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Creativity in an Introductory Engineering Course

Abstract

A two credit hour introductory electrical and computer engineering (ECE) course is the forum for this research project. The course introduces ECE majors to the profession with a lecture component that emphasizes circuit analysis, simulation software, lifelong learning, and ethics. The laboratory component consists of five laboratories where students analyze an automobile lighting system to reinforce fundamental principles, use a breadboard to create a circuit with an operational amplifier, and assemble a radio from a kit. In addition, a laboratory where students design and build a functional product with attention to aesthetics has been introduced to exercise their creativity. The creative process is marked by progression through various stages such as brainstorming, forming a construction plan, drawing schematic representations of the product, and implementation of the design. This project is motivated by the need for creative thought in engineering undergraduate students to enable enhanced product design. Each semester the product changes and to date, three laboratory modules have been developed. The three variations include: designing a lamp from musical instruments, designing the housing for a low power computer, and designing a solar powered wind chime. The students are tasked to design and build the products within a three week time period. The major components for each product are supplied with budgets in the range of $25-50 per group for additional items. Assessment results show that the majority of students enjoy several aspects of the "creative" laboratory. At the same time, they consider it to be one of the most difficult laboratories.

Introduction

Engineering students need to solve problems during their studies and in their profession. Much attention is given to teaching students fundamental principles and systematic approaches to problem solving. Educators also have a desire for their students to be creative in their approaches to problem solving. Many engineering students are given this opportunity in their capstone senior design courses although it is becoming common to bring design experience to students earlier in the curriculum.[1,2,3,4] At the senior level, design projects are assigned that are complex enough to require a team of students brainstorming and implementing their designs. Emphasis is typically placed on producing a functional product or system. While creativity may be employed in a student design project, it is not always emphasized or discussed. An exception to this statement is described by a group of educators using design notebooks to highlight creativity throughout the design process.[5] Their motivation was to help distinguish individual creativity from team creativity. Attention to aesthetics in the design process is generally a low priority. The goal of this project was to raise awareness of creative thinking and aesthetic appearance in the design process early in the ECE curriculum. Several others are doing this by integrating creativity in the classroom,[6] assigning an innovative embedded systems project,[7] developing a course and accompanying textbook,[8] and offering a technical course to students with a background in the arts.[9]

Motivation

A pilot lab was conducted in the spring semester of 2008 that began as a request by the music department at the University of Alabama. The department was holding a fund raising activity in

April of that year called the *Arty Party*. The annual event highlights the Fine and Performing Arts programs. The music department was willing to donate musical instruments to the department if students would turn them into lamps that could be auctioned at the event. The ECE department head decided that this would be an interesting project for the students in our introductory course, ECE 125: *Fundamentals of Electrical and Computer Engineering*. The course is two credits with two lectures per week and five laboratories. The lecture introduces students to basic circuit analysis, simulation software, engineering ethics, professional societies, and a survey of the ECE discipline. The laboratories involve using breadboards, soldering, analysis of an automobile lighting system, configuring op-amp circuits, and building an AM radio. One of the laboratories to study maximum power transfer was replaced with a laboratory to design a lamp from a musical instrument. The students were given three lab periods to conduct this project and a budget of approximately $50 for each team. In this pilot lab, the students were creative in their designs and implementations and they also seemed to enjoy the process. The lamps sold for an average of $500 per lamp and were considered to be a success by the faculty members in the music department. Details of this project were presented in 2009.[10]

CCLI Project Objectives

After the successful pilot project had been completed, a proposal was submitted to NSF in the CCLI Phase 1 program. When funding was secured, the project team began planning for development of laboratory modules that could be implemented in ECE 125 each semester for the grant period of two years (four semesters). The goal of the proposed laboratory was to exercise and enhance the creative process in lower level ECE students. It was our desire to emphasize creativity and visual appearance in the design of a product. The project objectives included:

1) Making ECE more appealing to students early in their academic career;
2) Demonstrating that engineering is a creative process; and
3) Prompting students to think about problems in a non-formulaic manner.

These objectives helped to drive the evaluation activities for the project. Evaluation efforts were coordinated by faculty in the university's Institute for Social Science Research (ISSR). They developed a set of surveys to be given to students after each laboratory and a set of surveys for the graduate teaching assistants at the end of the semester.

Laboratory Modules

To date, three laboratory modules have been created and offered in the following semesters: fall 2009, spring 2010, and fall 2010. The fourth module will be created and offered in spring 2011. The design of lamps from musical instruments was the first lab to be offered. This lab was repeated from the pilot since it had not ever been formally evaluated. The second lab involved designing a housing for the circuit boards and power supply of a low power computer and the third involved designing a solar powered wind chime. Each semester, the project team attempts to find a product that will appeal to students from a technical standpoint but also has an artistic component. The typical class size is approximately 55-60 students per semester and is taught in two nearly equal sized sections. The lab is taught in six sections with 8-12 students per section. Student teams are formed with 3-4 students each.

The creative lab is the third lab taught in the sequence of five labs so it comes at about midsemester. At that point, fundamental principles of resistance (series and parallel combinations), voltage/current division, and some circuit analysis techniques have been covered. For each of the creative labs, it has been necessary to provide some additional material that pertains specifically to the components that will be used in that lab. This has been done both ways (lecture and laboratory) with the most efficient being the lecture (requires repeating once for the second section). Using laboratory time means many repetitions of the material although if the graduate teaching assistant is comfortable with the material, the students prefer this information in this format because they are preparing for the design project. For the creative lab, they are given a chance to brainstorm ideas, construct sketches, document and request any parts/tools needed, prepare a budget, and describe their product in a lab report. At the end of each semester, a competition was held where student projects are judged on both function and appearance. The event was widely advertised. Faculty from ECE, the College of Engineering Teaching Academy, the Engineering Dean and Associate Deans, ECE staff and students, Co-op, and Career Center personnel, and staff associated with the Creative Campus Initiative are invited to the competition. T-shirts or bookstore gift cards have been given in the past as prizes.

Lamps (Fall 2009)

The purpose of this lab, as mentioned in the description of the pilot project, was to build a lamp from a musical instrument. Students worked in teams to create a unique lamp. The lab was held over three sessions. Previous to the first session, a general lecture on lamp wiring was presented on safety issues and the importance of electrical codes. We felt that this lecture was necessary when we observed during the pilot project that students encountered problems such as an instrument resting on the electrical cord and interference between an audio amplifier and a touch sensitive switch. In the first session, students were told to appoint a team leader to help moderate discussions, guide activities, and delegate the required work. In this session, they inspected their instrument and lamp wiring kit. Students brainstormed ideas as a team and documented this activity for their report. In the second session, they began to formalize a plan for implementing their design and selected one member from the team to produce a schematic drawing of their lamp. Students generated a list that included all parts and tools they would need before their next meeting. The third session was held two weeks later and in that session, students finalized the construction of their lamp. Some example lamps are shown in Figure 1.

Figure 1. Example lamps from ECE 125; Fall semester 2009.

The students were asked to provide a name for their lamp: Bourbon Bon, Saxy Time, Ben Dellophone, The Swinging Sax, Disco Piccolo, Tuba Tantrum, Tubeytrue, and Mellodramatic.

Computers (Spring 2010)

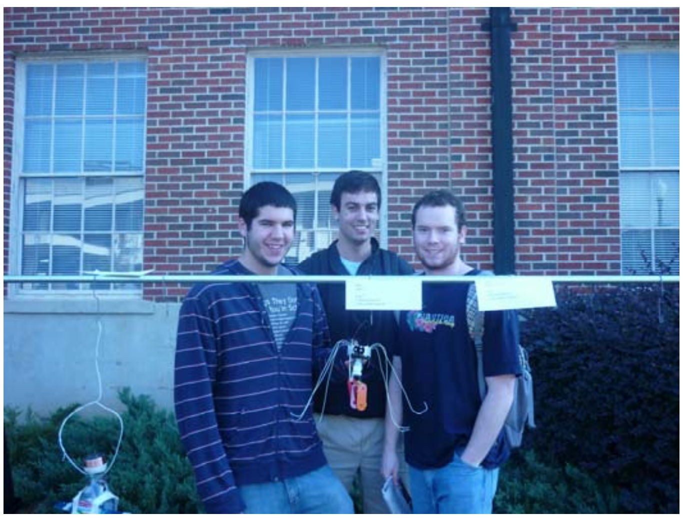
In this semester, a new laboratory was developed that built upon an outreach project to high school students in rural Alabam. In this lab, students were given the parts to a computer (keyboard, memory, motherboard, mouse, monitor, power supply, power switch) and asked to assemble them into a working computer. They spent some time working on this while he also discussed the aspects of a low power computer. The creative aspect of this laboratory was to build a decorative housing for the computer using recycled or recyclable materials. In the same approach as the lamp laboratory, students were asked to brainstorm and document their ideas before proceeding on to the design and build stages. Three laboratory sessions were used to complete this laboratory. Each group consisted of 2-3 students resulting in a total of 18 unique computers. Because of the large number of computers, prizes were awarded in four areas: artistic appearance, reuse of materials, biodegradability, and overall appearance. Some highlights for housing materials included a toaster, a suitcase, a log house built from newspapers, sticks, and a speaker. A few example photographs are included in Figure 2.

Figure 2. Example computers from ECE 125; Spring semester 2010.

The students were asked to name their computers for the end of semester competition. The winners of artistic appearance: Speakuter and Zazu's House; Reuse of Materials: Smart House and Lean Mean Machine; Biodegradability: Granny Smith and Woody; Overall: Montecristo and Toasty Computer.

Wind Chimes (Fall 2010)

After conducting two labs where electricity and computing were major themes, the project team decided the third lab should include solar energy. In this lab, students were given a solar powered yard light and small motor from a hobbyist web site. Students were shown how to disconnect the solar cell from the light and tasked to build a solar-powered wind chime. They designed the actual chime and implemented a switch. A sustainable design theme was used again so students were encouraged to incorporate materials that can be recycled or repurposed. In the same approach as other labs, students were asked to brainstorm and document their ideas before proceeding to the design and build stages. Three laboratory sessions were also used to complete this laboratory. At the end of the semester, a competition was held. Prizes were awarded in four areas: artistic appearance, acoustics, reuse of materials, and overall appearance. A few example photographs are included in Figure 3.



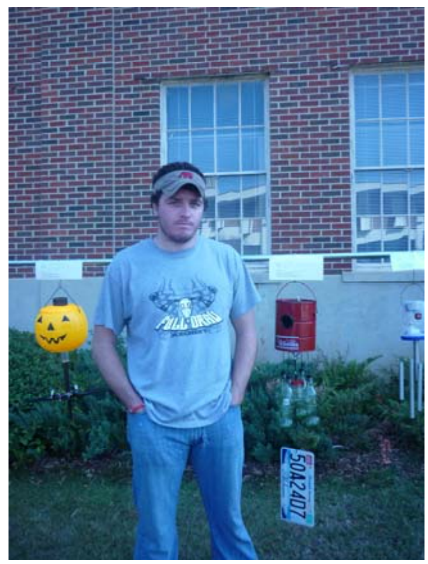


Figure 3. Example chimes from ECE 125; Spring semester 2010.

The winners of artistic appearance: Headless Horseman's Head; Acoustics: Furin and Fork N Tubes; Reuse of Materials: Shiny Fate; Overall Appearance: Hells Bells.

Evaluation of the Participants

Evaluation efforts were coordinated by Debra McCallum, Director of the UA Institute for Social Science Research (ISSR). The findings reported here are only from fall semester 2009 and spring semester 2010. At the time of this writing, analysis is underway for the data acquired from recent surveys. Table 1 shows the comparison of labs based on student surveys. These surveys were administered after completion of each lab. In terms of what lab students enjoyed most, Lab 5 (AM radio kit) had the highest rating with a similar rating for Lab 1 (siren). Both labs are essentially soldering exercises but the students experience a working product if they are careful with soldering components. The creative lab has the third highest rating with an average of 3.68 between two semesters. This lab had a higher standard deviation than the others (0.4) with the Fall 2009 project (lamps) receiving the higher rating. Student ratings for the question about how much they think they learned were the highest for labs 1 and 5 (consistent with the ones they enjoyed most) although all labs received above a 3.6 rating. The creative lab had the highest ratings for the amount of brainstorming, problem-solving, and creativity, which is expected given the nature of the lab. For lab 3 when students were asked how much they contributed compared to other group members (1 being the least and 5 the most), the creative lamps rated 3.87 and the computers rated a 3.82. These results indicate a similar sense among students of their contribution to the overall project. At the end of each semester, a survey asking questions about the lab overall indicated that students enjoyed the labs (4.08) and felt they learned from them (4.0). They felt the course contributed to their engineering background (4.2). They felt creativity is important in engineering (4.25) and they were likely to continue majoring in engineering (4.65). When asked if they had shared anything they learned in class with a friend or family member, 76% responded yes from Fall 2009 (lamps) while 66% responded yes from the Spring 2010 (computers).

Table 2. Comparison of labs in ECE 125

Legend: Lab 1 – European siren
Lab 2 – Auto lighting system
Lab 3 – Creative Lab (Lamps/Computers)
Lab 4 – Amplifier/oscilloscope
Lab 5 – AM radio

Answer ratings: 1 = Not at all; 5 = Very Much;
1 = Very Little; 5 = A lot *Note, F09 and S10 ratings are averaged

Question	**Lab 1**	**Lab 2**	**Lab 3**	**Lab 4**	**Lab 5**
How much did you enjoy the lab?	4.19	3.27	3.68	3.56	4.29
How much do you think you learned?	3.88	3.65	3.81	3.76	3.99
To what extent did the lab require brainstorming?	2.29	3.25	4.36	3.06	2.62
To what extent did the lab require problem solving skills?	2.36	3.49	4.03	3.13	2.82

To what extent did the lab require you to be creative?	1.92	2.33	4.52	2.27	2.54
How involved do you feel you were in the activities required?	4.45	4.15	4.4	4.12	4.58
How confident do you feel about your performance?	4.73	4.3	4.38	4.33	4.68
Compared to other group members, how much did you contribute in this lab? (1 = contributed the least; 5 = the most)			3.87 (F09) 3.82 (S10)		

Summary

In summary, a project where students are exposed and involved in the creative process while designing a functional product has been described. Attention was given to the artistic component and visual appearance of the product. Three laboratories have been described for this purpose with a fourth under development. The forum for this lab was an introductory course for students in electrical and computer engineering. Assessment of the lab portion of this course was done by student surveys. Students generally rate all of the laboratories highly with the most enjoyable labs being the kit-based projects. While they appear to enjoy the creative lab, the fact that the project is open-ended and requires a process of brainstorming, planning, and implementation of their design makes it more time consuming and different than the other more formulaic labs. This fact makes it difficult to compare the labs. The project team feels the experience is valuable for the students and that awareness of creativity is raised.

Acknowledgments

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