AC 2009-32: PICASSO'S CLARINET: WHEN ART AND ENGINEERING COLLIDE

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Picasso's Clarinet: When Art and Engineering Collide

Abstract

A pilot-scale laboratory was explored in an introductory electrical and computer engineering (ECE) course designed to exercise creativity. The idea for this laboratory was initiated by the music department as a way to promote collaboration and as part of a fund raising activity. In this lab, students built lamps from retired musical instruments. The creative process was marked by progression through various stages including brainstorming, formalizing a construction plan, drawing schematic representations of the instrument/lamp, generating a parts/tool list, and implementation of the design. This project addressed the need for promoting creative thought in engineering undergraduate students for enhanced product design. Attention was given to the artistic component, a view often neglected. There were 43 total students in the class and they were arranged into seven groups. The music department donated the instruments that included a: saxophone, clarinet, bassoon, piccolo, trumpet, mellophone, and trombone. The students were tasked to design and build a lamp from these instruments and the team budgets averaged $60 per group. The laboratory activity and completed lamp designs will be described in this paper. A competition was held and the lamps resulting from this laboratory were sold at a fund raising auction event. The faculty members associated with this project indeed considered the lamps to be a very creative product.

Introduction

In spring semester 2008, a laboratory to infuse creativity into the design process was explored in the first required course for freshmen in Electrical and Computer Engineering (ECE). The course, ECE 125: *Fundamentals of Electrical and Computer Engineering*, is a two credit course with two lectures per week and a total of five laboratories held throughout the semester. The lecture introduces students to basic circuit analysis, programming in MATLAB, and a survey of the ECE discipline. The laboratory component includes: promoting breadboarding and solder skills, analyzing an automobile lighting system, building basic op-amp circuits, and building an AM radio from a kit. This lecture/laboratory combination provides instruction of basic concepts and promotes basic skills. The laboratory, however, does so in a somewhat formulaic, step-by-step approach. The intent of the experimental laboratory described in this paper was to raise awareness of the creative process in ECE students as a powerful skill to possess in problem solving. This process can be considered to be linked closely to design, an area that is emphasized in engineering programs, although in this project, the artistic component is given equal billing. Creativity/artistry is especially important in today's competitive environment.

The goal of the laboratory was to exercise and enhance the creative process in lower level ECE students. This trait, creativity, is considered to impact globalization[1] yet most engineering programs do not emphasize this skill. Globalization is stressed as a critical issue for the success of future STEM professionals in *The Engineer of 2020*[2] and *Educating the Engineer of 2020.*[3] A disadvantage in de-emphasizing creativity is that functionality may dominate the design process with little regard to visual considerations.[1] Project objectives include:

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.

Motivation

As part of a fund raising activity by the University of Alabama (UA) Music Department, students were tasked with building lamps from retired musical instruments. The lamps would be auctioned near the end of the semester at what is referred to as the "Arty Party." Each year, this event highlights the Fine and Performing Arts programs. This partnership between music and engineering was motivated by a university-wide initiative called Creative Campus. Creative Campus is a student-led arts initiative that began in the 2005-2006 academic year. Their goal is to increase the profile of the cultural arts by promoting collaboration for creative activities to other parts of the campus and community. The Creative Campus Initiative "is an unprecedented attempt to broaden the scope and to deepen the experience of arts, culture, and creativity through collaboration, cohesion, and connectivity". Figure 1 shows the lamp and team that inspired the title of this paper. Note the placement of the clarinet mouthpiece as the lamp finial. Their creativity shows in their lamp design and their name for their lamp. The lamp was so named because of the abstract nature of the positioning of the instrument parts.

Figure 1. *Picasso's Clarinet.*

Background

The creative process is widely acknowledged as a valuable approach to problem solving. Creativity is one of many skills needed for the future engineering and technology workforce to provide innovations that help to maintain competitiveness in the nation.[4] This trait is considered to impact globalization[1-3] yet most engineering programs, with a few exceptions,[5] do not emphasize, or exercise, this skill. The disadvantage is that functionality may dominate the design process with little regard to visual considerations.[1] Exercising creative thinking[6,7] and teaching creativity as a systematic process is encouraged by educators from various science and engineering disciplines.[8,9,10,11] In an introductory CS course where creativity was incorporated into the project, 64% of students surveyed indicated that they shared at least one program they created with a friend or family member.[11] This display of ownership for their programs was considered a primary method for determining student enthusiasm in creative exercises. This same sense of pride was observed in the creative lamp experiment when one student's grandfather became involved in making and staining a wooden base to match the bassoon.

Educators concerned with traditional engineering curricula and meeting ABET criteria have recognized the importance of the design process in exercising creativity. Some institutions incorporate design projects early in the curriculum.[12,13,14,15] As an example, freshmen at the U.S. Air Force Academy design, build, and fly a boost glider that they create.[16] Nature has even been used to inspire design in a course for non-engineering majors.[17] An example given in the paper involves gecko inspired adhesive that explores the ability of geckos to climb up vertical glass surfaces. Clearly, this type of course content provides interest to students and creates enthusiasm for learning.

Another approach to foster creativity is allowing students to work in multidisciplinary teams from disciplines far from their comfort zone. A junior year design course combined a team of engineering, art, and marketing students to create ideas for consumer products with a focus on design within constraints and commercial viability.[18] Engineering and design students joined together to work on projects involving composite materials.[19] In another institution, art students have been used in a Capstone Design course to enhance the creativity of the project[20] while engineering, art, and architecture students solved a community lighting problem as part of a service learning project.[21] A summer program where students and faculty work with teenagers for creating a "magic show" based on scientific principles is an example of a creative way to involve youth.[22] The creative design process is considered by some to integrate the engineering design process and the creative process established from the field of cognitive psychology.[23] In creativity workshops, through a mixture of experiential and cognitive techniques, the mean IPAR Creativity Index has been shown to change from a number typical for engineering students to a number more characteristic of practicing architects.[24]

The creative process has been defined as a progression through four stages: 1) identifying a need (problem definition), 2) investigation of that need (testing, preparation, analysis), 3) an articulation of a solution (modifying, synthesis), and 4) a validation of the idea or solution (communicating, evaluation).[25] This attempt to define a procedure for the creative process makes this seemingly strange process more familiar to students.[25] When documenting historical creative discoveries and inventions to gain insight into the nature of creativity, reflection is considered to serve as a catalyst for creativity.[26,27] This is an interesting finding as many would agree that the most creative ideas progress over time once sufficient thought and modification has been given to them.

Many think of the activity of brainstorming as an initial stage in the creative process. This activity is very important in conducting research, yet few students, undergraduate or graduate, get a chance to participate in these activities. Brainstorming can be very effective although when performed in a group, team dynamics play an important role. An introductory engineering course demonstrated the Myers-Briggs personality indicator test to illustrate individual personality effects on team dynamics through the process of problem solving[28] and the test results were used for formation of project teams. Other researchers have assessed student thinking preferences with the Herrmann Brain Dominance Instrument. Their research project showed that many engineering students become more left-brain dominant (highly analytical, logical, structured) as they go through their curriculum. Yet quadrant C thinkers, (empathetic, emotional, interpersonal) according to their experience, are preferred by industry.[29] A freshman course and textbook[30] was developed by this research team to train engineering students to think more creatively.

Interestingly, music and engineering have many parallels in the sense that both disciplines involve applying fundamental principles to create a product with efficiency, typically, in mind. Musicians apply fundamental principles to the precise arrangement of sounds for a functional product. Kaplan *et al.* describe relationships between ABET criteria and music.[31] Recognizing the fact that music resonates with students (creating music, listening to music, playing musical instruments), educators have used this forum to provide interesting projects in engineering and computer science courses[32,33,34,35] that increase students' enthusiasm for learning. While our laboratory activity involves musical instruments, the artistic component is clearly emphasized. At the same time, musical instruments appeal to students and this aspect provided a high interest level in this laboratory.

Project Implementation

A few years ago, ECE faculty at The University of Alabama decided to focus on teaching circuit analysis in an introductory course (ECE 125) to better prepare students for subsequent Circuits and Electronics courses, courses that rely on fundamental concepts and skills and are the cornerstone of the ECE curriculum. This course is the first required course in the ECE curriculum and sets the stage for the remaining courses in the curriculum. The lecture portion contains instruction on fundamental circuit analysis techniques as well as lectures on engineering ethics and the profession. The laboratory spans two hours and includes instruction in basic circuits, breadboarding and solder skills, analyzing an automobile lighting system, basic op-amp circuits, and building an AM radio. A laboratory involving maximum power transfer was removed when the creative lamp exercise was inserted because that concept could be covered easily in lecture.

ECE 125 had an enrollment of 43 students in the 2008 spring semester. The students enroll in separate laboratory sections with a total of seven sections. The laboratory activity therefore required seven instruments to allow one instrument per laboratory section. The instruments included a saxophone, clarinet, bassoon, piccolo, trumpet, mellophone, and trombone. For the lamp exercise, students were given two laboratory periods (four hours total) guided by a set of instructions and supervised by the TA. Musical instruments were assigned to lab sections with first priority given to students that had actual experience playing that instrument. A surprisingly large number of the ECE students played a musical instrument. For the first meeting, they were told to: appoint a team leader for moderating discussion and guiding/delegating work; inspect their musical instrument and lamp kit; brainstorm ideas for creating the lamp and document the brainstorming; formalize a construction plan; create a schematic drawing of the lamp; and generate a "parts/tool" list. This laboratory took place just before spring break. This gave the groups some time to place orders for parts and to request specific tools. In the second meeting, they were told to complete construction of their lamp from the supplied parts/tools. This approach seemed to create an organized work flow.

The students were asked to provide a name for their lamp and information on activation to be displayed at the auction. This information is provided in Table 1. Once complete, a judging was held in which students, staff, and faculty members were asked to vote for their three "favorite" lamps. This competition was held primarily due to the competitive spirit observed in most students. The first three instruments listed in the Table were judged to be the favorites. A photograph showing the complete set of lamps is shown in Figure 2. Figure 3 shows the trumpet and trombone with their lights turned on. Building lamps from musical instruments has a unique way of bringing the instructor and students together. It is easy to find humor in a lamp built from a musical instrument which seems to put everyone at ease.

Table 1. Lamp names and activation methods.

Lamp name	Activation instructions
The 'Smoooth' Bassoon	Touch sensitive bassoon lamp with a 3-way dimmer activated by touching upper metal pieces.
Picasso's Clarinet	Two claps with a half-second pause in between.
'Swingin" Sax	A regular light switch near bulb; also plays music from an iPod, CD player, computer, etc.; switch located on lamp base.
The Crimson Piccolo	Hand clapping or switch.
Music Illuminates the Globe (trombone)	Pull-chain located on bell.
The Horn of Fury (trumpet)	Switch located on base. "Blue" mode activated by pressing the first valve. This valve acts as a toggle to turn off the "blue" mode made possible by LEDs.
Mellolamp (mellophone)	Touching the switch located on the middle valve.

Figure 2. Lamps built from musical instruments.

Figure 3. “The Horn of Fury” (left) and “Music Illuminates the Globe (right).

There were a few problems encountered in this laboratory. Time was an issue for design implementation in that most students had to work outside the laboratory to finish their lamp which created problems in fairness of work load as well as safety concerns. It is encouraging, however, that students were so captivated by the project that they spent a significant amount of time working in their dorm rooms or apartments. One group (trombone) did not receive all of the correct parts and had to redesign their lamp in the second lab. Their original design had the trombone mounted so that the horn could be used as the lamp shade. They quickly redesigned and learned to appreciate engineering constraints.

Because the lamps were going to be sold, the students were asked not to finalize their lamps until they had been inspected. A faculty member familiar with safety regulations provided expertise in this area and assisted with inspection. While most teams followed the procedure for inspection, not all teams did. The teams also varied in how familiar they were with simple wiring practices and this led to problems where some teams had one or two students dominate leaving the other team members to observe. In future classes, these project implementation issues will be addressed with solutions shown in Table 2.

The main approach to solving the problems encountered in the laboratory experiment is to provide dedicated mentors, provide students with information on technical methods and safety considerations, and provide more time in the laboratory for implementation. One interesting note is that many students chose to use clapper activation or touch sensitive switches. In the future, explanations of fundamental principles related to these functional parts will be provided.

The saxophone group also encountered interference between their touch sensitive switch and audio amplifier which resulted in the team disabling the touch sensitive switch. These aspects provide valuable content for lecture material.

The class TA did an excellent job in the original experiment but seven teams were too many to provide adequate mentoring. One possibility would be for the TA to mentor one team and senior level ECE students to serve as the remaining mentors. IEEE, HKN, and SWE officers provide a logical starting point.

Table 2. Methods to address problems encountered in the "Creative Lamps" Project.

Problem	**Solution**
Time	A lecture class (50 min) will be devoted for the brainstorming activity and a Music student will be involved to share their perspective; Two full laboratory periods will be devoted to constructing the lamp that do not include time for brainstorming.
Safety	An upper level ECE student will mentor each team and provide assistance with safety and requesting any special technical services. The teams will not be allowed to work on the instrument unsupervised.
Parts ordering	The ECE mentor will monitor the parts/tool list and coordinate with the TA and instructor regarding the order or any special technical assistance from the machine shop or technicians.
Inspection	Safety inspections will take place during the second laboratory meeting.
Technical Skills/ Sharing work load	A lecture will be provided on proper techniques to be used in building lamps that meet safety regulations. The ECE mentor will monitor the work load so that all students have a role in the implementation.

Evaluation of the Participants

Unfortunately this project idea was formulated and implemented in a short time frame. Because of that, the project was not formally evaluated. This aspect will be a primary focus during the next implementation. Anecdotal evidence from the creative lamp experiment indicated a high level of interest by students. The students did seem to enjoy the laboratory and competition held at the completion of the lamp building. The main feedback provided in class was that they would have liked more time to complete the lamp. Some aspects required more professional help, which a few groups received from the campus machinist. This interaction was positive causing students to interact with a broader population than is typical for them. That coordination would be improved with the assignment of a team mentor. The students enjoyed the competitive aspect and they were very interested in how much the lamps were sold for at the auction. The people that judged the lamps (ECE faculty/staff, Music Faculty, College of Engineering Dean and Associate Deans, students outside ECE 125) had very positive comments about the artistic component.

In one lab report, the students wrote in their conclusion section …

> "The simple idea that a musical instrument can be transformed into a lamp helps bridge the gap that is often thought to exist between art and science. It also

> allows students to think outside of the box, by giving them creative freedom to make the lamp in whatever fashion they choose. Hopefully, this collaboration between Music and Engineering will continue in the future. If the results are good, Engineers may begin to ask Music students to compose pieces with or create instruments out of old or faulty tools!"

This quote illustrates an interesting outcome regarding this laboratory, the fact that the creative thinking expressed by students went beyond the design and building of the lamps.

A primary goal of the evaluation portion in a future implementation of this laboratory will be to determine the role that incorporation of creative exercises in an introductory engineering course plays in the perception of the students' chosen major discipline. This perception is important in that introductory courses can affect career decisions. This problem can seriously impact student retention in the major discipline. Another important goal of evaluation is to determine the level of confidence that is built in a student by exercising the creative process. Attempting to determine the students' view of the importance of diverse perspectives in the team is another important goal.

Evaluators with the University of Alabama's Institute of Social Science Research (ISSR) will assist in developing a qualitative and quantitative data gathering process for measuring the success of the project. Multiple respondents will be used for most assessments including student, mentor, and instructor assessments and multiple measurement techniques will be employed including self-report surveys, enrollment/demographic information, and interviews. Surveys will include both close-ended and open-ended items, generating quantitative and qualitative data. The UA Teaching Evaluation Form will also be used which includes rating scales for the instructor's communication skills and preparedness for class, as well as questions about the course requirements, assignments, and other materials and overall ratings of the course and instructor.

The expected outcomes for this project over the long term include: a) developing a laboratory to exercise creativity to give students experience in creating a functional yet aesthetic product; b) increasing enthusiasm for the major and establishing networks between faculty member and classmates; c) increasing awareness of the importance of skills that make up the creative process (idea generation, design aspects, costs, influence of different perspectives, importance of balance between function and aesthetics); and d) demonstration of an approach to problem solving that is not captured by a single process but involves a variety of methods to arrive at an answer.

In addition to addressing the specific objectives and expected outcomes for the project, other interesting questions can be addressed through the evaluation activities. Examples of these issues include the following:

- Does the creative exercise appeal to particular types of students, such as students typically underrepresented in engineering (e.g., females, minorities)?
- How is interest in the creative exercises related to performance in the course and overall academic performance?
- How does the mentor contribute to the overall quality of the students' experience with the creative exercise?
- How would the mentor describe the experience level, enthusiasm, and leadership skills of the students overall?

- What improvement in confidence is built in a student by exercising the creative process to problem solving?

Sustainability

Sustainability issues have been considered. Once educational materials are developed, the most significant costs are simply the materials/supplies for the creative project. For the lamp project, "retired" instruments were donated and subsequently auctioned. The lamps sold at auction for an average of $500/lamp while the cost of building each lamp was approximately $60. The auction fund raiser may be an unusual situation although if the instruments can be acquired through donation or an inexpensive source (e.g. thrift stores) and sold later, the overall costs may be insignificant.

Summary

In summary, a project involving building lamps from musical instruments promotes creative thought in electrical and computer engineering students for enhanced product design. Attention was given to the artistic component. The creative process was marked by progression through various defined stages that result in a finished product design. The forum chosen was an introductory course, ECE 125 at the University of Alabama. This freshmen level combination lecture/laboratory provides: instruction on circuit analysis; a survey of the discipline; discussion about future career paths; and basic soldering and breadboarding skills. A new laboratory has been described in which students exercise creative thoughts and artistic talents. This trait, creativity, is an important one for the future science and engineering workforce in terms of maintaining national competitiveness.

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