Incorporating Project Based Learning in Introductory Electronics Course

Maria Javaid
Jacksonville University

Abstract

This paper explains how project-based learning (PBL) was incorporated into an introductory level electronics course. It also explains the impact of this approach on student performance and their learning experience as well as their perception of the course.

The main challenge in incorporating PBL into introductory level engineering courses is effectively teaching core course content while conducting a project or projects to enforce class learning. This paper explains how various topics of an introductory course can be taught to students as a part of project. Students were assigned a project of developing a DC power supply at the start of semester. They were informed that the instructor would assign the project in stages designed to help them achieve multiple milestones throughout the duration of the course. Each milestone was evaluated separately. This helped them know the importance of each topic and how it can be applied.

Keywords

Project-based learning, pedagogical innovation, introductory level course.

Introduction

Project-based learning (PBL) involves learning through the project. The term project is used to refer to a complex task accomplished over an extended period, which produce in some realistic products[1-3]. Projects emphasize application of knowledge rather than acquisition of knowledge[3]. PBL benefits have been supported by research studies. PBL benefits include enhanced student participation in learning, deeper learner, stronger motivation to learn, and enhanced communication skills[4-7].

PBL is considered an important part of engineering education. Most undergraduate engineering programs involve a semester or year-long capstone PBL experience in the senior year. Due to the PBL benefits, the use of PBL in traditional courses is increasing as well. PBL is also incorporated into introductory level engineering courses[8].

This paper details the use of PBL in an introductory electronics course. The details of the approach and its implementation are provided in next section. Finally, the results of this approach on student learning and their perception of the course are presented.

Method

A foundational engineering course like introductory electronics involves teaching basics of the subject. Course content to be covered is quite standardized and students do not have much prior engineering knowledge to complete an engineering project autonomously. The main challenge this author faced when implementing PBL in her introductory electronics course was to deliver the primary course content along with executing a project involving application of the subject matter. Another concern was how much autonomy and flexibility are beneficial for sophomore students.

The approach adopted by the author was to consider an engineering device which involves learning the main concepts taught in course. Students are then informed that they are working towards making a device for a class project. Instructor covers various course topics as different components of class project.

The list of main topics taught in introductory electronics course at Jacksonville University include:

- Semiconductor diode
- *Diode applications*
  - *Rectification*
  - *Clippers*
  - *Clampers*
  - *Zener Diodes*
- Bipolar Junction Transistors (BJT)
- DC biasing of BJT
- AC analysis of BJT
- Field-Effect Transistors

Notably, all the topics on this list relating to diode applications are involved in DC-power supply. Thus, the instructor informs students that they will be developing a dc-power supply as a class project. They were taught about diode properties as it was done earlier. However, now they are informed that they are learning about a component which they will utilize in developing a DC-power supply. Similarly, various diode applications are also taught as they were in a class which did not involve PBL However, after incorporating PBL, students began to view each topic as a component of their project. This changed their overall perception about theoretical concepts taught in class. They could then begin to view the importance of each topic and look forward to the application of the learned knowledge in building their first useful engineering device.

Student knowledge of theoretical concepts was tested in the same way as implemented before incorporating PBL and the structure of examinations and homework had not changed at all. Therefore, this method of incorporating PBL into an introductory level electronics course was different than the methods implemented at some other institutions at the introductory level[8].

Development of DC Power Supply

Development of DC power was incorporated during laboratory time. Various components of a dc power supply had already been implemented as stand-alone experiments on applications of a diode. Author termed those laboratory experiments as tasks towards achieving the multiple milestones of a class project. Students perform the same experiment as they did before PBL incorporation and were evaluated in the same way as before. However, they seem more enthusiastic as they indicate that this time, they are making progress towards developing a useful device, namely a DC power supply. Table 1 shows the list of laboratory experiments covered before incorporating PBL, and Table 2 shows the list of experiments covered after including PBL in course.

EXPERIMENT NO.	**TITLE**
1	Silicon Semiconductor Diode Characteristics
2	Characteristics of Light Emitting Diode and Zener Diode
3	Half-Wave Rectifier
4	Full-Wave Bridge Rectifier
5	Clippers
6	Clampers
7	DC Power Supply Design
8	Transistor Input and Output Characteristics
9	DC Analysis of Fixed Bias Configuration
10	DC Analysis of Emitter Bias and Voltage Divider Bias Configurations
11	Voltage Divider Bias Configuration as AC Amplifier

Table 1. Pre-PBL list of experiments shared by author.

	TITLE
EXPERIMENT NO. 1	Silicon Semiconductor Diode Characteristics
EXPERIMENT NO. 2	Characteristics of Light Emitting Diode and Zener Diode
PROJECT TASK NO 1	Half-Wave Rectifier
PROJECT TASK NO 2	Full-Wave Bridge Rectifier
EXPERIMENT NO. 3	Clippers
EXPERIMENT NO. 4	Clampers
EXPERIMENT NO. 5	Zener Diode as Voltage Regulator
PROJECT TASK NO 3	DC Power Supply Design
EXPERIMENT NO. 6	Transistor Input and Output Characteristics
EXPERIMENT NO. 7	DC Analysis of Fixed Bias Configuration
EXPERIMENT NO. 8	DC Analysis of Voltage Divider Bias Configurations
EXPERIMENT NO. 9	Voltage Divider Bias Configuration as AC Amplifier
PROJECT TASK NO 4	Making a Printed Circuit Board

Table 2: List of Experiments After Including PBL

Results

The instructor observed a significantly enhanced student enthusiasm and an increase in their desire to acquire further knowledge. Students presented their project at a Jacksonville University internal conference, the JU Symposium, which enhanced their sense of achievement.

This approach also improved student performance in exams. However, since less than 10 students were enrolled in the class, the statistical significance of exam results improvement cannot be established.

The students' perception of the course improved after utilizing the PBL approach. The student ratings of instruction using the IDEA evaluation system[9] showed high scores in all aspects of teaching and learning. The overall average of IDEA scores for the course was 4.7 out of 5. This score is in the top 30% of all IDEA ratings. The qualitative comments by the students also indicated that they had a very good learning experience. Students particularly praised the value of their assigned project in the IDEA comments.

Conclusion and Discussion

Overall the approach of combining various topics of an existing introductory level course as a project has a very positive impact on student learning experience. The author has utilized this approach for her electronics course; however, it can be extended to other introductory level courses as well. The author suggests that instructors may provide a solution for components of a project, which are not covered as a part of the original course curriculum.

The most interesting part of this approach is students learn the same concepts and performed the same experiments as they would have done without PBL. However, with the new approach, they can understand the importance and usefulness of different components. This results in increasing their interest and enthusiasm for the course. They also get a sense of achievement when developing an engineering product utilizing the knowledge gained from the course.

References

1 Thomas, J. W. (2000). A review of research on project-based learning. San Rafael, CA: Autodesk Foundation.
2 Mills, J. E., & Treagust, D. F. (2003). Engineering education—Is problem-based or project-based learning the answer. Australasian journal of engineering education, 3(2), 2-16.
3 Thomas, J., Michaelson, A., & Mergendoller, J. R. (1999). Introduction to Project Based Learning. Buck Institute for Education Project Based Learning Handbook.
4 Geier, R., Blumenfeld, P. C., Marx, R. W., Krajcik, J. S., Fishman, B., Soloway, E., & Clay-Chambers, J. (2008). Standardized test outcomes for students engaged in inquiry-based science curricula in the context of urban reform. Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 45(8), 922-939.
5 Finkelstein, N., Hanson, T., Kevin (Chun-Wei) Huang, Klarin, B., & Huang, M. (2010). Effects of problem based economics on high school economics instruction. US Department of Education.
6 Beckett, G. H., & Miller, P. C. (Eds.). (2006). ProjectBased Second and Foreign Language Education: Past, Present, and Future. IAP.
7 Mergendoller, J. R., Maxwell, N. L., & Bellisimo, Y. (2006). The effectiveness of problem-based instruction: A comparative study of instructional methods and student characteristics. Interdisciplinary Journal of Problem-based Learning, 1(2), 5.
8 Gustafsson, G., Newman, D. J., Stafström, S., & Wallin, H. P. (2002). First-year introductory courses as a means to develop conceive–design–implement–operate skills in engineering education programmes. SEFIrenze 2002, Florence, Italy, 8-11 September 2002.
9 URL http://www.ideaedu.org/Services/Services-to-Improve-Teaching-and-Learning/Student-Ratings-of-Instruction

Maria Javaid, PhD

Maria Javaid received her Ph.D. in Electrical and Computer Engineering from the University of Illinois at Chicago (UIC) in 2014. She is currently an Assistant Professor in the Department of Engineering at Jacksonville University. Her research interests include human robot interaction, haptics, game-based learning and pedagogical innovation.