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The Comparison between Project Based Learning, Micro Learning and Traditional Learning in Teaching Advanced Digital Electronics Subject through Designing CPU

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Abstract: ***This study has been conducted for helping students comprehend and initiate complicated projects using Field Programmable Gate Arrays (FPGA board) in three learning methods , Project Based Learning (PBL), Micro-learning (ML) Traditional learning. in these methods we work to help students accomplish multifaceted projects within a tight deadline. The main objective of the current study is investigation of the real-time impact of applying the mentioned technical education technologies (PBL and ML) for advanced digital electronics subject in comparison with the traditional learning process. It has been accomplished through: a) simultaneously using ML and FPGA techniques (Micro-Learning Process), b) PBL and FPGA techniques (Project-Based Learning Process) and c) traditional teaching (Traditional Learning). Efforts were made to find the best option that assures better learners' performance, deeper knowledge, and handles design complexity for learners that brings students closer to practical CPU design through instructional mechanism, attractive examples and successful project accomplishments. It also makes the learning process substantially quicker, effective, confidence-boosting and performance-enhancing. In the nutshell, this study tested three educational models for imparting CPU design training through FPGA, project-based learning, and micro-learning. The central processing unit (CPU) design is based VHSIC (Very high-speed integrated circuit), which is used for VHDL (VHSIC Hardware Description Language) that helps to accomplish complex projects by applying both PBL and ML methods.***

Keywords: CPU, ALU, FPGA, VHDL, Digital Design. Electronic, Engineering Education, Micro Learning, Project Based Learning

1. Introduction

This Higher education forms the basis for the society to grow its industry, economy, and employment; so, universities focus on developing their higher education systems to remain in sync with the requirements of the real professional world. Besides, dissatisfactory academic performances of students and their slow thinking processes are major challenges, which the educational systems are facing all over the world. Moreover, compromising standards for helping low-performing students learn creates a vicious cycle. There is a need to develop teaching methodologies to help students get rid of the ongoing failure cycle.

Traditional education is a lagged model for advanced digital electronic systems because it doesn’t have flexibility for dealing with real projects like CPU design and its incremental complexity [1]. This issue can be dealt through a basic and quickly connectable project, its testing, and adding a touch of real market for enabling students to do jobs. Moreover, today's projects have large numbers of electronic gates, and electronic circuits; therefore, it is difficult and frustrating to implement such projects in conventional laboratories. For staying in touch with advanced digital electronic design development, students need to accomplish design projects with incremental complexity that isn’t possible through traditional approaches [2].

In higher electronic engineering education, digital design is very significant, and to understand the remarkable complicated projects in digital design developments, improving digital electronic education is essential to train high-profile digital engineers, who can effectively perform to meet the demands of their jobs. For assuring this, deeper, effective, and time-saving learning process is needed to assure quality education. The current study, as mentioned earlier, has been conducted to test project-centric and micro learning engineering education methods. Such initiatives offer promising alternative educational strategies for improving the students' performances and efficiencies. FPGA technology is a well-established method, which is used for modern and complicated digital design projects, model design, CPU architecture modeling, and has benefit in terms of reconfiguration and simulation [3]. The mentioned benefits provide basis to apply the new learning approaches such as project-based and micro learning techniques for educating engineering students.

The current study introduces new methods (PBL and ML), which are applied to teach advanced digital electronic and system design with FPGA with the help of VHDL. It helps teaching how to design digital circuits and systems in a practical way. During the course, students design complex electronic circuits, and accomplish relatively complex projects like the multi-version processor design.

2. Methodology

We applied quantitative research methodology for collecting data through distributing survey questionnaires. For the study there are three models were applied: 1) The using of the micro-learning method in teaching the subject by using FPGA technology as the main laboratory device (Micro-Learning Model), 2) The using of project-based learning method in teaching the subject by using FPGA technology as the main laboratory device (Project Based Learning Model) and 3) Traditional education/learning model.

The comparison is based on the factors and the impact of using FPGA technology applying the traditional learning model, micro-learning model, and project-based learning model. The comparison factors include instructive factor, attractive factor, effective factor, proficiency factor, allowing complexity factor. The quantitative research methodology was implemented based on the survey questionnaire.

Initially, the students were facing problems in traditional education, which were identified in the beginning of this research. A plan was then formulated to solve these problems using a new technique (FPGA), and teaching methods (PBL, ML) in three separate semesters.

In this project, three groups of students were selected as the population for this study, as given in Figure 1.

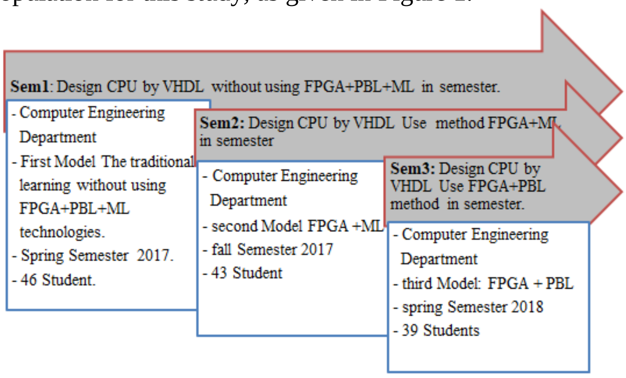

Figure 1: Content of three semesters

Semester one: In this semester, design of CPU by VHDL was taught at the Computer Engineering Department through traditional learning method without using FPGA+PBL+ML technologies (Spring Semester-2017). The number of students in this class was 46, as shown in Figure 1.

Semester two: In this semester, design of CPU was taught by VHDL using the micro-learning method at the Computer Engineering Department using FPGA + ML technologies (Fall Semester-2017). The number of students in this class was 43, as shown in Figure 1.

Semester three: In this semester, design CPU was taught by VHDL using project-based learning method. The course was taught at the Computer Engineering Department using FPGA+PBL technologies (Spring Semester-2018). The number of students attending this class was 39, as shown in Figure 1**.**

A. Field-programmable gate array (FPGA)

FPGAs are commonly applied in digital electronic designs and prototype projects. Their re-configuration feature and free-simulator programmable properties also provide substantial advantages [4]. These advantages attract students to engineering education. In addition to engineering applications, FPGAs are also used in many electronics and computer engineering departments at universities all over the world. The FPGAs are important for electronics/computer engineering education, and using FPGAs allows an increase in design complexity, which saves both time and money.

B. Traditional learning.

The traditional instructional methods may not be sufficient for providing engineering graduates with the essential skill set, knowledge, and attitudes, which are required to meet the professional demands in the coming decades. The alternative methods, which have been extensively tested, provide good outcomes in terms of imparting engineering education [5]. Another significant need for successful learning is regularly performing learning activities. Learners generally avoid modern learning to develop themselves when they aren't motivated enough to use advanced systems [6]. To produce the project in the course, without FPGA technology, Micro-Learning method, and project-based learning

method, it will problems, as depicted in **Error! Reference source not found.**.

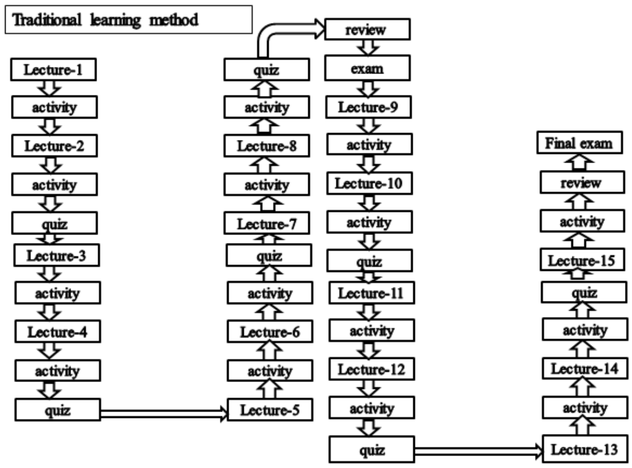

Figure 2: Dividing lectures for the first group with traditional learning

C. Micro-learning

Micro-learning involves learning in smaller steps that work best in terms of following the curriculum. Micro-learning activities typically include short-term lessons, projects or courses designed to provide the students with the required information. For example, instead of trying to teach a student a broad topic at once, the lesson is divided into smaller lessons or tiny project segments [7].

Micro-learning is process that delivers content to the students in specific small parts. Micro- learning is based on micro-content. Micro-learning involves learning in smaller steps, and it goes hand-in-hand with the traditional e-learning processes. Micro-learning helps students deal with the sub-block components, create modules for each part, and increase productivity of modules in educational sense [8].

To produce a good project in the course, the FPGA technology, and the Micro-Learning method should be combined, it will develop students' abilities to solve complex design problems, as depicted in Figure 3.

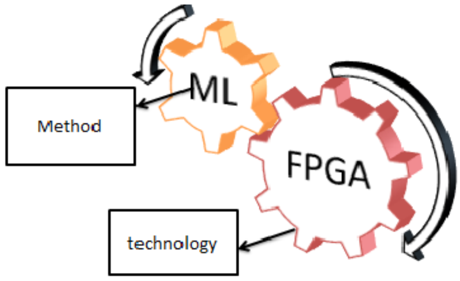

Figure 3: Interacting the two (FPGA, ML) ideas to produce a good project in the second course.

Each lecture has been divided into three levels of activity ranging from easy to difficult to complex figure 4.

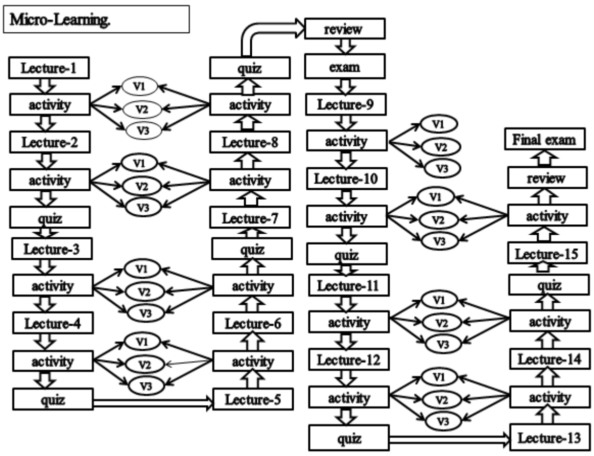

Figure 4: Dividing lectures for the second group with micro-learning.

The steps used to develop students' understanding of three levels (V1, V2 and V3) were identified in each lecture, as shown in Table 1.

Table 1: Types of lecture levels

Code	Code Name	Code Type
V1	Version one	Homework I, the same subject was taught during the lecture.
V2	Version two	Homework II, between V1 and V3, and the mid-term project.
V3	Version three	Homework III, complex project.

D. Project-based Learning PBL

Project-Based learning is gaining researchers' and experts' attention in the world of engineering education. PBL enhances students' participation in the overall learning process by promoting self-learning and active learning. It also improves their communication skills when they study under varying learning styles, and apply their thinking skills for solving complex problems. PBL positively affects certain personal skills, which are needed to perform as an engineering graduate [9-14]. For helping students accomplish a good project, the FPGA technology, and the project-based learning method should be combined; consequently; it will enable students to solve complex design problems, as depicted in Figure 5.

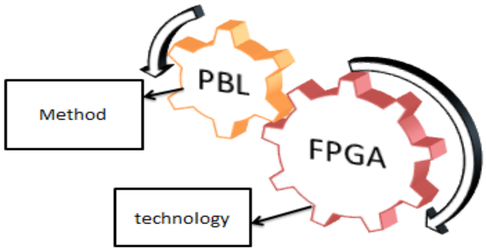

Figure 5: Interacting the two (FPGA, PBL) ideas to produce a good project in the third course.

Each project combines the topics covered in the lectures before, such as the first project combines the first and second lecture. The fourth project, for example, combines the first, second, third, fourth, fifth, sixth, seventh and eighth lecture, as shown in figure 6

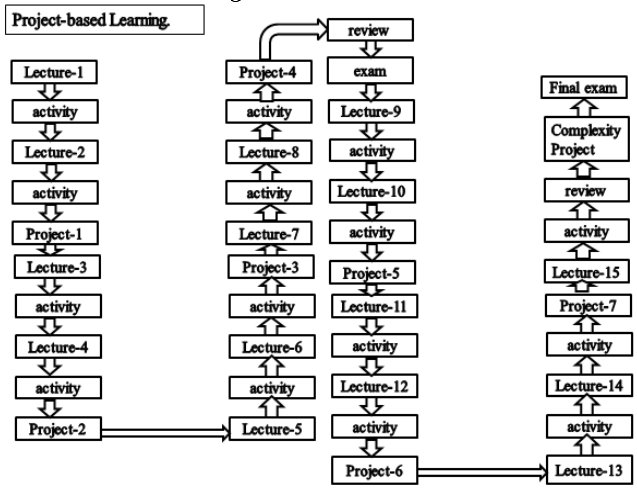

Figure 6: Dividing lectures using PBL for the third group

E. The CPU Design Experiment

It is important to add major examples in advanced digital electronics course plans and then splitting them into smaller sub-blocks in such a way that each sub-block must address certain topic pertaining. Furthermore, these blocks must be formed only to educate students. While designing a curriculum-based project, the design can be divided into smaller sub-blocks or steps as micro-learning. This has been illustrated and it was noticed in the previous tests when PBL was used, access to the final design became easier. As shown in figure 7, each title in the lecture has been divided separately.

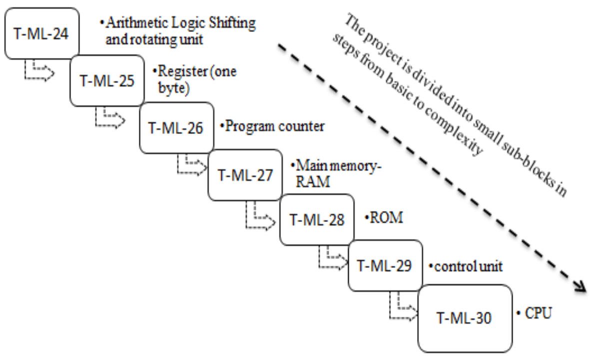

Figure 7: CPU Project Divided into Small Sub-blocks.

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3. Analysis of Teaching Data

The test consists of five factors, which decide the effectiveness of a teaching technique:

- Instructive factor
- Attractive factor
- Effectiveness factor
- Proficiency factor
- Allowing the complexity factor

1) Tests of Normality to factors

The major aim of the current statistical technique is to explore if the current sample data has a normal curve. The current sample data set was normally distributed. It can conclude from the results of Table **2**, this indicates that the null hypothesis is supported. That is, the null hypothesis states that "the sample comes from a normal distribution.

Table 2: Tests of Normality to factors

Tests of Normality			
Factors	Shapiro-Wilk		
	Statistic	Df	Sig.
Instructive	0.987	162	0.150
Attractive	0.987	162	0.140
Effective	0. 990	162	0.304
Proficiency	0.990	162	0.317
Allowing complexity	0.990	162	0.297

2) Reliability Analysis of factors

In this research, the item-total correlation is not low for any question; so, the current scale seems to be good. On another hand, it is obvious that the value of Cronbach's Alpha coefficient of the factors was very good, which indicates that the current Cronbach's Alpha coefficient has a high degree of the internal consistency.

Table **3**shows that the reliability coefficient of the factors of the study (factors studied by questionnaire) is over 0.83. It should be noted that Cronbach's Alpha for this study ranges from 0.83 to 0.88.

Table 3: Reliability coefficient of the factors

The factors of the study	Number of items	Cronbach's alpha
Instructive factor	26	0.889
Attractive factor	24	0.834
Effective factor	35	0.839
Proficiency factor	35	0.842
Allowing complexity factor	30	0.839

3) ANOVA analysis of factors.

ANOVA analysis has been conducted to find out whether significant differences exist among TR, ML, and PBL techniques. It has been demonstrated in table 4 that PBL and ML have higher means while TR has lower means, which shows that significant differences exist among TR, ML, and PBL techniques.

Table 4: Descriptive Statistics to factors

Factors	Variables	N	Mean	Std. Deviation
Instructive	TR	46	2.63	0.404
	ML	43	3.47	0.316
	PBL	39	3.04	0.314
Attractive	TR	46	2.83	0.266
	ML	43	3.23	0.218
	PBL	39	3.07	0.255
Effective	TR	46	2.65	0.244
	ML	43	3.21	0.244
	PBL	39	3.14	0.312
Proficiency	TR	46	2.67	0.189
	ML	43	3.07	0.230
	PBL	39	2.96	0.293
Allowing complexity	TR	46	2.67	0.256
	ML	43	3.28	0.321
	PBL	39	2.98	0.448

This analysis has been conducted to find out whether significant differences exist among, TR, ML, and PBL techniques, at in instructive, attractive, effective, proficiency, and allowing complexity factors. As can be seen in Figure 8, there is a relationship between the means calculated for each factor of TR, ML, and PBL teaching techniques such as ML Mean > PBL Mean > TR Mean

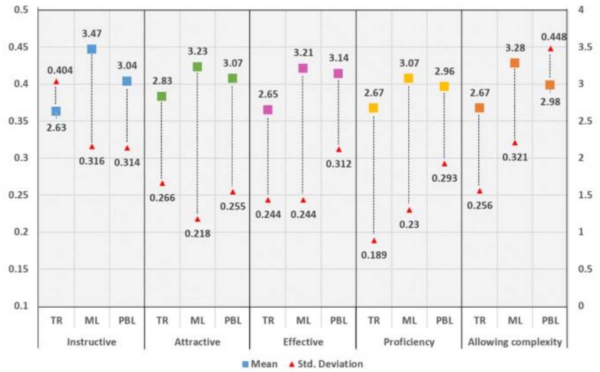

Figure 8: ANOVA analysis of TR, ML, and PBL techniques

4. Conclusion

The learning using FPGA technologies, Project Based Learning and Micro Learning methods (projects and examples) is more instructive and attractive to the students as compared to the traditional learning methods.

It was found that using micro-learning and project-based learning techniques showed better results when they were used to teach advanced digital electronics design using FPGA as compared to the traditional methodology. The aforementioned techniques showed substantial improvement in terms of studied factors.

Making advanced digital electronics design education more attractive and instructional improved, building students' capacities to design and implement complex projects, increasing their confidence for implementing practical projects, and improving their satisfaction levels with the education they receive; it is recommended that micro-learning and project-based learning models should be applied in combination with the assistance of llaboratory technologies such as FPGA.

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