Actively engaging project based learning through a Mini Maker Faire in an Engineering Technology Program

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Actively Engaging Project Based Learning Through A Mini-Maker Faire in An Engineering Technology Program

Abstract

Many engineering technology students struggle with theoretical concepts. Cookie-cutter laboratory activities and courses projects that are more like academic exercises can only provide limited help for student to make the connection between theories they learn in classroom and real-world problems.

Maker Culture is an attractive way of enhancing student learning. The Maker Movement can achieve learning-by-doing in an informal environment, which works well for engineering technology students. Maker Culture also allows for the implementation of several student centered learning options such as active learning, cooperative learning, peer-led team learning, peer instruction, problem-based learning, project-based learning, inquiry-based learning, and challenge-based learning.

In the Control Systems course in the Electronic Systems Engineering Technology (ESET) program at Texas A& M University, students were introduced to the Maker Culture in class. Laboratories were re-structured to support students' effort to work on course projects that they chose on their own. This had a positive impact on the motivation of the students. A Mini-Maker Faire was organized at the end of the semester where student did demo and presentation. The project evaluation was also changed to reflect the Maker Culture spirit: whether your design works or not is not as important as what you learned in the process.

Although the subject has been discussed by many educators, the authors learned from their first trial that a successful implementation requires careful planning and flawless execution in a specific course. This paper presents the design of lectures, laboratories and the course projects. Assessment methods and lessons learned are also discussed.

Introduction

Engineering technology (ET) is a major often misunderstood by some parents of students and potential employers[14,18,23]. Four-year ET programs offer BS degrees but are quite different from traditional engineering programs. Typically, hands-on learning is the emphasis of ET programs. Courses involving more math, such as Control Systems, can be a challenge for ET students. Majority of ET courses rely on laboratories to reinforce student learning. However, many cookie-cutter laboratory exercises are not effective. Students do not necessarily understand the reason for each step in the lab instructions and may not be able to make the connection between the concepts taught in the lectures and what they do in the laboratory.

Many ET courses also have course projects with the purpose of motivating students to apply the theories they learn to solve real-world problems. One of the drawbacks of course project is that the technical merits of course projects are over-emphasized and the importance of learning and students' interests is underestimated.

There are other efforts such as introducing product development[20] and creating high impact learning environment[29] that have been made to motivate student learning. Maker Culture is another attractive way of enhancing student learning. It is a grassroots movement consisting of mostly tinkers, hobbyists, and engineers, who design and build gadgets while learning by themselves or from one another about techniques and use of software and hardware tools. It can provide informal and shared learning-by-doing experiences with fun and self-fulfillment as the motivation for students[1,13,15,22]. Maker Culture also allows for the implementation of several student centered learning options such as active learning, cooperative learning, peer-led team learning, peer instruction, problem-based learning, project-based learning, inquiry-based learning, and challenge-based learning. Maker Culture is effective in enhancing student learning because it involves high-level learning of analyze, evaluate, and create in addition to the lower levels of learning of remember, understand and apply in Bloom's taxonomy[4,5].

Make Faires are events to celebrate Maker Culture. There are several commonly used keywords in Maker Culture: make, design, tinker, build, Do It Yourself (DIY), Do-It-With-Others (DIWO), learning by making, invent, create, and fix[31], these are all relevant activities for ET students.

Extensive research work has been carried out in the area of Maker Culture[8,9,12,26]. Wang *et al.* [27] and Zhan *et al.* [31] explored the feasibility of using Maker Culture to enhance student learning in engineering and engineering technology programs.

Integration of Maker Culture in an ET program

Many researchers concluded that Maker Culture provides excellent learning opportunities for students[2,6,11,16,17]. It helps with cultivating lifelong learning[28] as well. Large amount of presentations at ASEE Maker Sessions in ASEE Annual meetings are the clear evidence of interests among engineering major educators[7,10,21,24,30].

Many aspects of Maker Culture fit well with course projects for ET courses; however, as the authors learned from their experience, it is challenging to successfully implement Maker Culture in ET courses. The incorporation of Maker Culture in educational institutions require careful planning and research[31]. Vossoughi *et al* [25] caution against the unprepared adoption of Maker Culture into the educational institutions. The structural changes and material and pedagogical resources required to support the adoption of Maker Culture must be carefully considered[3,19].

The intention of this paper is not to reinvent the wheel, instead, the uniqueness of ET students and Control Systems course requires special attention in the implementation.

After literature review, it was decided that the implementation of Maker Culture should be started in the Fall semester of 2019 and be continued in the next a few semesters. Each semester, feedback from earlier semesters will be used to improve the implementation process.

The final project demo and presentation were planned and organized as a Mini-Maker Faire. For students to have good demonstrations for their project, they must have enough knowledge in design, analysis, fabrication, and testing. In ESET program, most courses with course projects use about half of the semester for regular laboratories and only about seven weeks for their course projects. Given the time limitation, making a gadget for the Mimi-Maker Faire could be a challenge for some lower level courses. In Make Culture, people are supposed to learn many knowledge and skills on their own before they can make gadgets. As students move through the ESET program, they know more and more about designing electronic gadgets.

Control System (ESET 462) is a senior level course. Students typically take this course together with their Capstone I (ESET 419), as illustrated in Fig.1. ESET 462 has two pre-requisites: Electronic Instrumentation (ESET 359) and Embedded System Software (ESET 369). By the time students take Control Systems, they should have taken most of the courses in ESET curricula. They should know how to design electronic circuits, complete the board layout, populate the board, program micro-controllers, setting up wireless communication systems, and design instrumentation systems. They have learned how to conduct engineering test and conduct statistical analysis. In ESET 462, they would learn how to analyze and design control systems. In summary, they should be ready to start their capstone projects. Therefore, the Control Systems course is one of the best choices for Mini-Maker Faire. The course projects in this course can also help students to be ready for a large scale, but similar project: their capstone projects. Other courses may also be able to participate in Mini-Maker Faires, but more careful planning is needed.

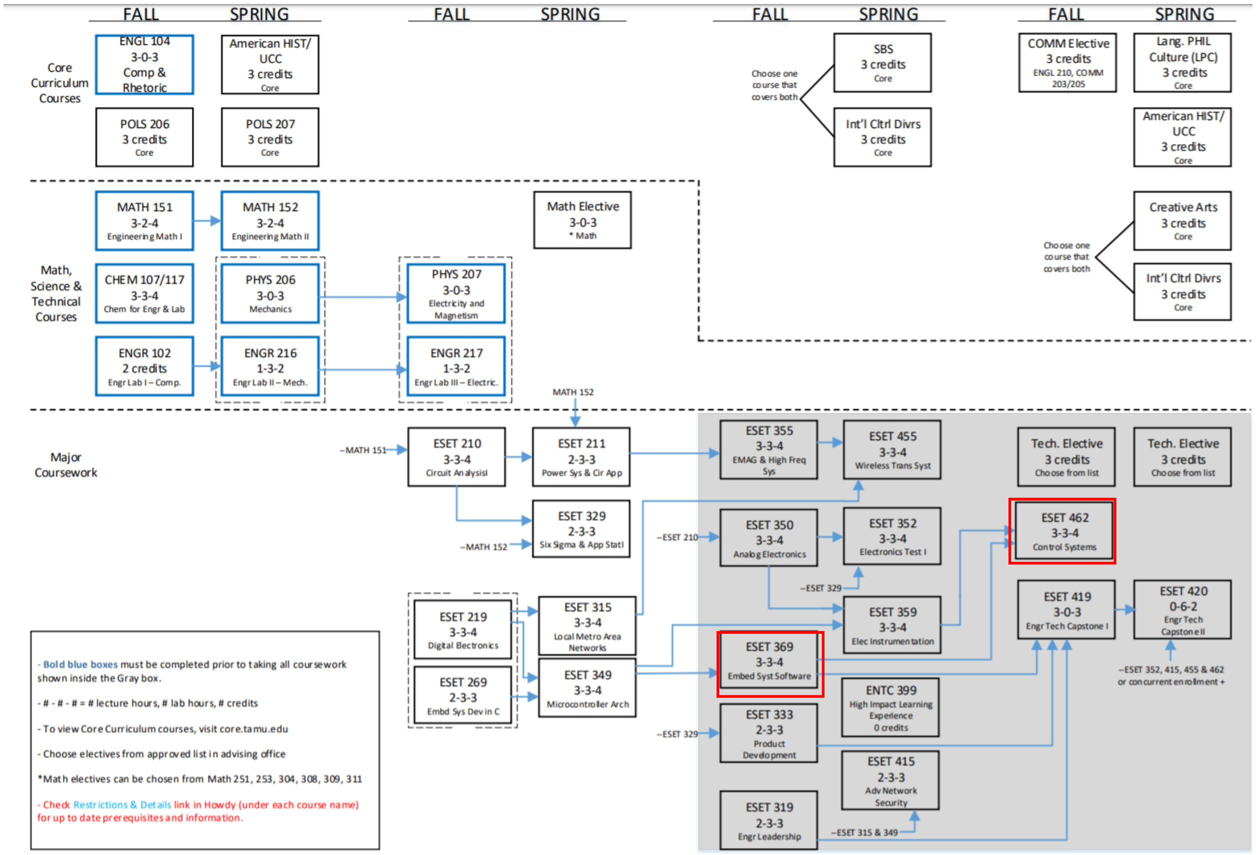

Figure 1. ESET Curricula

To make the final project presentation more like a real Mini-Maker Faire, instructors from two courses coordinated the project presentations for two courses, Control Systems (ESET 462) and Embedded System Software (ESET 369). This was the first attempt by ESET to have more than one course's presentations to be held at the same time at the same location. The goal was to gain experience from this event and eventually to organize a program-wide Mini-Maker Faire.

The implementation plan required changes to be made in lectures, laboratories, and course projects. The focus of this paper is on ESET 462, similar effort was made in ESET 369, which will be discussed in a separate paper.

For the lecture part, the Maker Culture was introduced to students in the beginning of the semester. Students were informed that in the second half of the semester, they would design and fabricate products based on their own ideas using the knowledge they learned throughout the semester and what they learned in other courses. They brainstormed for product ideas and thought about the necessary skills and tools. If they needed additional knowledge, they were expected to learn by themselves or from one another. The self-learning part was important because it helped students with life-long learning. Several lectures were devoted to Maker Culture, importance of life-long learning[28], and project related discussions. Students gave presentation on their project ideas during lecture time.

For the laboratory part, students learned some basic skills such as designing a circuit, building a breadboard circuit, populating a printed circuit board, using a sensor to measure some variable, and programing a microcontroller to control certain variable in labs during the first half of the semester.

In the second half of the semester, students designed their own products as course projects. The project part was the most challenging one, which required significant changes in project evaluation. In Maker Culture, you can learn even when your design fails. In traditional course projects, students are expected make something work. In Maker Culture, communication is more informal. Formal presentations and project reports were added to the course project requirements to help students improve on communication and writing skill, which are important part of ABET student outcomes.

The following project guidelines were given to students beforehand so that they knew the requirements and rubric for the course project.

Control Systems Course Project (Mini-Maker Faire) Guidelines

The course project requires your team to design a gadget and you need to have a prototype ready by the last week of the Fall semester (Before the reading days).

Project requirements

1. Design a product that has potential commercial value or that has potential use in your daily life.
2. It must have a micro-controller (use of myRIO or other equivalent device needs to be approved by the instructor).
3. The prototype must have at least one sensor and one control action (for example, controlling motor speed, turn something on/off)
4. Use at least one thing you learned in Control Systems (PID control, transfer function, stability analysis, digital system, etc.)
5. This project can be a part of your capstone project.

Team formation

This work should be carried out in teams of four. Please talk to your classmates and form your own team by October 3. The project leader should send an email to the instructor with the following information: A name for the team and the team members' names. Teams with five members should receive approval from the instructor. Your team may be assigned extra work.

Mini-Maker Event

1. Participation in the event is mandatory.
2. The event will be held in the last week of the Fall semester (The exact event date will be scheduled and announced before the end of October).
3. A poster presentation is required for each team. If you miss the event, this will result in zero credit for both peer evaluation and instructor's evaluation of the project.

Project report

1. An abstract containing no more than 500 words must be submitted through eCampus before October 12th. The abstract should contain a brief description of your project.
2. A project report is mandatory and due by the 1st reading day.
3. A video recording of your demo must be submitted together with the report.
4. Project report should follow the writing style and formatting rules of the IEEE conference. https://www.ieee.org/conferences_events/conferences/publishing/templates.html
5. The report should be submitted through eCampus.

Project Evaluation

	Instructor	non-team members	teammates
Originality (or Significance)	10		
Complexity	10		
Functionality	10		
Demo/Poster	15		
Report	15		
Contribution to your team			15
Peer review (by non-team members)		15	
Abstract	10		

(Peer Evaluation Guide: A+: 15, A: 13, B: 11, C: 9, D: 7, F: equal or less than 5)

Each team was required to submit an abstract, which was reviewed by the instructor to make a preliminary decision to approve or disapprove the project. According to the rubric, a prototype that did not work could still receive relatively high scores. What's important is how much the students learned during the project.

Mini-Maker Faire

A Mini-Maker Faire was organized in the end of the semester to replace the normal final project demonstration. To make the final project presentation more like a Mini-Maker Faire, two courses with course projects combined the final demos and preentation as one event. The idea was to promote interaction among students from different courses. The room used for the Mini Maker event was too small, so the plan was to have students from the two classes coming at different times.

Figure 2. Mini-Maker Faire

Student teams set up their posters and demonstrations in the room. The instructors of the two courses and students listened to each project team's presentation and demonstration. Both instructor reviewed projects and student peer reviews were conducted.

Assessment

The presentations at Mini-Maker events are typically more informal. The assessment of course projects needs to be more rigorous. In addition to the instructor and peer review (by other teams), peer reviews among each project team were added to the assessment. This provided a way for teammates to identify the high and low performers.

	member 1 (name)	member 2 (name)	member 3 (name)	evaluator (name)
Team member's	John Doe			Your name
team work spirit	10			
personal effort	8			
timeliness	5			
techinical competence	7			
overall contribution	8			

1- 10: 1 being the worst and 10 being the best
You only give evaluation to your teammates, not to yourself.
Add columns if necessary.

At the end of the semester, a student survey was conducted. The survey form is shown as follows.

Control Systems Student Survey

5: strongly agree, 4: agree, 3 neutral, 2, disagree, 1: strongly disagree

1. Did you learn something new on your own during the course project? ____
Additional comments: ____
2. Did you course project involve critical thinking? ____
Additional comments: ____
3. Was your project intellectually challenging for you? ____
Additional comments: ____
4. Did your project involve writing?
Additional comments: ____
5. Did your project involve reading?
Additional comments: ____
6. How relevant was your project to lifelong learning? ____
Additional comments: ____
7. Do you prefer a course project that you choose over a course project that is assigned to you by the instructor? ____
Additional comments: ____
8. How much do you know about Maker Culture? ____
Additional comments: ____
9. Overall, was the Mini Maker Faire successful? ____
Additional comments: ____
10. Were you able to apply what you learned in this course to your project?
Additional comments: ____

The survey results, with the sample size of 16, are summarized in Table 1.

Table 1. Survey results summary

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Average	3.25	3.44	3.75	4.00	3.75	3.88	3.81	3.06	2.79	4.06
Std	0.93	0.89	0.93	0.63	0.86	0.89	0.83	1.12	0.70	0.68

Analysis and lessons learned

The survey results in Table 1 shows that the implementation in the first semester was not very successful. There were only two questions that received 4.0 or higher out of 5.0, these are Questions 4 and 10. Question 4 was about writing. Since students were required to write a final project report in IEEE style, it is not surprising to see a relatively high score in this category. Question 10 indicated that students thought the projects were relevant to the material they learned in the course.

There were many lessons learned in the first trial of a Mini-Maker Faire. The first one is the organization of the Mini-Maker Faire. Because the room was too small and some teams took longer to set up and finish their presentations, this caused a chaotic situation. Many teams were struggling because of the shorter time available to them. They had to go through other teams' presentations and evaluate them in a short period of time. This probably had a negative impact on the quality of peer reviews. Some students skipped the voluntary student survey, which was the main cause of low sample data from the survey.

In the next phase, the authors intend to take a step back. Instead of combining two courses' final presentations, a Mini-Maker Faire will be organized for individual course. A larger room will be reserved. More time will be allocated for the event. Students will be given sufficient time for peer evaluation and survey. The combination of different course is something that is worth trying after the successful Mini-Maker Faire for individual courses. A potential solution to the large number of teams when multiple courses are involved is to select a few representative ones from each course within the ESET program to participate in the Mini-Maker Faire.

From the survey results, in particular from Question 8, it is clear that more effort needs to go into the lecture part. For example, more time can be spent in lectures for project discussion.

Due to the COVID-19 pandemic, the Mini-Maker Faire had to be canceled for the Spring semester of 2020. Students had to switch to projects that did not involve hardware fabrication and testing. The subject of the course projects was changed to "How to control the COVID-19 pandemic?" The result of the revised course projects will be discussed in a separate paper. The Mini-Maker Faire will be planned for the Fall 2020 semester, if students are allowed to come back to campus.

Conclusions and future work

In theory, Maker Culture is definitely a good fit for ET students. One can integrate the Maker Culture in ET curricula to enhance student learning. Based on the limited experience of Maker Culture implementation in a course in ET program, it was found to be challenging to make it work. Any mistake in the implementation can cause the result to be less desirable. Although the first effort in the Fall semester of 2019 was less than ideal, improvement steps are being taken based on the lessons learned. Additional data are being collected and analyzed. Future work includes organization of Mini-Maker Faire with multiple courses and collaboration with another university.

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