of the concepts and the effective development of automation projects. The fundamental points that were treated in this investigation are shown below.

A) Versatility and simplicity of the teaching modules: In the first instance, the teaching modules for the programmable logic control should allow the student to perform the practices in a way that clearly identifies the terminals, involved components, system ignition, indicators, inputs , outputs, as well as communication terminals. The identification of the elements, as well as their relation to the theoretical concepts studied in class, should be clear and as far as possible, even intuitive. Versatility, simplicity and efficiency are important and desirable characteristics which are related and have been studied in several investigations [17][18].

B) Optimization of time and space: It is a fact of nature that saving time and space make it possible to take better advantage of these resources to achieve important goals in the development of projects, in the case of modules, not only simplicity is desired, but also optimization of the space that contains the necessary components to perform all of the course practices, thus, the time in the delivery of material and the time used to reduce the number of connections for the development of practices, presents a considerable reduction and allows better use of laboratory sessions [19][20].

C) The improvement of academic performance of students: It is evident that the most important results are aimed at improving the academic training of students, in this sense didactic modules must meet in addition to the aforementioned feature, others that make it attractive and efficient to students, such as a suitable distribution of components, striking colors, lightweight but resistant material, as well as a friendly graphic interface [21][22][23].

Evaluations were designed to measure the reduction of time and space in the delivery of material and implementation of practices, as well as to determine the academic performance of students. The variables to be evaluated were the following:

1.- Delivery time of material and equipment.
2.- Average time of connections.
3.- Space occupied by the components for the development of the practices.
4.- Interpretation of truth tables.
5.- Translation of equations to ladder diagrams.
6.- Logic of sequences.
7.- Implementation of control systems.

After, control and experimental groups were defined selecting groups which were also established at the beginning of the course, both in the Technological Institute of Cerro Azul as well as the Technological University of Altamira. The study was realized through four months, during the teaching of the subject of Programmable Logical Control. Diagnostic tests were applied at the beginning of the course, then a group of 50 students received the traditional education, while another of 50 students received the classes using the didactic modules. Evaluations were conducted during the course and the results were compared at the end.

IV. FINDINGS AND COMMENTS

The results are reflected in two items, the first one considers the academic performance of the students while the logistical aspects are considered in the second. Table 1 shows the academic performance of students in groups A and B before and after the course. Measurements were performed in each of the four indicators. Group A received a traditional treatment whereas group B was instructed with the didactic modules.

Table 2 shows the average material delivery times and connections as well as the size of the spaces used in the development of typical Programmable Logic Control practices before and after implementing the modules. Fig. 1 shows the external aspect of the didactic modules.

Table 1. Averages of exams applied by indicator before and after the course.

Grupo	Academic performance indicator			
	Truth tables interpretation	Equations to diagrams translation	Sequences logic	Control systems implementation
A (before the course)	57	52	47	42
B (before the course)	56	55	49	41
A (after the course)	85	82	84	80
B (after the course)	88	86	88	91

Fig. 1. Set of training modules

Table 2. Averages of times and spaces for the development of a typical practice.

Condition	Indicator		
	Delivery time of material and equipment	Average time of connections'	Area occupied for components when carrying out the practice
Without the modules	2 minutes	7 minutes	1800 cm^2
With the modules	1 minute	1 minute	900 cm^2

V. CONCLUSION

The project has already been completed, with the initial construction of five didactic modules that have been used successfully for the rapid and effective development of typical Programmable Logic Control practices. In general terms, after applying the course, an improvement was observed in each of the four academic performance indicators, both in the students who carried the traditional education and in those who used the didactic modules, however, the improvement was superior in the second group in each of the evaluated aspects.

In the interpretation of truth tables there was a difference of three points. In the translation of equations to ladder diagrams as well as in the sequence logic indicator, students who used the didactic modules improved in four points to the group that did not used them, but the most significant point was the implementation of control systems, in which there was an important difference of eleven points, being this aspect that is directly related to the practical implementation of automation and control systems.

On the other hand, the delivery time of material and equipment was reduced from two to one minute, because the teaching modules already contain buttons and indicator lamps, but the connection time was reduced considerably from seven minutes to only one, due to which it is not necessary to screw cables nor make most of the routine connections because they are already made in the modules themselves.

As far as the space occupied is reduced from 1800 cm^2 to only half of this amount, because additional elements such as indicator lamps, buttons and special external power supplies are not necessary, as they are included in the modules.

In summary, a reduction of time and space in the development of the practices was obtained, as well as a favorable academic performance of the students who used the didactic modules in the practices of Programmable Logic Control, both in the Technological University of Altamira and in the Technological Institute of Cerro Azul.

Acknowledgements

Part of the resources used for this research were granted by the Common Space of Higher Technical Education through its Teacher Mobility Program. The facilities granted for the use of workspaces as well as for the disposal of materials and necessary equipment, were granted by the Director of Technological Institute of Cerro Azul M.D. Yeyetzin Sandoval González, and by Ing. Fidel Aguillón Hernández, rector of the Technological University of Altamira.

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