Paper #139: Eng 107

Teaching Circuits to Multiple Disciplines: Hardware, Software, Both?

Noureddine Bekhouche and Mr. Terry Marbut
Jacksonville State University
bekhouch@jsu.edu, tmarbut@jsu.edu

Abstract

The importance of appropriate laboratory activities has long been recognized in electronics technology programs. With advances in simulation software, a study has been conducted to determine the effectiveness of utilizing software laboratories in lieu of or at least in addition to traditional hardware laboratory exercises.
The study is carried out at a comprehensive regional institution using a basic circuits course required for all technology students. The results of the study are presented and discussed.

Introduction

Simulation software tools are becoming very popular. They offer several advantages such as powerful processing and simulation capabilities, user friendliness, and precision, and although not inexpensive, they can be much more cost effective than electronics measuring hardware. Moreover, several companies are now offering simulation software with advertisements suggesting that the software provides students with lab experiences equal to or better than those offered through traditional hardware laboratories. The increased utilization of these packages has spurred an ongoing debate as to whether these tools will convey similar principles as those learned within a hardware laboratory environment, making the expense of hardware labs unnecessary. In other words, can the software tools totally replace traditional "hands-on" experiments in a laboratory setting? A study is being conducted to attempt to answer some of the questions related to the subject.

The research takes a slightly different twist in exploring the effectiveness of electronic simulation software, MultiSIM, in a basic circuits course required for all technology students majoring in any of four areas of technology available in the Department of Technology and Engineering at Jacksonville State University (JSU) located in Jacksonville, Alabama. The areas of study include electronics technology (ELT), computer integrated manufacturing (CIM), occupational safety and health (OSH), and industrial technology management (ITM). Most of the students are not necessarily preparing for careers in the electronics field and will not be expected to utilize electronic measuring equipment on a daily basis. Can simulation software provide adequate experiences for all these students? Will the software experiences adequately reinforce classroom concepts? Will they provide students with enough "hands-on" activities that they would be able to perform basic measurements using real multi-meters, power supplies, and breadboards? This ongoing project is attempting to answer some of these questions. Ronen and Eliahu [1] tried to answer some of the questions in a secondary education setting for a group of 15-year-old students, but with the software portion being optional. The results of their study suggested that simulation software enhanced students' confidence and motivation to stay on task.

This paper provides the results from the first two years of the project. Although every student participates in this study, the relatively small class sizes will require several years of data to be collected before any conclusions can be strongly validated.

Methodology

Students in the basic circuits course are divided into two groups of equal size. Group A begins the semester with lab assignments that are predominately software simulation exercises, while group B begins the semester with lab assignments that are predominately traditional hardware circuit exercises. The members of the software group (A) are required to complete a hardware version of the last exercise in their packet, and the members of the hardware group (B) are required to complete a software simulation of the last exercise in their packet. Halfway through the semester, the groups swap roles, and Group A completes a packet of exercises that are predominately hardware, while Group B completes exercises that are predominately software simulations. This arrangement assures that all students get adequate exposure to the traditional hardware exercises while the effectiveness of the software exercises is being evaluated.

Toward the end of the semester, students are asked to complete a questionnaire to assess their lab experiences in an effort to provide insight into the effectiveness of the software exercises.

Results and Summary

In this section, the results of the study are listed and discussed. The answers to some of the questions that are asked during the study are summarized in the tables below.

The total number of students involved in the study according to their majors is listed in Table 1. Table 2 shows the students' gender distribution.

Table 1: Distribution according to major

Major	Number	Percent
ELT	16	28.07%
CIM	12	21.05%
OSH	15	26.32%
ITM	14	24.56%
Total	57	100%

Table 2: Students' gender distribution

Gender	Male	Female
Number	49	8
Percent	85.96%	14.04%

Students are asked to rate the level of difficulty for both the hardware and software labs, and the results according to each major are listed in Table 3. The largest response for each answer is marked in red.

Table 3: Levels of difficulty according to each major

	Which were most difficult?		
Major	Hardware	Software	No Difference
ELT	62.50%	18.75%	18.75%
CIM	58.33%	16.67%	25.00%
OSH	86.67%	0%	13.33%
ITM	71.43%	26.43%	2.14%

Students are asked to identify which method helped them reinforce the classroom concepts, and the answers according to each major are listed in Table 4.

Table 4: Activities that reinforced classroom concepts

	Which better reinforced classroom concepts?		
Major	Hardware	Software	No Difference
ELT	78.57%	14.29%	7.14%
CIM	58.33%	25.00%	16.67%
OSH	33.33%	40.00%	26.67%
ITM	35.72%	50.00%	14.28%

One of the questions asks students what type of lab activities they prefer (only hardware, only software, or a mixture), and the results according to each major are listed in Table 5.

Table 5: Most effective lab activities

	Most effective lab activity				
Major	**100% Hardware**	**100% Software**	**50/50 mix**	**70% Hardware 30% Software**	**30% Hardware 70% Software**
ELT	12.50%	0%	50.00%	25.00%	12.50%
CIM	12.50%	16.67%	41.67%	20.83%	8.33%
OSH	0%	6.67%	46.67%	13.33%	33.33%
ITM	7.14%	28.57%	35.71%	7.14%	21.44%

The tables to follow provide a comparison between male and female students. These tables address the same questions used in Tables 3, 4, and 5.

Table 6: Comparison between male and female

	Which were most difficult?			Which better reinforced classroom concepts?		
	Hardware	**Software**	**No Difference**	**Hardware**	**Software**	**No Difference**
Female	100%	0%	0%	39.89%	50.00%	11.11%
Male	55.10%	14.29%	30.61%	48.98%	28.57%	22.45%

Table 7: Comparison between male and female

	Most effective lab activity				
	100% Hardware	**100% Software**	**50/50 mix**	**70% Hardware 30% Software**	**30% Hardware 70% Software**
Female	0%	18.75%	18.75%	12.50%	50.00%
Male	12.24%	10.20%	44.90%	20.42%	12.24%

<u>Summary</u>

- The majority of the students for all the majors agree that hardware is the hardest part of lab (see Table 3). This is because students have to perform actual circuit wiring instead of building it or opening a file using the MultiSIM software. Students also have to make sure that the circuit is working properly, which requires troubleshooting in some cases. Moreover, students have to perform additional tasks, such as turning the power on and off and taking all the required measurements.
- Table 4 provides a clear distinction between students in technical majors, ELT and CIM, and non-technical ones, OSH and ITM. Students with a technical background think that performing the experiment using the hardware is a better way of reinforcing classroom concepts even though it is the most difficult part. Non-technical major students think that software is the approach to better grasp and understand classroom concepts.
- The majority of the students prefer a mixture of both hardware and software as an effective way to do lab experiments, as shown in Table 5.
- All of the participating female students think that the hardware part is the most difficult one and the software is more helpful in understanding classroom concepts. On the other hand, the majority of male participants think that the hardware is a better way to digest concepts learned in the classroom.

Conclusion

The data indicates that females may view things differently than males, with females giving preference to software labs. This difference could potentially be attributed to the assumption that males typically have more experiences in dealing with various tools and putting things together before reaching college age and are not as intimidated by having to physically build the circuits. Moreover, five of the eight females were not CIM or ELT majors, so most of the difference could be more related to major than gender, but it was interesting that no female students preferred hardware labs. It should be noted, however, that the number of females represented in the surveys is still statistically insignificant. The discrepancy between the number of males and females completing the course is indicative of another issue facing technology programs: the need to increase female participation in these programs.

The fact that students enrolled in the more technical majors strongly believed the hardware labs do a better job in reinforcing classroom concepts leads to questions concerning possible curricular change. Should separate courses be developed? Should there be one course for CIM and ELT majors and another for ITM and OSH? Is it OK to have all students take the same course but assign mostly hardware labs to students in the more technical majors and mostly software labs to the other students?

At this point in the research, the data does not support the elimination of hardware labs in favor of labs based on software tools such as MultiSIM, although some exposure to the analysis of electrical circuits through simulation seems to be desired.

References

[1] Ronen, M. and Eliahu, M. **“**Simulation – A bridge between theory and reality: the case of electric circuits,” *Journal of Computer Assisted Learning*, Vol. 16, no. 1, Dec. 2000, pp. 14–26.

Biography

NOUREDDINE BEKHOUCHE is currently an associate professor at the Department of Technology and Engineering at Jacksonville State University (JSU). He is the coordinator of the Electronics program. He teaches a wide variety of courses at both the graduate and undergraduate levels at JSU.

TERRY MARBUT is currently the head of the Department of Technology and Engineering at Jacksonville State University (JSU). He also teaches undergraduate courses ranging from AC/DC circuits to quality control.