Work in Progress: Discovering Pathways of Engineering Undergraduate Students Related to Engineering Identity

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Abstract

Studies show that while efforts of increasing retention are being made in schools of engineering, many students are changing majors or leaving the university after their first two years in an engineering program. These early years are crucial as students are introduced to many of their departmental courses during this time and are affirming or shaping their identities as engineers. A deeper look into both the classrooms of U.S. schools and the general workforce is needed to understand why this is occurring and what pedagogies can be added, removed, or enhanced to slow the rapid decline of underrepresented students in engineering. The object of this research is to discover pathways of engineering undergraduate students in their first two years in order to better understand their engineering identity and the relationship to graduation. Assessment of the engineering identity and mindset during the sophomore year will be done to both understand the growing diverse student body and to suggest changes in student and faculty engagement and instructional activities. In this project, the authors will: (1) identify biases formed by students when they choose their major, (2) describe the design and pedagogies used within an engineering course and, (3) evaluate the effect of these practices on underrepresented engineering students. To address the objectives, the authors created a prototype of a competency-based learning module and distributed to a sophomore-level aerospace engineering classroom. By creating a minimum viable product for this classroom, the authors could tailor the module throughout the semester according to the feedback received from students and instructors. Early results showed that, while students benefit from the module academically, the prototype did not address the general student concern of curriculum diversity and perceived career applications. To benefit future semesters in the aerospace program for sophomore classes, the authors are currently developing the competency-based learning module and building a framework for overall degree satisfaction based on prototype results.

Keywords: competency-based modules, sophomore engineering classrooms, biases, engineering identity, underrepresented students.

Introduction

While departments across the U.S. are continuously making efforts to increase diversity in engineering, many underrepresented students are changing majors or leaving the university after their first two years in an engineering program. An increase of research focused on first-year engineering programs has lead to changes in the curriculum and department levels. However, the second-year experience for engineers is still largely unexplored. Students are introduced to many of their departmental courses during their second year, forcing them to begin shaping their

identities as engineers. The sophomore year, then, is critical by nature. Assessment of the engineering identity and mindset during the sophomore year will be done to both understand the growing diverse student body and to suggest changes in student and faculty engagement and instructional activities

The focus of this project is a novel approach toward improving student diversity in aerospace engineering. Additionally, the proposed research will provide new knowledge regarding the pathways of engineering undergraduate students related to engineering identity and graduation rates. The authors found that most first year engineering students who left the program transferred to non-engineering majors, whereas the second aerospace engineering students who changed their majors (10-15%) transfer within the college to another engineering program. A campus-wide engineering survey showed that students most commonly change from aerospace engineering because 1) they believe the degree is very specific and therefore limits the diversity in skill sets for future careers and 2) department courses are more demanding and difficult than expected.

Literature Search

Scientific and engineering innovation is vital for American competitiveness, quality of life, and national security [1]. However, there is less than a 40% completion rate for undergraduates attempting to receive their degree within six years in any science, technology, engineering and mathematics (STEM) field [2]. As the U.S. aims to increase their STEM workforce, they are faced with the harsh truth that, while women and ethnic minorities represent 70% of college students, less than 45% are pursuing a degree in STEM [3]. Women represent nearly half of the workforce in the U.S. however, only a quarter of these women hold STEM jobs [4]. With these troubling facts of the U.S. schools and workforce, studies would further suggest that, while recruitment efforts are being geared further towards racially and ethnically diverse men and women students, little is being done to ensure their retention in their STEM careers. A deeper look in the classrooms of U.S. schools and workforce is needed to understand why these things are occurring and what pedagogies can be altered, added, removed, or enhanced to alter the rapid decline of these underrepresented students in engineering.

Studies show that extensive efforts have been made in the first year of engineering programs across the nation to increase retention. However, these changes have not necessarily resulted in reducing the number of students who change majors or leave the university during their second year in engineering. The knowledge gaps regarding practices to create a more inclusive environment for engineering students are still being studied in regard to shaping an engineering identity, fostering an entrepreneurial mindset, and implementing pedagogical approaches and how these practices affect retention.

Implementation of Competency-Based Module

A preliminary study of self-paced, personal learning modules for a sophomore engineering class was created to help students measure their existing knowledge of previous math and physics

courses. The idea from this prototype was based on input from professors of the department as they expressed concern that certain students were not able to recall prerequisite material. This forced professors to take time out of class to review the material, therefore saving students from an otherwise dropping grade. The authors launched the original prototype to collect basic information regarding student background: where and when they took their prerequisite classes, and a knowledge check of physics questions that they would need to know for their class.

Figure 1 shows the process through which we built our minimum viable product (MVP) for the classroom. Students would first take a survey regarding their academic background that would identify when and where their prerequisite courses were taken. Students were then asked to solve a problem that was developed from prerequisite material that would be covered in that week's learning module. After inputting their answers, students would be given the solution as well as learning material that would help them understand the problem. A second question, similar to the first, was given to reinforce the learning material. Once done, students could then give feedback regarding the usefulness of the product. Results showed that over half of the students believed that the first solution helped them in answering the second question.

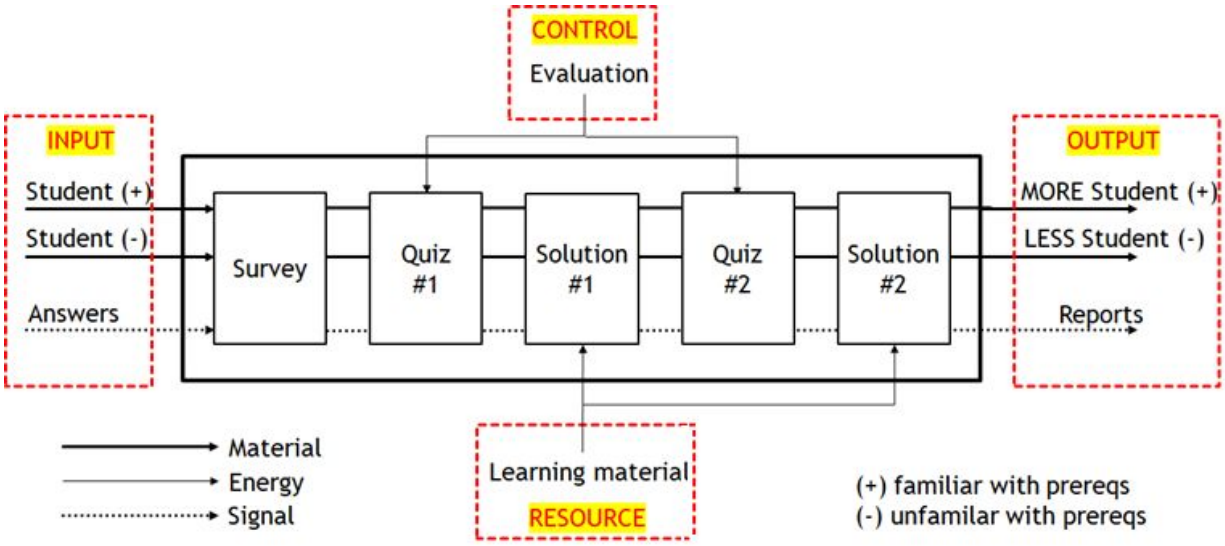

Figure 1: Minimum Viable Product (MVP) for Aerospace Sophomore Classroom

While the initial learning module was geared to help students bridge the gaps of knowledge to assist them through their engineering courses, our team has begun to pivot the direction of the modules. Interviews from students within the department have suggested that lack of diversity in the engineering field may be the cause of students switching majors. As of now, our team is working on how to gear the personal learning module questions so that they reflect the needs of the students and professors in regards to diversifying the engineering applications. The literature background done in this study is being used to incorporate the types of questions and problems that could be best used to capture the interests of the students in their engineering field.

Future Work

The current research investigating undergraduate students in engineering is making great strides toward counteracting biases and correcting unconscious beliefs students may have in identifying as an engineer. Current improvements to the MVP are incorporating employer-based questions so students can make connections between classroom applications and future career skills. Improvements will also help to provide a knowledge-based check that is tailored to help students with gaps in their prerequisite material. Results of this study can aid with programs seeking to build a more inclusive environment for undergraduate students and overall decrease the dropout rate while also encouraging students to diversify the applications of their engineering field.