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Effectiveness of the improvised logic gates simulator in basic digital electronics instruction

Ramil B. Arante*, Caraga State University Cabadbaran Campus, T. Curato Street, Cabadbaran 8605, Philippines

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Abstract

This study was conducted at Caraga State University—Cabadbaran Campus, particularly in the College of Industrial Technology and Teacher Education, Electronics Technology Area. It aimed at determining the effectiveness of the improvised logic gates simulator as an instructional device in basic digital electronics instruction to enhance the teaching-learning process. Effectiveness of the simulator was evaluated using the experimental method of research through the administration of pre-test and post-test to both the controlled group and experimental groups. Fourteen students were utilised as the experimental group and 14 were used as the controlled group. The experimental group was taught with the aid of the simulator, while the controlled group was taught using the traditional method of teaching. *T*-test result shows that there is a significant mean difference between the performance test results of the experimental and controlled groups. The findings proved that the improvised logic gates simulator is an effective instructional device to simulate logic operations.

Keywords: Digital electronics, effectiveness, experimental method, improvised instructional device, logic gates, improved performance, simulator.

* ADDRESS FOR CORRESPONDENCE: **Ramil B. Arante,** Caraga State University Cabadbaran Campus, T. Curato Street, Cabadbaran 8605, Philippines. *E-mail address:* ramilarante69@yahoo.com / Tel.: +63-917-711-0034

1. Introduction

Logic gates simulator is an improvised instructional device locally developed by the researcher. It will be used to simulate the operation of the seven logic functions in digital systems for learning clarity. It also has a logic probe section that will provide students an alternative way in determining the logic state of a digital signal flowing in digital circuits. In many cases, the common multimeter device is not enough to determine the logic state of the digital signal since, in the digital world, there is what we call the undefined state or the 'Don't Care' where the voltage is approximately in between 5 and 0 V which is considered not high or not low. A diode tester section is also included to offer a solution to problems of determining the correct polarity of the diode when its markings are already erased. The colour ring printed on one of its end usually marks the cathode terminal. But if this colour is erased, the problem of determining its correct polarity can be solved using a multimeter. However, when one must test a large number of unmarked diodes, multimeter becomes very uncomfortable to use. The best way to accomplish this kind of job is to use this section of the simulator. This circuit not only determines the polarity of the diode but also tests whether the diode is open or short-circuited. Another feature of the improvised simulator is the breadboard section which allows the student to temporarily construct a given circuit without soldering it into a printed circuit board (PCB). This is very useful, especially in verifying the state of the different electronic components involved in building a particular circuit. You can easily detect and replace defective components temporarily constructed in the breadboard before the actual construction into a PCB.

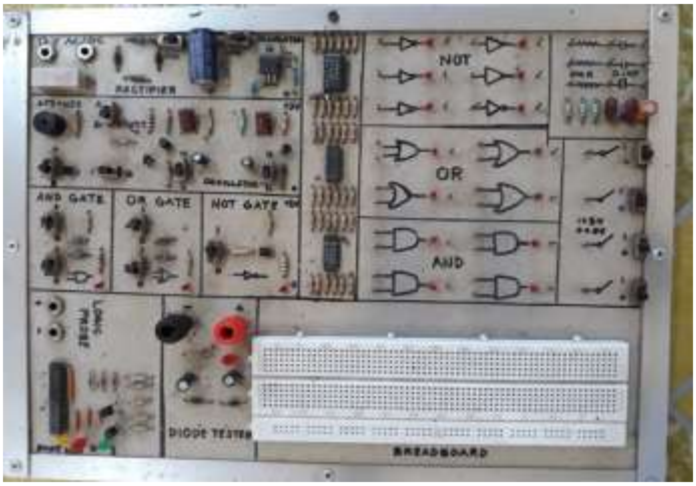

Figure 1. Improvised logic gates simulator

The advent of the Fourth Industrial Revolution 4.0, a name given to the current trend of automation and data exchange in manufacturing technologies, triggers all educational institutions to keep up the pace in producing well-rounded technicians. The manner of instruction in this field is geared towards understanding and developing skills in troubleshooting and maintenance of digital equipment which is now the trend. By doing so, they aimed to shorten the gap of skills between the young graduates and the skills recently in need in the industry.

Some educators pointed out that instructional devices are indispensable tools to convey the knowledge and skills from the instructors to the students. In fact, the quality of education largely depends on the availability of instructional equipment and devices in various learning institutions which is believed to play a vital role on the hands-on training of the students to develop their technical skills. Training aids have five distinct advantages: clarify verbal explanation; give out more information in less time than talking can; demonstrate principles difficult to visualise; help memory retention and help arouse the interest of the student.

Caraga State University Cabadbaran Campus (CSUCC), a state university which caters technical—vocational education answers the call of producing well-rounded technicians. In recent years, faculty members and students tried to maximise the use of facilities and equipment in the laboratories that are deficient in number and quality, much more, are obsolete. The College of Industrial Technology and Teacher Education redirected its accumulated meagre resources to design and assemble less expensive but equally effective instructional devices which may facilitate instruction. However, this newly developed training equipment has not been tested for its instructional effectiveness; thus, there is a need to conduct research to find out how effective are these training equipment in facilitating instruction.

1.1. The problem

The primary purpose of this study was to test the effectiveness of the simulator as a tool in basic digital electronics instruction. Specifically, the study sought answers to the following questions:

- How effective is the simulator as a tool in basic digital electronics instruction based on the result of the pre-test and post-test scores of the group taught without the trainer (controlled group) and the group taught with the trainer (experimental group)?
- Is there a significant mean difference between the pre-test and post-test results of the:
    - controlled group and
    - experimental group?
- Is there a significant mean difference between the test results of the respondent groups as to:
    - Pre-test and
    - Post-test?

1.2. Null hypothesis

At 0.05 level of significance, the following null hypotheses will be tested and be presented for verification and clearer interpretation:

Ho1: There is no significant mean difference in the pre-test and post-test of the controlled group.

Ho2: There is no significant mean difference in the pre-test and post-test of the experimental group.

Ho3: There is no significant mean difference between the controlled group and experimental group pre-test.

Ho4: There is no significant mean difference between the controlled group and experimental group post-test.

2. Materials and methods

This study utilised the experimental method of research. This method was used for testing its effectiveness as an instructional device for improving basic digital electronics instruction. Pre-test and post-test were also given and *t*-test was used to determine the mean difference of the pre-test and post-test ratings of the respondents being compared.

2.1. Flow of the study

The first activity was to craft the performance evaluation exam based on the course content utilising table of specifications. Pilot testing was done and item analysis was conducted to ensure the validity of the examination content. Final critiquing was also done by experts in the field of digital electronics before finalising the questionnaire.

The second activity of the study was the selection of the respondents which were taken from the Bachelor of Science in Industrial Technology (BSIT) program. The respondents were divided into two groups; the experimental group which would be taught using the improvised logic gates simulator and the controlled group that would be taught using the conventional method.

The third activity was to conduct a pre-test to the experimental group and the controlled group. The two groups were using the same questionnaire.

The fourth activity was the actual theory and skills lesson presentation. The experimental group was reinforced by the newly developed simulator, while the controlled group continued using the conventional method of teaching.

The fifth activity was the conduct of a post-test. The questionnaire that was used was the same as of the pre-test although the sequence of the questions was altered.

The sixth activity was the analysis of the pre-test and post-test results using the mean, standard deviation and *t*-test.

Finally, the drawing of conclusions based on the findings and giving out some recommendations completed the research process.

2.2. Respondents

The respondents of this study were composed of sophomore students from the BSIT major in electronics of CSUCC, which validated the effectiveness of the improvised logic gates simulator as a tool in digital electronics instruction. There were 28 sophomore students of BSIT, 26 of them were males and 2 were females. These students were divided into two groups. The first group which was composed of 14 selected students; 13 males and 1 female were the experimental group and the second group of another equally selected 14 students; also 13 males and 1 female were the controlled group. The selection of the respondents for grouping was actually based on their final shop grades during their first year of attendance and they were normally distributed in such a way that the two groups will have approximately the same mean of their grades.

The experimental group was taught using the newly developed logic gates simulator as reinforcement in the teaching and learning process, while the controlled group was taught using the conventional method or without the aid of the newly developed simulator.

2.3. Research instrument

A self-made performance evaluation questionnaire was crafted by the researcher. The content of this questionnaire was examined and validated by the experts for relevance and appropriateness. This questionnaire was given to both the experimental and the controlled group in their pre-test and post-test evaluation. The contents of this evaluation test are based on their technical understanding of the topic discussed. The test results drawn from this examination were used to determine the logic gates simulator’s effectiveness as an instructional device to the teaching-learning process in basic digital electronics.

3. Results and discussions

The testing for the effectiveness of the improvised logic gates simulator was based on the performance test results of the experimental group and controlled group. Table 1 presents a summary of the scores obtained by the respondents during their pre-test and post-test. Mean of both pre-test and post-test of the experimental group and the controlled group was also indicated. It can be seen that the pre-test means of both experimental and controlled group were approximately the same while in their post-test; the experimental group significantly had a much higher mean compared to the controlled group.

Table 1. Summary of scores obtained by the respondents during pre-test and post-test

Respondents	Experimental Group		Controlled Group	
	Pre-test	Post-test	Pre-test	Post-test
A	7	19	7	21
B	6	19	5	8
C	5	25	4	9
D	9	21	5	23
E	14	21	7	14
F	5	17	7	13
G	9	14	10	19
H	7	21	7	8
I	7	18	17	22
J	11	15	12	23
K	6	24	7	17
L	13	21	9	11
M	8	18	8	17
N	8	20	12	12
Total	115	273	117	217
Mean	8.21	19.50	8.35	15.50

Presented in Table 1 are the pre-test and post-test results of the experimental group and the controlled group, who had both 14 student respondents. For the experimental group, it was observed that the highest score obtained for the pre-test was 14 and a perfect score of 25 for the post-test, while their lowest scores were 5 and 14, respectively. When a 50% cut-off score be considered as a standard of passing, 12 will be considered the passing score. Based on the pre-test results of the experimental group, only 2 out of 14 student respondents actually passed the exam. On their post-test results, all of the student respondents of the experimental group passed with one student who got perfect and their lowest score is 14, which is two points above the passing score of 12. These findings revealed that the student respondents of the experimental group significantly improved their scores after their lessons were reinforced by the use of the improvised logic gates simulator.

For the controlled group, it was also observed that the highest score obtained for the pre-test was 17 and 23 for the post-test, while their lowest scores were 4 and 8, respectively. Considering again a 50% cut-off score and 12 as the passing score, only 3 out of 14 student respondents passed the pre-test but on their post-test, it significantly improved as 10 out of 14 student respondents already passed the exam. These findings also showed that the controlled group also significantly improved their scores even though their lessons were not reinforced by the improvised logic gates simulator.

When both groups are compared in terms of their performance, it can be noted that their pre-test means were almost the same (8.21 for the experimental group and 8.36 for the controlled group). One factor that was observed during the conduct of this research was to maintain homogenous respondents. Respondents were divided based on their shop grades during their first year. They were distributed in such a way that both groups were of equal footing. The pre-test was given to both groups with respondents having no background or knowledge on the topic of basic digital electronics. Female students were also divided equally in each group to maintain homogenous respondents. These factors were the very reason for having an almost the same mean on their pre-test. However, there were other factors in this study that were not considered. In terms of their post-test results, it can be observed that the experimental group has a relatively higher mean (19.50) as compared with the controlled group (15.50). This finding revealed that the experimental group has a higher passing percentage when compared with the controlled group. For the experimental group, 2 out of 14 respondents or 14.29% passed the pre-test, while 14 out of 14 respondents or 100% passed the post-test. For the controlled group, 3 out of 14 respondents or 21.43% passed the pre-test, while 10 out of 14 respondents or 71.43% passed the post-test. These findings were computed based on the data shown in Table 1. The experimental group had performed better when compared with the controlled group after using the improvised logic gates simulator as an instructional aid, especially on the concept of basic logic gates operations.

4. Test on significant mean difference

This section presents the needed data and tables for the computation of the following:

1. Significant mean difference between the pre-test and post-test of the controlled group.
2. Significant mean difference between the pre-test and post-test of the experimental group.
3. Significant mean difference between the pre-test of the controlled group and the experimental group.
4. Significant mean difference between the post-test of the controlled group and the experimental group.

It was necessary to determine the mean difference between the pre-test and post-test of both controlled and experimental groups in order to establish a comparison on which group had better performance. A higher mean indicated better performance. A test on the significant mean difference between the post-test of the controlled and experimental groups would otherwise determine the learning impact of the improvised logic gates simulator as a tool in basic digital electronics instruction. A relatively higher computed value when compared to the table value will reveal its effectiveness in enhancing the teaching-learning process.

Table 2. Test of significant mean difference

Respondents		$\bar{x}$	σ	Computed value	Table value at α= 0.05 one tailed	Findings	Decision
Controlled group	Pre-test Post-test	8.36 15.50	3.45 5.53	4.10	1.71	Computed value is greater than table value 4.10 > 1.71	Reject Ho_1 *There is a significant mean difference between the pre-test and post-test of the controlled group*
Experimental group	Pre-test Post-test	8.21 19.50	2.78 3.06	10.26	1.71	Computed value is greater than table value 10.26 > 1.71	Reject Ho_2 *There is a significant mean difference between the pre-test and post-test of the experimental group*
Experimental versus controlled	Controlled Group Pre-test Experimental Group Pre-test	8.36 8.21	3.45 2.78	0.13	1.71	Computed value is lesser than table value 0.13<1.71	Accept Ho_3 *There is no significant mean difference between the pre-test of the controlled group and experimental group*
Experimental versus	Controlled Group Post-test	15.50	5.53	2.37	1.71	Computed value is greater than	Reject Ho_4 *There is a significant mean difference between*

Experimental Group Post-test	19.50	3.06		table value 2.37 > 1.71	*the post-test of the controlled group and experimental group*

Revealed in Table 2 are data used in testing the significant mean difference between the pre-test and post-test of the controlled group. The pre-test mean was computed at 8.36 and for the post-test, it was 15.50 while their standard deviations were 3.45 and 5.53, respectively. Using these values, the computed *t*-test value was 4.10. The computed *t*-test value is larger than the table value of 1.71 at 0.05 level of significance and degree of freedom of 26. This finding revealed that the null hypothesis is rejected. It means that there is a significant mean difference between the pre-test and post-test of the controlled group. The significant increase of means from the pre-test to the post-test indicated that the respondents had improved their learning.

Table 2 also shows the data for testing the significant mean difference between the pre-test and post-test of the experimental group. The mean of the pre-test was computed to be at 8.21, while for the post-test was 19.50. Their standard deviations were 2.78 and 3.06, respectively. Using these values to compute for the *t*-test, a computed value of 10.26 was obtained. When compared to the *t*-test table value of 1.71, the findings showed that the computed value of 10.26 is very much bigger. This finding revealed that there is a significant mean difference between the pre-test and post-test of the experimental group. A very large increase in means from the pre-test to the post-test confirmed that the respondents had tremendous improvement in their learning as a direct result of using the improvised logic gates simulator as reinforcement during the teaching-learning process.

The data for the test of the significant mean difference between the pre-test of the controlled group and experimental groups are also presented in Table 2. Using the mean of 8.36 and a standard deviation 3.45 for the controlled group and a mean of 8.21 and a standard deviation of 2.78 for the experimental group, this resulted in a computed *t*-test value of 0.13. This value is smaller than the table value of 1.71; therefore, the null hypothesis is accepted. There is no significant mean difference between the pre-test of the controlled group and the experimental group. This also proved that the respondents are evenly distributed and of equal footing.

Table 2 also showed the data for testing the significant mean difference between the post-test of the controlled group and experimental group. The post-test mean for the controlled group is 15.50 with a standard deviation of 5.53 and for the experimental group; the mean is 19.50 and a standard deviation of 3.06. Using these data, a computed *t*-test value of 2.37 was obtained. This value is larger than the *t*-test table value of 1.71; therefore, the null hypothesis is rejected. There is a significant mean difference between the post-test of the controlled group and the experimental group. In this case, the experimental group performed better than the controlled group by virtue of having a bigger mean of 19.50 and a smaller standard deviation; thus, this finding confirmed the effectiveness of the improvised logic gates simulator as a tool in basic digital electronics instruction as manifested by the obtained scores of the experimental group. This finding revealed further that an efficient and a functional logic gates simulator is a very effective tool in enhancing basic digital electronics instructions, particularly on the topic 'logic operation' where users can have a meaningful learning experience by simulating logic functions. Herschback (1995) stressed that generalisations, theories, principles, technical maxims and procedures take on meaning as they are practically applied. Activity helps make explicit to the learner how knowledge is generated, communicated and used to analyse and solve technological problems. He further pointed out that technological knowledge is most clearly specified when it is linked to a specific activity, such as testing the strength of the material, calculating environmental damage, programming a computer, tuning a violin or plucking poultry. The technological activity conditions the use of knowledge. It is through activity that both the structure and substance of technological knowledge can be identified, and hence, generalised to instruction. Since much of technological knowledge is difficult to codify, an abstract treatment is incomplete without the accompanying activity. Therefore, using the logic gates simulator improves the learning condition of the learners.

5. Conclusion

Based on the findings of the study, the improvised logic gates simulator is a highly effective tool in basic digital electronics instruction to perform and simulate logic gate operations. This simulator generally enhanced the performance of the students, especially on the concept of logic operations based on the test results of the experimental group of respondents. Furthermore, this presents an innovative approach to solving the problem of instructional effectiveness.

References

Arante, R. B. (2017). *Design and assembly of an improvised logic gates simulator* (Unpublished Research). Caraga State University Cabadbaran Campus, Cabadbaran, Agusan del Norte, Philippines.

Brown, J., et al. (1973). *AV instructional technology media and methods*. New York, NY: McGraw Hill Inc.

Camarao, F. C. (1991). *Technology education in the Philippines*. Metro Manila: National Book Store Inc.

Effiong, O. E., et al. (2015). *Impact of instructional materials in teaching and learning of Biology in Senior Secondary Schools in Yakurr LG A*. Retrieved November 11, 2017, from https://www.scipress.com/ILSHS.62.27.pdf

Herschback, D. R. (1995). *Technology as knowledge: implications for instruction*. *Journal of Industrial Technology Education*. Retrieved from http://borg.lib.vt.edu/ejournals/JTE/jte.html

Jones, R., et al. (1990). *Do hands-on, technology based activities enhance learning by reinforcing cognitive knowledge and retention? Journal of Technology Education*. Retrieved from http://scholar.lib.vt.edu/ejournals/JTE/v1n2/jones.html

King, K. P. (2017). *Technology and innovation in adult learning* (1st ed.). San Francisco, CA: John Wiley & Sons Inc.

Lantharthong, T. (1991). *The construction of power electronics training kit and the experimentation of its efficiency* (Abstract) (Master's thesis). Central Library of KMITNB. Retrieved from http://202.28.17.1/thes/educat/MTE/mte003e.html

Penaso, A. M., et al. (2001). *Methods of research.* Research and Development Unit—College of Education, Central Mindanao University, Musuan, Bukidnoon, Philippines.

Seron, S. L. (2002). *Operational amplifier circuits trainer: a modular device for improving electronics instruction at Southern Leyte State College of Science and Technology* (Unpublished master's thesis). CSCST—Main Campus, Cebu, Philippines.

Stahmer, T. (2017, April 24). *What is instructional technology?* Retrieved October 30, 2017, from https://vste.org/what-is-instructional-technology/

Yamauchi, L. G. (2008). *Effects of multimedia instructional material on students' learning and their perceptions of the instruction*. Retrieved November 12, 2017, from http://www.pendergast.k12.az.us/dist/vdpaz/stw.tech.html

Appendix A

Sample computations

1. Average Mean (Using data from Table 1 'Experimental Group Pre-test Scores').

$$\bar{x} = \frac{\Sigma X}{N}$$

$$= \frac{7+6+5+9+14+5+9+7+7+11+6+13+8+8}{14}$$

$$= \frac{115}{14}$$

$$\bar{x} = 8.21$$

2. Standard Deviation (Using data from Table 1 'Experimental Group Pre-test Scores').

$$\sigma = \sqrt{\frac{\sum x^2}{N-1}}$$

$$\sigma = \sqrt{\frac{100.30}{14-1}}$$

$$\sigma = \sqrt{\frac{100.30}{13}}$$

$$\sigma = \sqrt{7.72}$$

$$\sigma = 2.78$$

Experimental group		
X	***x* = *X* − *x***	***x*²**
7	−1.21	1.46
6	−2.21	4.88
5	−3.21	10.30
9	0.79	0.62
14	5.79	33.52
5	−3.21	10.30
9	0.79	0.62
7	−1.21	1.46
7	−1.21	1.46
11	2.79	7.78
6	−2.21	4.88
13	4.79	22.94
8	−0.21	0.04
8	−0.21	0.04
		Σx^2 = 100.30

3. *T*-Test (Using data from Table 1 'Experimental Group Pre-test and Post-test').

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(\sigma_1)^2}{N_1} + \frac{(\sigma_2)^2}{N_2}}}$$

$$t = \frac{19.50 - 8.21}{\sqrt{\frac{(3.06)^2}{14} + \frac{(2.78)^2}{14}}}$$

$$t = 10.26$$