Engaged Student Learning Project: Challenges and Lessons Learned

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Abstract

This engaged student learning project is focused on the development and implementation of a new software-assisted, project-based technical elective course and its associated laboratory in building energy efficiency and green building design. The primary goals of the project are to engage mechanical engineering students in the learning process and to make them prepared for the workforce in building-related fields. The purpose of this paper is to elaborate on challenges of conducting this project for the first year as well as lessons learned in overcoming these challenges.

The course was implemented for the first time in Fall 2016 in a minority serving university.
Three core components of the project are (a) establishing a building energy efficiency laboratory; (b) developing and implementing a new elective course curriculum; and (c) developing partnership with local building-related industry.

All three core components that were slated to happen as part of the initial planning and development phase were completed.
The major challenge that inevitably altered the project timeline was with the logistics of the lab establishment. There were challenges in delivering course materials with the new approach as well. The challenges at different stages of implementation of the project on allocating time, budget, and personnel as well as the curriculum development and delivery will be shared in this paper. Lessons learned from the first year implementation of this project can be used by the Principle Investigator as a formative assessment to improve the process for the second year of implementation. This paper can also inform engineering education researchers of the challenges and potential strategies to overcome these challenges and help them be more strategic during proposal writing and implementation of similar projects.

Introduction

Although the "chalk and talk" style of teaching has been used in engineering schools for a long time, the high dropout rate shows that this way of teaching needs to be changed. One of the constant complaints of the engineering students is that they cannot make a connection between pure theoretical materials presented in class and real world projects. Many students who have some experiences in the industry claim that most of the contents of even elective and so called practical courses have no application in their jobs. The primary goal of the Learning by Practice initiative, funded by the National Science Foundation (NSF), is to increase the engagement of mechanical engineering students in the learning process and to prepare them for the workforce through the development and implementation of a new high quality, software-assisted, and project-based elective course focused on energy efficiency and green building design.

In 1996, the Accreditation Board for Engineering and Technology (ABET) adopted a new set of standards and shifted the basis for accreditation from inputs, such as what is taught, to outputs, what is learned [1]. In a study conducted by the Center for the Study of Higher Education at the Pennsylvania State University, the effect of output-based accreditation has been investigated. According to program chairs and faculty members, engineering program curricula changed considerably following implementation of output-based ABET criteria [1]. There were applied

active learning methods that were implemented in classes to enrich the program toward new ABET standards. The methods which were ranked the highest in compatibility with new ABET standards, based on faculty reports, are increasing computer simulations, application exercises, case studies, open-ended problems, design projects, and use of groups in class [1].

Recognizing this reality, this project, while incorporating active learning strategies that were already shown to be effective in other institutions, has taken an innovative approach in designing the course through integrating a variety of best practices and instructional activities with an emphasis on providing rich work-related experience for students. The distinctive features of the course includes (1) **applied software training**, (2) **lab experiments**, (3) **fieldtrip to local Heating, Ventilation and Air Conditioning (HVAC) industry facilities**, (4) **invited guest speaker from building industry**, and (5) **real-world open-ended design projects** which are implemented in teams.

The course was implemented for the first time in Fall 2016. Thirty two students registered for the course and have been impacted by it. SERVE Center at the University of North Carolina at Greensboro serves as the external evaluator of the project. SERVE staff developed a pre/ post online survey (in Qualtrics Software) that was administered to all students of the class. The pre survey link was shared with all students during the first few weeks of the course, while the post survey link was sent to students nearing the end of the course (pre final exam). SERVE staff also developed a focus group protocol to gather students' perspective regarding their experiences in the newly developed course. Students were asked about various components of the Learning by Practice initiative, including: the curriculum, hands-on projects, lab experiments, software training, fieldtrip, guest speaker, and overall learning. SERVE staff developed an observation protocol for use by a fellow Engineering Department faculty member. The goal of this data collection effort was to determine if the instructional practices that were described in the proposal were actually demonstrated. A total of three classroom observations were conducted during the Fall semester, including one laboratory session and one focusing specifically on software use. The final assessment report of the first implementation of the course will be ready by April 2017. The pre/post survey raw data and the preliminary draft of the assessment report have been utilized in this paper.

Programmatic Components of the Project

The initiative was designed to increase Mechanical Engineering students' preparedness for the workforce via three overarching programmatic components: (a) establishing a building energy efficiency laboratory; (b) developing and implementing a new elective course curriculum; and (c) developing partnership with local building-related industry.

A progress summary for each of three program components after first implementation of the course is provided below.

(a) Establishing a Building Energy Efficiency Laboratory

As part of the initiative, it was proposed that a Building Energy Efficiency Laboratory (BEELab) would be established to complement the new technical elective course. In terms of the BEELab *equipment*, all five items that were proposed in the grant application were purchased and installed (armfield RA2 Air Conditioning Unit, GUNT HL 710 Air Duct Systems, Solar800 Campbell

Scientific Meteorological Station, Indoor Air Quality (IAQ) Sensors and loggers, and Energy Monitoring Devices).

(b) Developing New Elective Course Curriculum

The initiative centered on the development of a new elective course curriculum that was inclusive of the best practices in student-centered learning, including content-related simulation software, lab experiments, fieldtrip and guest speaker from building industry, and real-world hands-on design projects. Table 1 shows that all five proposed key features have been incorporated in the course syllabus and implementation.

Table 1: Results of a post survey question about the time allocation on different elements of the course

Post survey question: In this elective course, on average, what percentage of class time was spent on the following (total should equal 100%)			
Field	**Minimum**	**Maximum**	**Mean**
Lecture	2.00	60.00	28.61
Project-based work	10.00	90.00	24.12
In-class problem sets	0.00	30.00	8.47
Use of engineering software	0.00	30.00	13.39
Testing/Quizzes	0.00	10.00	6.61
Laboratory work	0.00	25.00	9.70
Guest speaker	0.00	15.00	4.38
Field trip	0.00	10.00	4.73

(c) Developing Partnership with Local Building-Related Industry

Learning by Practice elective curriculum was developed to increase students' exposure to local building-related businesses and industry as a means to increase students' preparedness for the workforce. More specifically, two distinctive activities were proposed to ensure relevant learning experiences for students: (a) field trip to a local HVAC facilities and (b) guest speaker presentations from local businesses regarding current engineering projects and challenges. The intent is that the combination of field trip and guest speaker will facilitate an exchange of ideas that will serve as a catalyst for the design of relevant, real-life student projects during the course.

A partnership with Goodman Manufacturing has been developed. Goodman Manufacturing manufactures commercial grade room air conditioners and specialty cooling products for residential and light commercial applications. Goodman Manufacturing has a 525,000-square-foot cooling plant in Houston. During the middle of the semester, students visited Goodman Manufacturing.

Another distinctive feature in the developed course was the inclusion of a guest speaker. A faculty member from the architecture department was invited as the guest speaker for the class. She is the principal of a community design, consulting, research and development firm in sustainable housing as well.

Accomplishments

In this section, the pre/post survey raw data and the preliminary draft of the assessment report have been utilized in order to evaluate project success in implementing five distinctive features of the course.

Applied Software Training

The developed course curriculum emphasized an increased focus on the use of simulation software (eQuest). The intent was for software usage to be an integral component of the hands-on projects. Based on student survey responses at the end of the semester, the use and exposure to the engineering software was ranked the highest among the five class features/activities in terms of the value added to the elective course. More specifically, during the focus group, the students stated that their work with the simulation software helped them make a connection to the energy efficiency concepts they had been learning. Their hands-on experience with the simulation software also made them feel like they could have a conversation with someone in their field of interest.

Lab Experiments

Throughout the course, students used the BEELab to conduct two experiments. The developed course is the only technical elective course in the Department that has a lab. Even nationwide, a lab for a technical elective class in engineering majors is a rare occasion. During the focus group, students stated that they liked the lab because it was "very clean" and "refreshing to have everything function like it should." One of the overarching goals of the Learning by Practice initiative is preparing students for the workforce and the students felt, that the facility itself would lead to them learning more for their future profession. While this is just the first class to use the BEELab, the students' feedback has been overwhelmingly positive. They were not only happy to work with new, modern equipment, but felt that the experience would increase their marketability as they entered the workforce.

Fieldtrip from Local HVAC Industry Facilities

During the semester, students visited Goodman Manufacturing. Both on the survey and during the focus groups, students provided positive remarks about the field trip. Many students mentioned this as a *"real-world connection."* On the post-course survey, when we asked students to "Briefly describe what contributed most significantly to your learning in this course", one-third of them mentioned the field trip.

Guest Speaker from Building Industry

A faculty member from the architecture department who is the principal of a community design, consulting, research and development firm in sustainable housing was invited as the guest speaker for the class. During the focus group, the students stated that they enjoyed the guest speaker and thought she imparted some "real-world" information. They were able to connect her work to what they were learning in the course and current issues like climate change.

Real-World Open-Ended Design Projects

The students were asked to work on two real-world projects using the software in a team. In the first project each team worked on a different plan in order to calculate the heating and cooling load of the house and also design a proper air conditioning system for it. During the the second project

they investigated different strategies to increase the energy efficiency of the first house and evaluate the cost and environment impacts of those strategies. Students stated that the projects lead to their engagement and the instructor should keep focusing on the projects for future implementation of the course.

Challenges and Lessons Learned

Course Development Challenges and Lessons Learned

The major challenge of the development stage of the project was with the lab establishment that inevitably altered the project timeline. According to the original proposal, the BEELab was supposed to be established during the summer of 2015; however, funding for the project was not allocated until September 1, 2015. There were additional challenges with establishing the BEELab. Allocating the appropriate space to establish the BEELab was the first identified challenge. One of the equipment (GUNT HL 710 Air Duct Systems-Figure 1) needs a space with at least 30 feet length. It took more than 2 months to locate the proper space in the college and negotiate with other departments to exchange and relocate their lab space to allocate the room with proper length for the BEELab.

Figure 1. Thirty feet length space is needed for GUNT HL 710 Air Duct Systems installation.

The other challenge that the Principal Investigator (PI) encountered was moving the Air Conditioning Unit to the second floor without tilting it. It took 2 weeks to find the proper lifting tool (Figure 2) on campus to move the unit to the second floor.

Other issues such as providing power requirements of the equipment in the lab may not be overlooked.

All lab establishment problems were resolved along the way by the PI's negotiation skills and persistency in following up with the processes. The lesson learned is when major equipment needs to be purchased for the project, between 6 to 8 weeks should be added to the estimated company delivery time (approximately 20 weeks for this project) for necessary internal financial processes and paperwork. Also, based on this first-time experience working with the department and the university at this level, proper timing needs to be allocated for making and executing logistics decisions such as space allocation and clean-up, moving and installing lab equipment, and possible power adjustment for equipment. Considering a student worker as a project personnel in the proposal in order to assist setting up the lab could expedite the lab establishment process.

Figure 2. Lab Establishment Challenges: Moving the Air Conditioning Unit to the Second Floor without Tilting

Course Implementation Challenges and Intended Modifications

Despite the many accolades regarding the introduction to and use of the eQuest software, the functionality of the software was identified as an issue. For example, during the focus group,

students indicated that they had experienced some challenges with the eQuest software. A student stated,

> *"So the projects were a little difficult at times, I guess with the software. There was something about it that didn't function appropriately. So it's like we had some issues and we had to figure out how to get around those things by doing these things, but I mean other than that Dr. [PI] did a very good job of identifying those things and trying to come up with a solution to them."*

A free software package (eQuest) has been considered to be taught in class which has most of capabilities of other commercial software in building simulation and HVAC system design. It is free and students can download it on their personal computers. It was noticed during the implementation of the course that some of the features of the software were not working properly when the software was installed in a computer lab (computers in a network) and alternative solutions should be found to get the desired results. Since these issues were identified and the alternative solutions were determined for them last Fall, this challenge will be resolved by adding to the software training time during the semester and teach them the alternative way of doing some parts of the simulation during the second implementation of the course.

There were comments about sequencing of course/assignments and the course load in survey response which can be categorized as follows:

- Although the theoretical topics for the lecture sessions have been selected carefully from the wide range of topics in building energy efficiency and green building design, students suggested to have less lecture time and more of other elements like lab experiments and software training sessions. Possibility of reducing the lecture time and revising the topics will be investigated for the second implementation of the course.
- The high work load of the course at the end of the semester which is mainly because of the projects is one of the students' critics about the class. Such an issue is common in most engineering courses which include one or more projects. Before the end of theoretical sessions and software training sessions distributing the project statement is not useful. Nevertheless, working on the sequence of the materials delivered in each session will be on the agenda of the PI for the second implementation of the class.

As previously noted, this course is an elective. During the focus group, we asked the students to discuss the tension, if any, between elective and core courses. The students stated that there is a stereotype that elective courses are usually easier than core courses. In addition, students pay more attention to their core courses versus their elective courses; they put in more effort. Overall, there is a perception that the elective courses are there to boost your grade point average. One student stated,

> *"Well me, like being honest, like I do put more of an emphasis with the core courses rather than the electives, just because like past history, like students talk about oh how electives are much easier, like you take them to like boost up your GPA kind of thing. So going in with that mentality just based on your past history, like you do kind of have that notion that, oh, he's not going to be as hard or you don't have to spend as much time on them as you would your Thermo 1/Thermo 2 courses"*

However, this course was not designed in that vein and the PI made them work. Another student stated,

> *"This class is like -- it made us work, I'll tell you that. It blew the stereotypes out of the water."*

To address this issue at the second implementation of the course, at the first session of the class the philosophy behind technical elective classes will be discussed with students in more details. The instructor will talk about the importance of technical elective classes. It will be emphasized that an elective class should give them some good information about application of the topics that they learned before. They should choose classes that can help them more with their career after graduation by adding to their skills. They should not look for just easy A classes. In this way, the students will have a more realistic expectation of the work load of the course.

Conclusions

A new software-assisted, project-based technical elective course and its associated laboratory in building energy efficiency has been developed through integrating a variety of best practices and instructional activities with an emphasis on providing rich work-related experience for students. Applied software training, lab experiments, fieldtrip to local industry facilities, invited guest speaker from industry, and real-world open-ended design projects are distinctive features of the course. The raw data from pre/post survey and the preliminary draft of the assessment report support the success of the first implementation of the course in Fall 2016. The main challenge at the course development stage was with the lab establishment which can be resolved in similar projects by allocating additional time and personnel at the proposal planning stage. At the course implementation stage, the identified challenges included issues with software package in performing the complete simulation of the building and system, students' work load distribution throughout the semester and students' mindset about technical elective courses compared with core courses. To address these issues, working on the lecture and software training contents, sequence of the materials delivered in each session, and emphasizing the importance and philosophy behind technical elective courses at the beginning of the semester will be on the agenda for the second implementation of the course.

Reference

[1] Lattuca, L.R., Terenzini, P.T., and Volkwein J.f., 2006, Engineering Change, A Study of the Impact of EC2000, Executive Summary, Center for the Study of Higher Education, The Pennsylvania State University