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WIP: Strategies to Increase Value and Retention for Undergraduates in Engineering

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Abstract

At a large southwestern university, efforts are being made to grow the engineering student body significantly by 2025. One of the challenges to this goal is students switching majors or leaving the university during 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 also affirming or shaping their identities as engineers. Most first year engineering students who left aerospace redirected their studies outside of the college of engineering and the remaining transferred to other engineering departments. As a whole, the aerospace department does not have a threshold of how many students should be retained, but there are investigations when certain classes have higher student drop outs than normal. Students most commonly change from the aerospace engineering major because 1) they believe their major is too specific, therefore providing a more limited range of job opportunities post-graduation and 2) they perceive courses to be harder than expected (freshman year, in contrast, was a review for them).

This paper addresses the second given reason in an effort to increase retention among the students. One of the outputs of the project was the creation of self-paced, personal learning modules for second-year aerospace students. The driving idea behind this prototype came from engineering department professors' collective input as they expressed concern for their students' inability to recall prerequisite material, forcing professors to use class time to provide teaching for old material, without which the students' grades would have plummeted. With these modules,

students and professors can quantify the existing knowledge of their math and physics courses while the department provides customized learning material for areas in which students are lacking. Ideally, these modules would be created for their sequential years and students would be able to revisit the material they have learned as needed. In these modules, assessments would be given in the beginning of the semester to fill in any knowledge gaps. The first assessment covered prerequisite calculus topics that professors identified as essential to the second-year aerospace courses. The second assessment covered additional math topics, however we focused more on student feedback on the value of the assessment. Our next steps for this project are to incorporate more higher math topics and find a platform that can support our needs.

Introduction

As the need for diversity in engineering increases, research shows that incorporating a sense of belonging, positive psychology, and mentorship into STEM programs has the power to increase retention and value for undergraduate students (Lichtenstein, Chen, Smith, & Maldonado, 2014). Studies would further suggest that while recruitment efforts are being made geared towards undergraduate students, more practices of retention need to be implemented to ensure students have the environments they need to continue pursuing their STEM degrees (Geisinger and Raman, 2013). Students who are calculus-ready when entering college have been shown to be more likely to remain and graduate with their engineering degree than those who do not (Bowen, Wilkens, & Ernest, 2019). Many students have math deficiencies even prior to entering their sophomore engineering courses, which negatively impact student retention (Ricks, Richardson, Stern, Taylor, & Taylor, 2014).

One way an engineering program at a southwestern university is working to better prepare their

students in their classes is by implementing a competency-based math assessment in one of their critical second-year engineering courses. The exam was created through Pearson's MyMathTest which uses Artificial Intelligence (AI) to adapt a study plan based on the student's correct and incorrect answers. The administrators customized the exam to test students on math topics that were considered important in order to successfully pass the engineering course. The assessment was given to students on their first week of school and was available for four weeks in order to give students adequate time to take the exam, review their material, and remediate any math knowledge that the students would need to know for the course.

Competency-based assessments give students equal opportunities to be successful in their classes as many students have different backgrounds of learning. Flagging "at-risk" students and giving them the tools they need to learn the course prerequisite material can help build their sense of belonging and positive attitude in the classroom. Similar competency and remedial assessments from other departments and universities have proved to be helpful to their students by lowering the D/F/Q rates, creating shifts in letter grades, and increasing the rate of students passing courses when compared to the years where AI assessments were not used.

Testing

Fall Math Assessment

In the fall semester, 200 engineering students were given an mathematics assessment to evaluate their knowledge of prerequisite math courses in their second-year aerospace course. The students were each given an access code to Pearson's MyMathTest, which was customized to cover the required concepts that would be used in their engineering course. The assessment used Adaptive Testing, which produced various questions based on the number of correct answers. If a student

failed to submit a correct answer, the test would supply a similar question and continue going back to determine what mathematical concepts needed to be remediated for each individual student. Students were given two weeks to complete the assessment and raise their grades in the system by reviewing the material and taking quizzes for each concept that they had missed.

Spring Math Assessment

For the spring assessment, we added more math topics to include prerequisite subjects from other second-year aerospace courses. Instead of focusing on the student grades, we gathered data from a post-survey in order to gauge the value of the assessment to the students and what resources they used in order to complete the exam. We created a comment section for the students to leave feedback regarding the math topics that were covered and if having the test resources available to them at the beginning of the semester would be useful for them. Feedback from the students in both the fall and spring assessment would help determine what the next steps would be for the next iteration of the math competency test.

Results

Within the first four weeks of class in the fall semester, approximately 90% (n = 177/200) of the students accessed the assessment and 86% (n = 173/200) completed the exam with the remaining not submitting or finishing the exam. Of the students who took the exam, 23% (n=40/173) retook the exam at least once and there was a 12% increase of those who received an A in the assessment. Table 1 shows the distribution of grades for the mathematics assessment. The effectiveness of the assessment on final grades of the students still needs to be retrieved from the previous fall semester and compared to the previous years to see if there were improvements or noticeable changes with the use of adaptive testing.

Grade	Number of Second-Year Aerospace Students		Percentage of Second-Year Aerospace Students	
	First Assessment	**Final Assessment**	**First Assessment**	**Final Assessment**
90 or above	76	97	43.9%	56.1%
80 or above	25	18	14.5%	10.4%
70 or above	27	22	15.6%	12.7%
60 or above	20	18	11.6%	10.4%
50 or above	13	9	7.5%	5.2%
40 or above	3	4	1.7%	2.3%
30 or above	5	3	2.9%	1.7%
20 or above	3	2	1.7%	1.2%
below 20	1	0	0.6%	0.0%

Table 1: Grade Distribution for Mathematical Assessment

For the spring semester math assessment, over half of the class (n=29/51) took the exam and post survey. Students noted that, while the exam covered useful topics, higher level maths would have added value to the assessment. Several students commented that some of the problems were subjects that they had forgotten, but did not feel that they would necessarily need in the future. Others commented that they were thankful for the refresher and valued the resources that the adaptive testing offered after the end of the exam.

Discussion and Future Work

Combined results from the fall and spring semester assessment and survey have helped us determine what topics the students and professors find useful in their engineering courses. As this is a work in progress, results from grade distribution and student feedback is still needed to determine the effectiveness of the adaptive testing. Students entering in the spring semester may also vary from those who entered in the fall as class sizes are significantly smaller and the cohort is usually transfer students or students repeating the course. Additionally, the test will likely expand in calculus and physics subjects as we make changes according to the material that is available on the software. Currently, the platform we are using does not offer adaptive testing for the higher level maths that the department and students are requesting, so next steps are to work with a team that can accommodate the necessary changes. We also intend to distribute a pre and post survey to the participants to gather feedback regarding the usefulness of the assessment.

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