Active Learning for Computer Engineering Students: An Experimental Approach

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ABSTRACT: *An experimental research method using a single group with a pre-test and post-test was conducted to introduce Active Learning to a class of 33 Computer Engineering students. The researcher developed instructional materials consisted of a pre-fabricated Printed Circuit Board (PCB), and Manual that were designed to demonstrate the Basic Logic Gates functions: AND, OR, NOT, NAND, NOR, XOR, and XNOR. Students were given exam to test their knowledge of the Basic Logic Gates prior to experiment and results showed that students did not have background on the subject. Lecture method was conducted during the first two weeks of classes. The different logic gates, their logic functions, diagrams, and truth tables were discussed. The pre-test was conducted and the results showed a mean distribution score of 5.79, with a standard deviation of 5.787. Students were then asked to use the Active Learning materials (PCB and Manual). Students were asked to assemble the PCB using the guide included in the Manual, and perform the experiments on their own using their assembled PCB. After one month, students were given a post-test. Results of the study showed a mean distribution score of 29.91, with a standard deviation of 7.539. The z-test for correlated samples @0.05 level (z = 13.797, ZCV = ± 1.96) indicates that there is significant improvement in the performance of the students during the post-test. Students were asked to evaluate the materials they used and the mean distribution scores suggests that students had improved understanding of the concepts through the use of the materials.*

1. Introduction

1.1 Active Learning

Active Learning is an umbrella term that refers to several models of instruction wherein the focus of the responsibility of learning is on the learners. In this set-up, teachers are not the source of information but are mere facilitators in the class. Researchers conducted have suggested that in order for learning to take place, students must read, write, discuss, be engaged in solving problems, or must be allowed to do things and think about what they are doing [4]. Studies further suggest that the use of different teaching methods in the classroom may help improve students' learning. Gains in learning have been associated with the application of different teaching strategies like the Active Learning techniques. Some cognitive researches have also pointed out that some individuals' learning styles are best served using other pedagogical methods than the traditional lecture method [2]. In this study, the lecturer-researcher designed instructional materials specifically for Computer Engineering students – applying technical skills in Engineering Design and teaching strategies to introduce Active Learning as an alternative method for teaching.

1.2 The Active Learning Materials

The researcher-made instructional materials were consisted of the Basic Logic Gates Printed Circuit Board (PCB) and Manual.
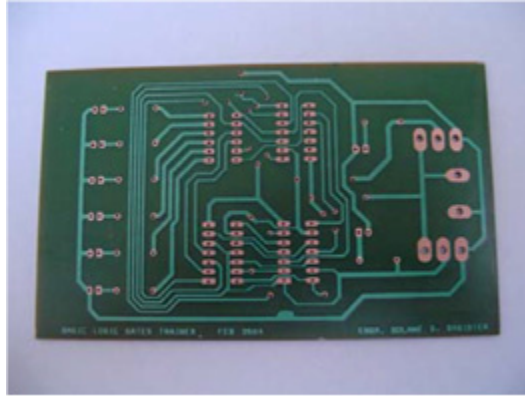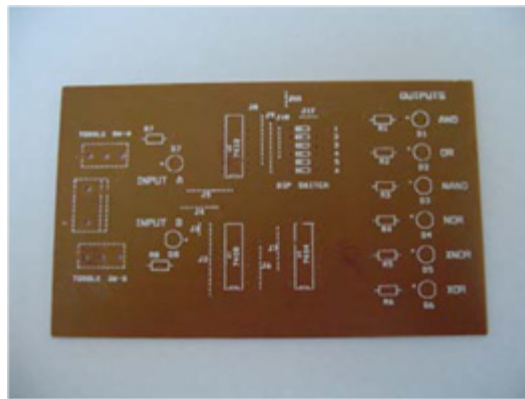
Figure 1. (a) the PCB artwork
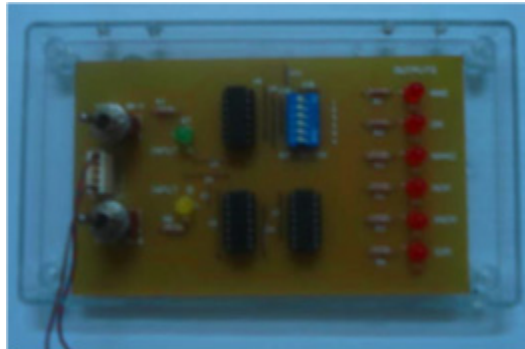

Figure 1. (b) Parts Placement Layout

Figure 1. (c) the assembled PCB

The PCB is a 3" × 5" pre-fabricated single-sided board with silk-screened parts placement layout, holes, and solder masks which students have to assemble using the accompanying Manual as a guide. The Manual, on the other hand, is subdivided into three parts: Part I is a guide on how to construct the PCB – which also included guides on how to test for the basic components like the LED, switches, resistor color coding, proper soldering techniques, basic troubleshooting, and other information needed by the students in assembling the PCB and to make sure that the board will be operational; Part II contains instructions on how to test for the operational function of the assembled PCB. During this stage, if the required output combination is not required, students need to troubleshoot on their own; and Part III contains the nine (9) experiments that cover basic logic gates operation - AND, OR, NOT, NAND, NOR, XOR and XNOR. The experiments include deriving the truth tables by observing the LED outputs (where on = 1, off = 0), schematic symbols, and logic operation.

1.3 The Printed Circuit Board

Figure 1(a) shows the PCB artwork, Figure 1(b) shows the Parts Placement Layout and Figure 1(c) shows the assembled PCB.

2. Statement of the Problem

The study purports to use the researcher-made instructional materials as a tool to introduce Active Learning in the classroom as an alternative method for teaching digital electronics concepts to Computer Engineering students.

Consequently, the study purports to determine whether gains in learning may be associated with the use of the instructional materials. Specifically, it sought answers to the following sub-problems:

1. Is there significant difference in the mean scores of the students during the pre-test and the post-test?
2. How do the students evaluate the materials in terms of: (a) content, and (b) usability;
3. What are the problems encountered by students during laboratory experimentations?

3. Research Methods and Procedures

The single group with a pre-test and post-test experimental research design was used in this study. The non-probabilistic sampling had been adapted in selecting the student-respondents. One class (taking Digital Design course) of 33 students was selected as experimental group. An exam was conducted to determine if students have background on logic gates. Result showed that students have no digital design background. The conventional lecture method was used during the first two weeks of the class covering the basic logic gates – logic functions, schematic symbols and derivation of the truth tables. At the end of the lecture method, a pre-test was administered and recorded. The active learning materials were then introduced, students were asked to assemble the PCB by using the Manual as a guide. During this phase, the lecturer-researcher acts as facilitator. Students assemble the PCB, troubleshoot (if necessary), and perform the experiments on their own. When all the students completed all the experiments, a similar exam was administered (post-test). The exam used the concepts of "on" and "off", instead of 1 and 0. The results were recorded. Students were also asked to answer a questionnaire to evaluate the materials they have used. Using the SPSS (Statistical Package for the Social Sciences) data was analyzed.
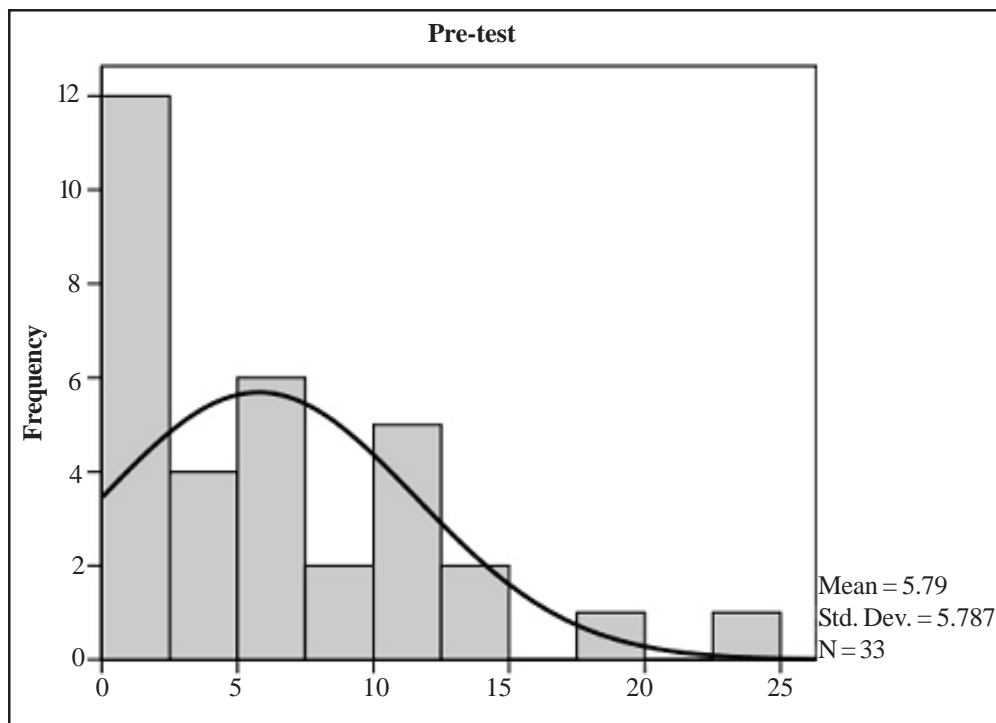

Figure 2. (a) Pre-test

4. Presentation, Analysis, and Interpretation

4.1 Students' Performance during the Pre-test and Post-Test
Figure 2 (a) shows the histogram of the pre-test, and Figure 2 (b) shows the histogram of the post-test.

Pre-test
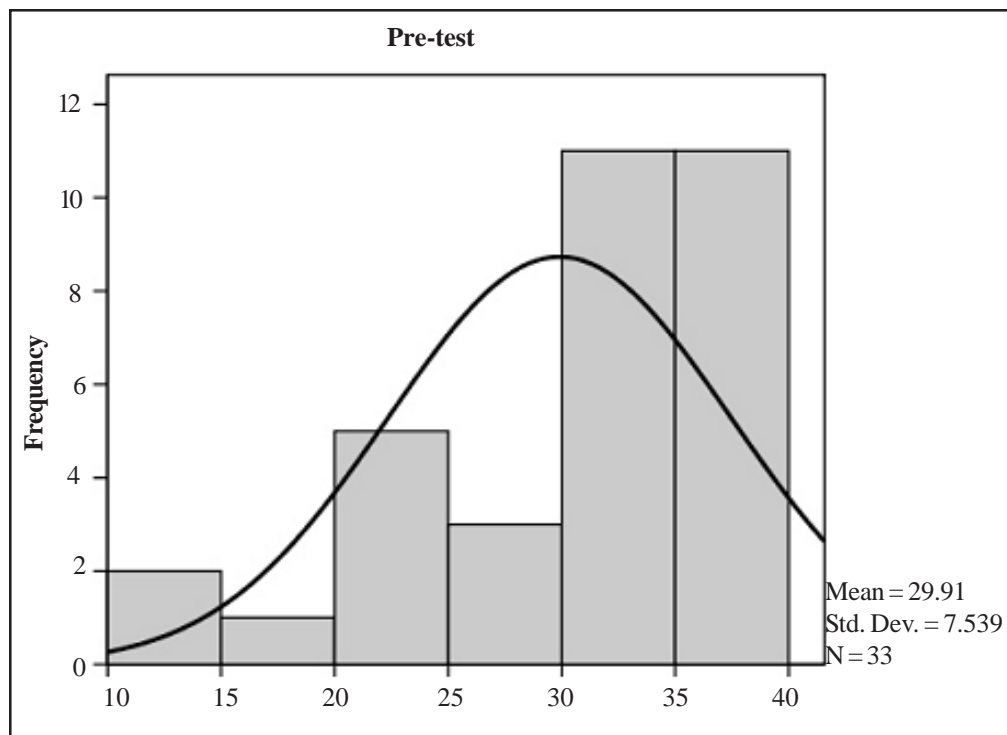
Mean = 29.91
Std. Dev. = 7.539
N = 33

Figure 2. (b) Post-test

Table 1 shows the frequency and percentage distribution of the students in the 40-item exam and Table 2 shows the mean distribution scores and the standard deviation.

Class Interval	Pre-test		Post-test	
	F	%	F	%
36-40	0	0.00	7	21.21
31-35	0	0.00	13	39.39
26-30	0	0.00	4	12.12
21-25	1	3.03	5	15.15
16-20	1	3.03	2	6.06
11-15	4	12.12	0	0.00
6-10	8	24.24	2	6.06

Table 1. Frequency And Percentage Distribution Of The Pre-Test And Post-Test

The z-test for correlated sample is 13.797 ($> ZCV = \pm 1.96$). Based on the z score, there is significant difference in the performance of the students during the pre-test and post-test.

Students' performance during the post-test was significantly improved.

	Pre-test	Post-test
Mean	5.790	29.910
Standard Deviation	5.787	7.539
N	33	33

Table 2. Mean Distribution Scores

4.2 Evaluation Results of the Active Learning Materials

Students were asked to evaluate the materials used and the following were the results:

(1) **In terms of Manual Content:** eighty-eight (88%) of the students agreed that the instructions in the Manual are clear and easy to follow; ninety-four percent (94%) agreed that the information is complete and informative; sixty-seven percent (67%) agreed that the materials are supplemental to classroom lectures; and ninety-four percent (94%) agreed that the use of the PCB and Manual improved their understanding of the concepts taught.

(2) **In terms of Usability:** eighty-eight percent (88%) of the students agreed the PCB and Manual are easy to use; fifty-five percent (55%) agreed that the experiments are of acceptable length and duration; and seventy percent (70%) recommends the use of the instructional materials.

Based on the evaluation results, improvement on the performance of the students may be associated with the use of the materials.

4.3 Difficulties Encountered by Students

Students were asked what are the problems they usually encounter in doing laboratory experiments Table 3 shows the difficulties encountered by students during laboratory experiments.

Difficulties	Weighted Mean	Rank
Inability to read Schematic Diagrams	3.39	1
Inability to understand and construct the circuits	3.45	2
Inability to relate classroom lecture with laboratory experiments	3.55	3
Poor understanding of the Basic Logic Gate Operations	3.61	4
Incomplete Tools (i.e. micro -nipper, long nose, etc.)	3.64	5
Too lengthy Experiments	3.67	6
Incomplete Materials	3.76	7
Experiments are not properly explained	3.85	8
Instructions are hard to understand	3.97	9.5
Lack of Interest in the subject	3.97	9.5

Table 3. Difficulties Encountered By Students

The following are some of the difficulties encountered by students when doing their experiment:

1) Inability to read schematic diagrams;

2) Inability to understand and construct the circuits;

3) Inability to relate the classroom lecture with the laboratory experiments;

4) Poor understanding of the basic logic gates concepts;

5) Incomplete tools;

6) Incomplete materials;

7) Too lengthy experiments;

8) Experiments are not properly explained;

9) Instructions are hard to understand; and

10) Lack of interest in the subject.

5. Conclusions

The study was conducted to introduce alternative approach to teaching basic logic gates concepts for Computer Engineering students. The researcher designed instructional materials to introduce Active Learning method and used experimental research method to determine if gains in learning may be associated with the use of such method. At the same time, the study also evaluates the instructional materials developed for teaching digital electronics concepts and to identify some of the difficulties encountered by students when performing laboratory experiments.

Based on the results of the pre-test and post-test of the 33 students in the 40-item exam, there was improvement in the performance of the students and this can be attributed to the use od the materials as indicated by the evaluation results where (94%) students agreed that the used of the materials improved their understanding of the underlying concepts. Through the used of the materials, students were able to experiment on their own which gave them experiential learning thus they were able to understand the concepts better. Through the used of the Active Learning method using researcher-made instructional materials, students were able to relate the 1's and 0's to its practical application - where 1 is when the lights will turn on, and 0 when it is off. Through the experiments, the students were able to remember the input/output combinations of the logic gates as compared to the truth tables comprised of 0's and 1's which they would ordinaruily simply memorize.

Based on the results of the pre-test and post-test, and the evaluation of the materials, gains in learning can be associated with the alternative teaching methods such as the Active Learning method.

6. Recommendations

In the light of the findings, the following are the recommendations:

1. For improved understanding and retention, experiential learning can be used in place of conventional lecture method, such as Active Learning to improve classroom teaching and learning;

2. Teachers are encouraged to explore different teaching methods;

3. The instructional materials (PCB and Manual) are recommended for use in subjects that cover basic logic gates operations;

4. Similar materials may be developed for other topics in Computer Engineering, as well as in other fields of specialization;

5. Teachers and administrators are advised to take into considerations the different difficulties encountered by students during laboratory experiments;

6. Similar researches using standardized assessment for the pre-test and post-test may be used;

7. Lastly, studies on different teaching methodologies may help improve the teaching and learning experiences.

7. Acknowledgment

References

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