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Work in Progress: Applying a First-Year Engineering Model to Introduction to Engineering Technology

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Abstract

This work in progress paper looks at different first year engineering (FYE) program models and pedagogical techniques to apply to an introduction to engineering technology course. The goal is to better prepare students for college and increase freshman success. Student success will be defined in this paper by freshman retention rates, student feedback, increased upper-level course and course learning outcome comprehension.

In the fall of 2022, the course included three of the six offered technology disciplines. The course was being taught by assigning readings, in-class activities, homework, and a project assigned halfway through the semester. The setup of the course led to two distinct eight-week courses being combined into one. The first part attempted to address the heterogeneity of math capabilities which ranged from remedial math to calculus II, while the second part attempted to teach engineering technology fundamentals and Microsoft competency. It was observed that students in higher-level math courses became disinterested, while lower-level math students struggled to grasp concepts. Freshman success activities had been incorporated but were insufficient as many students struggled with completing assignments. Most students were competent in using Microsoft products but struggled with accessing resources outside of class. Finally, students were eager to start projects and solve engineering problems but lacked understanding on how to apply the fundamentals to do so.

In the future, FYE program models and pedagogies will be applied. In the first iteration, a flipped classroom approach with project-based learning will be applied to the course. The course will be broken into three or four modules with a project per module. The structure will have fundamentals presented in a prerecorded lecture, and problems with experiments will be assigned to further develop engineering tools in class. This will give the students the next set of tools they need to solve the project for that given module. In addition, the first weeks of the semester will serve as onboarding to college, with freshman success workshops and career development activities continually being incorporated.

The hypothesis is that this approach will take the course from a refresher course to a true introduction to engineering technology. It is anticipated that a higher-level math student will stay engaged through the projects, and the application of teams will enable them to assist lower-level math students in learning fundamental concepts. The scaffolded approach of breaking the modules down into weekly parts will systematically teach students how to apply concepts to solve complex problems. It is hoped that by incorporating student feedback into the freshman success and career development activities there will be a growing sense of ownership in their engineering technology community and education.

FYE models and pedagogical techniques will be evaluated and modified for engineering technology students leading into the next iteration of the course. The course will continually be iterated and eventually will incorporate all technology majors transforming the one semester refresher course into a first-year engineering technology program.

Objective

This work in progress paper begins to investigate different first-year engineering (FYE) program methods and teaching pedagogies to apply to an introduction to engineering technology course at a regional campus that has a 47% first-generation college student demographic. The overall goal of this study is to turn an introduction to engineering technology course into a first-year engineering technology (FYET) program. A first-year program is being described as a curriculum that requires a majority of the students to take the same college specific course(s) within the first year of their college career regardless of what their major is.

Literature Review

FYE programs are common in engineering schools across the United States with a large portion of universities restructuring their programs in the 1990s and early 2000s [1],[2],[3],[4]. In 2005, the results of a survey of first-year programs showed that over 70% of the response had some type of freshman dedicated course either in their department or by the college. Over half of the responses had a FYE program for all students entering the college of engineering [1]. Part of this was attributed to a resurgence of emphasizing engineering design. Froyd *et al.* in 2012 [2] discussed five major shifts in engineering education. The first shift was switching from practical engineering to more theoretical and analytical, which occurred in response to World War II. In the 1990s, engineering education started switching back to an emphasis on engineering design which still holds true today.

A good example of this occurred at the University of Tennessee in the late 1990s [3]. At the University of Tennessee [3] the two first-year courses were redesigned in response to recommendations of an industrial advisory board and ABET. The result was a FYE program which was deemed the “Engage Program”. The first semester course was a non-calculus-based approach that focused on computer programming, graphic skills, and problem solving. The second semester course focused more on calculus-based content with emphasis on statics and dynamics. Basic concepts would be presented in a one-hour lecture and the concepts were reinforced during low-tech, hands-on laboratory exercises. Additionally, students would meet with graduate teaching assistants in a recitation format to develop analysis and fundamental skills. The fundamental concepts were applied to team projects where students designed, built, and tested their projects. Student success increased, and the university switched all FYE students to the “Engage Program” after a couple of years demonstrating the potential fruits of the redesigned curriculum.

The goal when redesigning curriculum is to increase student success. Student success can be measured by student retention, graduation rates, better grades in a course, better understanding of the material, or overall student wellness. In 2022 [5], a study looked at how effective curriculum-embedded interventions were at improving student wellbeing. Another group [6] looked at how to efficiently promote time management skills as freshman time management skills are typically thought to be deficient. The thought in both studies was that if student wellness and skills, such as study habits or time management, are increased then so will student success.

Another way to characterize student success is through academic performance and retention. Engineering and engineering technology student success and retention have been studied and compared to non-engineering students [7], [8]. Many have modeled and predicted student success by looking at information from high school or the first year of college [8],[9],[10],[11]. A common trend that proved to be significant was a student's math ability coming into college or a math ability that was increased within the first year of college which was shown to lead to an increase student success or retention [7], [8],[11], [12].

Math ability is important in engineering and engineering technology, and support can be given to aid students with a deficient background. One study in the United Kingdom [11] showed that attending a mathematics learning support system was significant in predicting students' overall first year performance. It is important to remember that student retention is a complex system [10] and that all models and results are dependent on the student population with which they were performed. However, trends can be used to give ideas on how a FYET program can be redesigned to provide the mathematical support students need.

One trend was shown by a study of 419 first-year calculus students. The study showed that people who lacked a strong mathematical background are more likely to fail calculus, but the study also showed that students can overcome these difficulties [13]. A study at a technical college in Chile displayed another trend [14]. The study displayed promise when students with a low math placement score who took a corequisite math course outperformed students in college algebra course who did not take the extra corequisite course. Another related trend that has been researched was the idea of "Math Swirling" [15]. Swirling is defined as students who go back and forth between two institutions. A recent study [15] looked at how taking entry-level math courses at a local community college affects success in upper division math courses, overall college success, and graduation rate at the student's home college. Overall, Math Swirling generated short-term success and students got to the next math course, but it did not increase graduation rates in a STEM field. The trends from these three case studies show that students can overcome mathematical challenges when given extra support such as corequisite course, but it may be better to do so within the program they are in.

Ownership and a sense of belonging are also important to student success. Students are drawn to examples that they can relate to and represent, as shown in a study where diverse scientist examples were applied in a science course [16]. Students need support and community, which is why learning communities or cohorts have shown success in a student's first year [17] especially for underrepresented, first generation, or low-income students. In a recent study [17], a learning community was built along with a summer immersion program, a peer mentoring program, and a first-year experience course. The summer immersion program linked science and social justice issues with hands-on activities and built a sense of belonging. The results showed increased success in the first year and those that participated were more likely to graduate. The study noted that this type of community may not be appropriate for commuter populations if student integration cannot be balanced with maintaining connections to their home communities. Overall, these case studies suggest more ideas on how to potentially increase student success through program structure.

Another goal of a FYE program is to engage and motivate students, which is typically done through project-based learning (PBL) [1],[2],[3],[4]. PBL has shown to be successful in increasing student success and sense of preparedness [18],[19],[20], [21]. Within PBL there are different models, such as the scaffolded model used by the “Engage Program” [3]. Models can include forms of design-build concepts [18], [21] demonstrating the more hands-on approach. However, success comes down to execution, like most pedagogy. Faculty need to be on board with the methodology, constant feedback is needed, equal teamwork needs to be monitored, and more facilitating is needed for the heavy workload [20]. Additionally, when using team projects, PBL can be overused, and students can have a lower belief in their own ability to work independently [19]. This further demonstrates the need to not overuse student engagement techniques such as PBL [2], suggesting a balanced pedagogy approach should be taken.

Looking at the examples and trends presented the questions are:

1. How does this translate to engineering technology?
2. How does this translate to a regional campus that historically has a large population of first-generation students and commuter students?

These are a couple of the many questions that come to mind when starting to look at the literature when considering designing a FYET program.

Demographic Observations

The FYET program is being developed at a regional campus that historically serves first generation students and commuting students. It has been observed that a large population of students are working while attending college full-time. The school of polytechnic accepts students of all math levels while at least college algebra ready is preferred. The school of polytechnic markets a hands-on approach and that the program is for “fixers” and “people that like to tinker”. It has been observed that many students consider themselves to be “good with their hands” but would not call themselves “book smart”.

There are many reasons why students picked the regional campus over the main campus:

1. They were not accepted by the main campus
2. It was cheaper to stay at home and commute
3. They need to stay close to family or
4. They need to maintain their current job.

There are also many reasons why they chose the school of polytechnic over engineering. Common reasons being:

1. It is not as math and theoretical focused
2. They were not calculus ready
3. They did not understand the major they chose, or
4. The marketing of “hands on” resonated with them.

The result is a student population at risk of burnout, and a large range of commitment levels, mathematical skills, ages, and understanding of college expectations.

Evaluating Literature given the Demographic

Considering the demographic, a learning community likely would not translate well, but a sense of belonging is still needed. Team projects may be appropriate to build those connections with peers, but the curriculum still needs to foster individual learning skills, while ensuring that the workload is being carried by the entire team. PBL is an appropriate pedagogy for the hands-on student, but the focus will need to be spent on the fundamental knowledge, especially for students that have a weaker math background. While traditional FYE programs focus on the design method, this may not be appropriate for engineering technology students and should be adjusted to focus on problem solving and troubleshooting [22]. Students need to have a purpose or a goal to strive for upon graduation. It would be advantageous to work with the Career Development Center and build content on career exploration. Additionally, students would benefit from bringing in industry professionals that students could relate to. Also, students need more onboarding to college to help them navigate tasks, such as registration. The course needs to show students what to expect when they graduate, while teaching them how to succeed in college and giving them the tools to do so.

Course History

In the past, the course was meant for Mechanical Engineering Technology (MET) students. The course has developed to also include Industrial Engineering Technology (IET) and Construction Management (CM). The school has a total of six majors with ambitions to require at least five of the six to take the course. The course has not had a dedicated faculty member to teach and develop it in the last seven years and previously has been taught by limited term lecturers, which is not uncommon for courses across the entire curriculum. The course is a prerequisite for notoriously difficult courses, such as Statics.

Recent Development Results

Recently, the course was being taught by following book chapter readings, in class activities, homework, and one large project assigned during the second half of the semester. The setup of the course led to two distinct eight-week courses combined into one. The first part attempted to address the heterogeneity of math capabilities and the second part attempted to teach engineering technology fundamentals along with Microsoft competency. It was observed higher-level math students lost interest while lower-level math students struggled to grasp concepts. Freshman success activities have been incorporated, but they were insufficient as many of the students struggled with completing assignments. Most students were competent in using Microsoft products but struggled with accessing resources outside of class. Finally, the students were eager to start projects and solve engineering problems but lacked the background on how to apply fundamentals to do so.

In the spring of 2023, the course was organized to spend the first few weeks doing onboarding activities such as how to access files at home. Microsoft basics were taught at the beginning so they can be practiced throughout the rest of the semester. The Career Development Center was brought in before the semester career fair to help students be more prepared but did not increase the likelihood of students attending. Student organizations were brought to class to market their club and activities. Teams and projects were assigned at the beginning of the semester and milestones were set to guide students through the process of problem solving, as well as technical writing and communication skills. The Student Success Center was brought in early on to talk about time management and have students use the basics they learned about, such as formatting an Excel worksheet to plan out a typical week in their semester. The Student Success Center was also brought in before the open registration period to walk students through how to meet with their advisor and check for holds. It is not yet fully known how the changes affected the students in the class. However, less students came to class and the course content was congested as students did not take advantage of the milestone guided approach which led to a rush to finish at the end. It is thought that too much onboarding early on and not enough fundamentals led to students becoming disinterested.

Overall, the spring observations need to be carefully considered as the number of students in the spring was a quarter the size of how many took the course in the fall. Regardless, it is evident that more time needs to be spent on course planning. The changes made were not well executed due to a congested course, as there are only three class hours a week to work with compared to the "Engage Program" [3] which had nearly nine hours a week for two semesters.

Data collection

Moving forward interventions will continue to be recorded. Students' academic success and retention will be tracked from semester to semester until graduation. Success in courses such as Statics, which the course is a prerequisite for, will be tracked by looking at grade distributions and passing rates. Success in math courses will be tracked in the same manner. Demographic data will continue to be collected and analyzed to understand how the students are changing. Surveys will be conducted to obtain student feedback.

Future Development

The next iteration of the course is to start flipping the classroom to provide more in-class time for tutoring and facilitating. Fundamentals to engineering technology will still be presented with a large emphasis placed on math skills and Microsoft basics. Doing so will make the course a pseudo-corequisite for college algebra and trigonometry course. The class will meet twice a week. The first meeting will be for in-class activities to practice the fundamentals and provide more tutoring similar to a recitation structure. The second meeting will be more of a low-tech laboratory structure to provide a more hands-on approach. This meeting time will employ PBL. Students will be guided through problem solving, as each week they will learn the fundamentals needed to solve the next part of their projects. The first week will be used as further onboarding to the campus, with the remaining being integrated throughout the semester so interest is not lost. The Career Development Center and Student Success Center will be built into the curriculum to teach students about well-being and to develop ownership over their career. This design is adapted from the University of Tennessee study [3], as well as what the author personally experienced during their FYE experience as an undergraduate student to given demographic of a regional campus. This is the next step in applying the FYE model to develop a FYET program.

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