AC 2009-2110: STUDENT-INITIATED SUPPLEMENTAL TRAINING CURRICULUM FOR SUPPORT OF BME DESIGN PROJECTS

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Student Initiated Supplemental Training Curriculum for Support of BME Design Projects

Abstract

Our Biomedical Engineering (BME) Department requires the undergraduate students to take a design course every semester beginning in their first semester sophomore year for six sequential courses. The students do client-based design projects in teams, wherein they apply the knowledge they learned in various classes to real-world problems. The design projects are diverse and often require fabrication and technical skills they have previously encountered in their coursework. A supplemental training curriculum was created by the more experienced students who act as Student Facilitators (SFs) to specifically to meet the needs of the BME students for their design projects. A similar supplemental training curriculum was developed and implemented by upperclass students to meet the needs of freshmen students for the Introduction to Engineering (InterEgr 160) design course at our university in the Fall 2007. The success of this supplemental training curriculum has inspired the BME Department to collaborate with the InterEgr 160 staff to provide hands-on training to BME students at all levels. The content of the supplemental curriculum is dictated by the experiences of fellow undergraduate engineering students when working on their design projects. Since the supplemental training curriculum is developed and implemented by the students, it results in the ability to offer *just-in-time* learning to students based upon their needs during the current semester. Students can request training on any specific topic, and seminars can be scheduled and offered in as little as a week's time. Students who become SFs gain valuable experience in mentoring, developing educational content, and evaluating learning outcomes. They also develop technical expertise in a variety of topics. These added educational opportunities for students impact all educational levels, from freshmen to graduate students. This paper will discuss the organizational framework of the partnership between InterEgr 160 and the BME Department, the educational content created by the SFs, the resources used to implement the supplemental training curriculum, and the costs incurred.

I. Introduction/Background

The Biomedical Engineering (BME) Department at the University of Wisconsin-Madison requires all undergraduate students to take a design course every semester beginning in their first-semester sophomore year for six sequential courses. The students work in a team on a client-centered biomedical engineering design project to learn concept generation, product analysis, specifications, evaluation, clinical trials, regulation, liability, and ethics. Thus the design course provides students an opportunity to learn about engineering design and the process of integrating engineering and life sciences to solve real-world biomedical engineering problems. It also teaches them how to function on diverse teams, develop leadership skills and to take initiative to communicate their ideas and thoughts effectively across disciplines[1].

The students work on a variety of interesting and challenging projects. Some examples of the projects are:

1. A combined thermistor, pressure, and CO_2 device for use in the sleep laboratory: Develop a design for a single device that can be used on infants and that can measure all three signals of interest which are a) temperature difference between inhaled and exhaled air, b) pressure sensors that show a flattening pressure profile during upper airway narrowing, and c) carbon dioxide sampling tubes to detect the exhaled CO_2 waveform.
2. Design for a self-contained, maneuverable, endoscopic, video camera: Develop the design for a self-contained, endoscopic video camera that can be placed into the abdomen or thorax and maneuvered throughout the body cavity for evaluation of internal organs.

II. Supplemental Training Curriculum

The design projects require the students to have and to learn diverse skills for successful project completion. Not necessarily all the students have already learned the necessary technical skills from their academic coursework when working on these projects. Thus a need for a supplemental training curriculum was identified by the more experienced students who acted as Student Facilitators (SFs) to specifically meet the needs of the BME students for their design projects.

A similar such, one semester design course, "*Introduction to Engineering Design*" (InterEgr 160) course is offered by the College of Engineering at the University of Wisconsin-Madison to the freshmen engineering students. This course was designed to provide the students with first-hand experience with working in teams on a design project for real-world clients, which typically consist of community-service organizations. The objective of the course is to introduce the students to the process involved in an engineering design and to provide them with information and experience necessary to make informed decisions about whether engineering is the correct field for them. The students come to engineering as freshmen with a wide variety of experiences, knowledge of engineering and physical sciences and enthusiasm for the field[2]. The teaching staff found it necessary to provide these students with some basic training on commonly used machines and equipment, to make them aware of the general rules and regulations and also to provide some specialized training based on projects at hand. In the Fall 2007 semester, a supplemental training curriculum was proposed and implemented by the SFs that consisted of two different kinds of training: a) Mandatory Shop Training for all students, as well as b) Specialized Training seminars that students could voluntarily enroll in. The Mandatory Shop Training consisted of training on four commonly used machines and taught the students general safety rules and protocol to be followed in the machine shop. The Specialized Training consisted of seminars and workshops on topics that the students could apply to their design projects. The topics selected for the Fall 2007 semester were 3D Computer Modeling, Welding and Electrical/Electronics Instrumentation[3-4].

All the design courses required the students to have wide variety of basic training to help them succeed in their design projects. The SFs for InterEgr 160 and BME established collaborations in order to institute a broader supplemental training curriculum to serve the students in both types of design courses. The supplemental training curriculum is thus a student-initiated effort with the goal of providing the BME/InterEgr 160 students working on design projects with hands-on training in areas such as electrical/electronics, programming (LabVIEW, CAD and microcontroller), machining and fabrication to help them succeed with their design projects[5].

III. Delta Principles and continuous improvement

The supplemental training curriculum was designed and implemented with the foundation of the three core principles from the Delta Program. The three principles are Teaching-as-Research, Learning-through-Diversity and Learning Community[6]. In the Teaching-as-Research phase the need for the supplemental curriculum was identified based on the constant informal feedback from the BME and the InterEgr 160 design students. The instructional material contents for the training sessions was inspired based on the problems the SFs faced during their experiences with the design projects in the past and the difficulties the students were facing at the time. A Kaizen-based strategy for continuous improvement was implemented with feedback from student surveys and personal communications. Innovation windows were set-up at regular intervals during the semester to analyze this feedback and accordingly make improvements in the training curriculum with the *just-in-time* approach to better serve the students' needs[5, 7]. The students work on a variety of projects each semester which require a host of technical skills. Through these supplemental training sessions the students were exposed to diverse topics which promoted learning through diversity in the training curriculum. We observed that the supplemental training curriculum benefited a wide range of the student body. It provided an opportunity for students at different academic levels from freshman to graduate students and students from different engineering disciplines to come together to learn and teach other. This diverse interaction helped in the formation of Learning Communities where students not only learned from the instructor but also from peers. Thus it promoted peer-to-peer learning and provided a better means to teach a wide range of topics.

The supplemental training curriculum was a student-initiated undertaking where students volunteered as SFs and used the *just-in-time* approach to identify the technical needs of fellow students. Based on the responses they designed training sessions to help students with their design projects. Other SFs took leadership roles to organize and teach these training sessions. The use of students as teachers resulted in promoting mentoring of inexperienced students by more advanced students, increasing the rate of acceptance of the material and also minimizing the cost of providing the training[4, 8-9].

IV. Supplemental Curriculum Training Topics

The following topics were taught during the supplemental training session in Fall 2008 based on the previous experiences of the SFs and the current needs of the students[5]:

1. Basic Electronics and Electrical Measurements: The training session familiarized the students with the basics of instrumentation and taught them to build and test electronic circuits.
2. Basic LabVIEW programming: The training session familiarized students with the software package LabVIEW from National Instruments (NI) for data acquisition and virtual instrumentation. The students built and tested electronic circuits using the NI hardware and implemented algorithms to create sequence and case structures for controlling the NI ELVIS variable power supply and in turn powering peripheral elements such as LEDs using transistors[10].
3. Introduction to SolidWorks: This training session provided the students with basic skills when using the 3D modeling program SolidWorks.
4. Practical Tips with Project Design: In this seminar, a group of BME students presented the

design projects they had worked on in previous semesters, shared their experiences and provided useful information to help students succeed with their design experience.
5. Pro/ENGINEER-3D Basics: This seminar was designed to provide students with basic skills when using the ProENGINEER software. Students were taught how to build parts, assemblies and drawings.
6. Introduction to MIG Welding: This seminar covered the practical essentials needed to successfully join steel pieces with the metal-inert gas (MIG) welding process. Proper welding safety techniques were emphasized.
7. Introduction to Soldering Technique and Medical Instrumentation Repair: This seminar was organized in collaboration with the Engineering World Health (EWH) University of Wisconsin-Madison Chapter, whose mission is to deliver medical expertise and equipment to underserved nations. This seminar provides a hands-on training to the students in a) basic soldering technique and b) repair of medical equipment.
8. Advanced LabVIEW Programming: This seminar served as an advanced LabVIEW training session where students were introduced to the basic principles of feedback control and design of state machines.
9. Shop Training: This training session consisted of training on four commonly used machines. The students were made aware of the general safety rules and protocol to be followed in the machine shop.

V. Evaluation and Results

We evaluated most of these training sessions by collecting pre-seminar and post-seminar surveys to get feedback from the students. We present the data from the pre and post-seminar surveys collected for the *Basic Electronics and Electrical Measurements* seminar. Appendix I shows the questionnaires distributed.

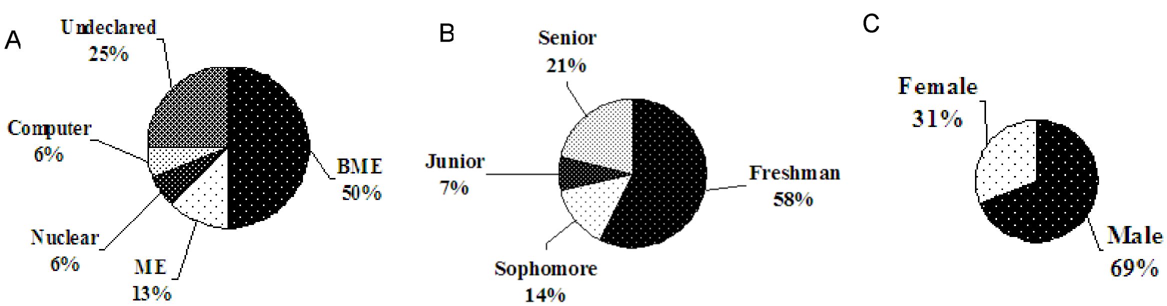

Figure 1 . Student participation by year in school, major, and gender.

The total number of students attending this seminar was 16. As shown in Figure 1, 58 percent of attendees were freshmen, and half were students in or intending to be in the biomedical engineering major. This large population is representative of the targeted students for which the seminar was designed and tailored. Additionally, the direct applicability of the basic electronics skills to many of the biomedical engineering students' design projects may also account for the high turnout of BME students.

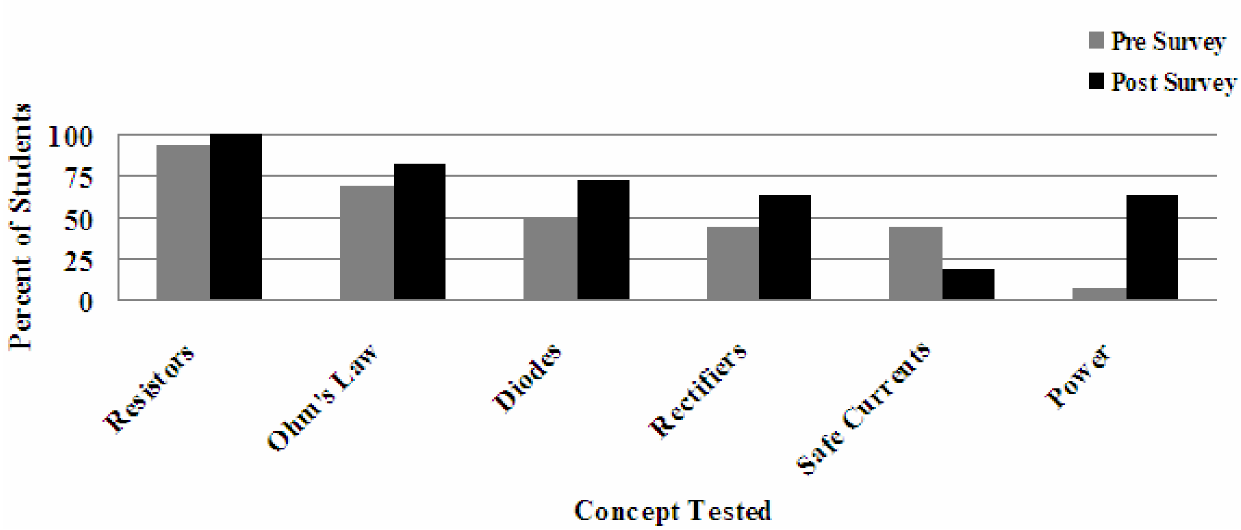

Figure 2. Pre- and post-seminar survey results for basic electronics seminar.

Figure 2 displays the results of the surveys administered at the start and end of the training session. As can be seen, significant improvement was made on five of the six tested concepts. After the seminar, students had a clearer understanding of resistors, Ohm's law, diodes, rectifiers, and power. The only concept for which students' scores did not increase was regarding safe levels of electric current. The majority of students responded incorrectly that a given low level of current was potentially fatal, when actually it was not. This may have been a result of the students having a greater appreciation and respect for the potential danger of electrical circuits.

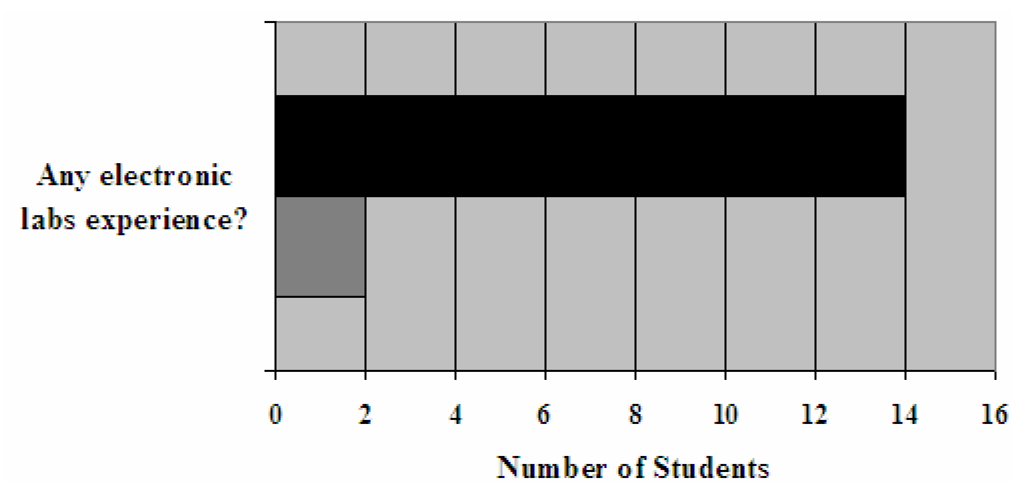

Figure 3. Student prior experience with electronics lab.

Figure 3 shows the number of students in attendance that had prior experience working with electronics or electrical circuits. For the vast majority, this training seminar was their first exposure to electronic circuitry. Because knowledge of basic electronics is an extremely useful concept fundamental to the success of a biomedical engineer, it is very important that supplemental training on the subject be available to students. The offered training enables students to excel in their studies and applications. This is especially critical for student design classes, where a basic understanding of electronic circuits can prove to be very helpful for many projects.

We were also able to perform some other useful studies through these training session series such as:

A. Comparison of SolidWorks and Pro/ENGINEER: By making systematic comparison between the learning outcomes from these two seminars we tried to examine why students at the University of Wisconsin-Madison choose to learn SolidWorks for their 3D modeling and design when the College of Engineering chooses Unigraphics and most of industry that recruits out of our school use Pro/ENGINEER[9].

B. Industry–Student Partnerships: We established collaboration with the Education Division at National Instruments to form a collaborative partnership for the necessary resources and to create teaching material to help students with their design projects. We studied the learning outcomes from the industry-student partnership in the development and sharing of educational content involving LabVIEW[10].

C. Student Initiated Organization for Community Outreach: We teamed up with the Engineering World Health (EWH) – University of Wisconsin-Madison Chapter to provide the instructional support and expertise for supplemental training sessions which involved training in soldering and basics of medical instrumentation repair. We evaluated the learning outcomes for this seminar to see how it affected student learning[8].

D. Kaizen strategy for Continuous Improvement: We analyzed the delivery of quality instructional material to the design students from an industrial engineering perspective and tried to implement a Kaizen strategy for continuous improvement of these training workshops[7].

VI. Conclusion

The design projects require the students to have a diverse skill set for successful project completion. We implemented the supplemental training curriculum to provide students with a broad range of technical help. The supplemental training curriculum is a student-initiated undertaking and uses a *just-in-time* approach to develop instructional material based on the current needs of students. These training sessions helped in the formation of Learning Communities where students took leadership roles to develop and teach these training sessions and help students from different academic levels and engineering disciplines to interact with each other for common learning goals. Since students are recruited as teachers, this strategy helps in minimizing the cost associated with the training sessions. These seminars also provide an avenue for freshman engineering students to learn about different engineering disciplines, meet students from different engineering majors and academic level and get involved with organizations such as the EWH – University of Wisconsin-Madison Chapter.

VII. Future Work

We plan to continue improving our seminars by collecting feedback from students and providing technical help based on their current needs. We will train and recruit more students to be SFs to help develop and teach these training sessions. Also one of our goals is to open these seminars and make them relevant and useful to engineering students of different disciplines working on their design projects. Since the supplemental training curriculum is a student-initiated undertaking, one of our future goals is to make this sustainable over coming years.

VIII. Acknowledgements

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Appendix I

Pre- Seminar Survey

Name:____________________ Are you currently taking a semester design class?
Year:_____________________ (circle one)
Major:____________________
Male/Female No InterEgr160 BME Other_______

Please circle one:

1. Have you taken any electrical/electronics lab before? Yes/No

2. Resistors are circuit element that impedes the flow of current? Yes/No

3. Ohm's law can be expressed by the following formula
a. $V= I^2R$ b. $I= V/R$ c. $I = V\times R$ d. $V = I/R$

4. What is the minimum voltage required to turn on a silicon diode?
a. 0.3 V b. -1 V c. 0.7 V d. 0.1 V

5. A rectifier is an electrical device that converts direct current (dc) into alternating current (ac)? Yes/No

6. If you were to pass 10 mA of 60 Hz current through your arm into your body, might you potentially kill yourself? Yes/No

7. You bought a bulb from Walmart which shows a power rating of 75 watts and you plan to use the power outlet to light it up. How much current would the light bulb draw?
a. 0.625 A b. 1.25 A c. 10.5 mA d. 15 A

The post- seminar survey was same as the pre-survey with the addition of the questions 8-10 as shown below:

8. This session improved my understanding of this topic. Yes / No

9. I anticipate what I learned here today to be useful in the future. Yes / No

10. Comment on what you liked/disliked about this session and indicate any concepts you would like to learn in future offered sessions.