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Effect of Targeted Tutoring, Study Group Formation, and Self-Efficacy on First-Year Engineering Student Success

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Abstract

FTIAC (First Time In Any College) students in the College of Engineering and Applied Sciences at Western Michigan University (WMU) who place into Algebra II (MATH 1110) are statistically less likely to be retained in the College and to complete their degree. Several interventions and support services have been put into place over the past few years to improve their outcomes, but the success of this group still significantly lags that of other FTIACs in the College. The current study seeks to evaluate the impact of a semi-intrusive tutoring scheme, student self-efficacy beliefs, and the formation of student study groups on success of students placing into Algebra II during their first semester. Mathematics tutoring is currently available both through College-sponsored centers as well as centers sponsored by the College of Arts&Sciences. However, past discussions with engineering students in MATH 1110 have revealed that many of them do not take advantage of these resources and many students also resist forming study groups for academic support. In this study, rather than hoping students will come to the tutors, we have reserved the same classroom space immediately after one section of ENGR 2100 (an academic support class into which most MATH 1110-placed students enroll). Students will be encouraged by the ENGR 2100 instructor to stay in the classroom, work in groups and receive help from the tutors on assignments in MATH 1110 and ENGR 1002 (a problem-based course that accompanies MATH 1110 for engineering students). The same instructor teaches all sections of ENGR 2100. For the two sections not scheduled immediately before these tutoring sessions, most students' schedules would still allow them to attend at least once per week. They will be encouraged to participate in the tutoring sessions as able, to form study groups regardless of whether or not they participate in these tutoring sessions, and to make regular use of other academic support services. All students in ENGR 2100 will be encouraged to participate in the study to determine whether this approach to tutoring has made a positive impact. The students' initial self-efficacy beliefs related to a variety of college-related activities will be surveyed and compared with results from the end of the semester to determine any changes and potential relationships with student success and retention.

Background

WMU-STEP (WMU STEM Talent Expansion Program) was initially funded via a grant from the National Science Foundation. It comprises multiple components within the College of Engineering and Applied Sciences (CEAS) to support student success. These include cohort class scheduling for the first year, faculty or staff mentors assigned to each cohort, multiple student success centers (SSCs) that provide free tutoring, a living-learning community, targeted intervention for at-risk students, a course on women and leadership in STEM that is aimed at female students in the College, and a study skills course for students who wish to declare a major in the College but whose math abilities are at the Algebra II level. The two-credit study skills course is designated ENGR 2100 and meets twice per week for 50 minutes. A list of topics covered in the course is shown in Table 1.

Table 1: Major topics of ENGR 2100

Reading Syllabi	Study Time and Time Management
Using the Learning Management System	Common Student Mistakes
Understanding the Academic Calendar	Changing Habits
Life Factors in Success	Procrastination
The Learning Cycle	Setting SMART Goals
Characteristics of Expert Learners	Getting Involved – Student Organizations
Working with Professors	Preparing for Career Success

Retention and student success data in the College from the early 2000's indicated that first-time students who placed into Math 1110 (Algebra II) were much less likely to be retained to the second year and to ultimately complete their degree (whether from the College or from another major at WMU) than students who entered the College placing into at least MATH 1180 (Pre-Calculus). Further refinement of the retention data showed that students achieving a grade in Algebra II of lower than 'B' were even less likely to complete their degree successfully than students who completed Algebra II with a 'B' or higher (a 'C' or higher is required by the Mathematics Department to proceed to Pre-Calculus). Based on these observations, starting in 2013, a separate cohort was created for all students in the College who placed into Algebra II regardless of their intended major within the College. This cohort is designated CEAS-Preparatory (PREP). In addition to Algebra II and other first semester courses required for their degree program, students in PREP are also enrolled in two other courses, ENGR 2100 and ENGR 1002. ENGR 2100, as mentioned above is focused on study skills as well as general topics related to connecting and succeeding in college. ENGR 1002 is a problem-solving course that has been designed to complement the topics being learned in Algebra II. It is a one credit course that meets in a three-hour block once per week. Neither class is required for any degree programs and students can opt out if they desire. However, by default students in Algebra II are also enrolled in ENGR 2100 and ENGR 1002 during summer orientation unless they request otherwise. The total student credit load is kept within the range of 12-15 credits during their first semester.

Research has shown that past academic performance is a strong predictor of future academic success, whether the consideration is high school GPA [e.g., 1] or the performance in the most recent high school mathematics course [e.g., 2]. Students enrolled in ENGR 2100 have a range of overall high school GPAs as well as high school mathematics courses. However, all of them placed into MATH 1110 at WMU by virtue of some combination of standardized test score or the ALEKS placement exam [3]. Due to their lower level of math preparation, available research in the literature as well as our own internal data (mentioned above) shows that they are statistically less likely to be retained in engineering, technology, and computer science programs. Previous research has shown the potential impact of focused tutoring interventions on first-year engineering student success [e.g., 4-8]. Drop-in tutoring has previously been available at multiple SSCs including one in a residence hall with a large first-year engineering population (open in the evenings) and one in the main engineering building (open during the day). However, usage of these SSC locations by students in ENGR 2100 has tended to be low. To make the tutoring more intrusive, time has been specifically set aside after one section of ENGR 2100 (in the same classroom) during which a tutor will be available to help students with their questions about MATH 1110 and ENGR 1002. Kuh [9] has made an extensive study of high-

impact practices in education, including collaborative assignments and projects. A primary goal of the current project is to increase student usage of tutoring resources while also encouraging earlier formation of effective study groups within the ENGR 2100 cohort.

Method

For the Fall 2019 semester, 83 incoming students were placed in the PREP cohort by virtue of their math placement scores or math transfer credits. Seven of these were transfer students, three were classified as continuing students, and the balance were first-time in any college (FTIAC) students. Seventy-four students enrolled in ENGR 2100; however, one student died tragically part-way through the semester and another requested a complete withdrawal. These students have been removed from the study. ENGR 2100 was split into three sections (each meeting twice per week) to provide a smaller group environment and more opportunities for personal interactions with the instructor. One section met MW and two sections met TTh. Following the second TTh section, one of the mathematics tutors came into the ENGR 2100 classroom to offer assistance with mathematics homework or preparation for upcoming exams. All ENGR 2100 students from that section were encouraged to stay in the classroom and students from the other ENGR 2100 sections were invited to attend. A review of the cohort schedule showed that approximately three-quarters of the ENGR 2100 students had schedules that would allow them to attend.

Students in ENGR 2100 were invited to participate in a survey related to their study habits (hours per week in class, studying alone, studying with a group), use of tutoring, used of faculty office hours, and work hours per week. Two forms of the survey were administered, one for the start of the semester related to students' plans for each of the categories and one for the end of the semester related to their actual time allocation. The pre-semester version of the survey is also shown in the Appendix. Students who completed both start- and end-of-semester surveys were entered into a random drawing for one of three $35 gift cards to the University bookstore.

In addition to the any relationships between students' time allocations and their retention and academic performance, we also hoped to gain insights into initial values and changes in the self-efficacy beliefs of ENGR 2100 students over the course of the semester (as measured by the College Self-Efficacy Inventory) in relation their academic outcomes [10,11]. Solberg *et al*. found that self-efficacy can play a significant role in student success, particularly for Hispanic students (and possibly other minority groups). This data could contribute to an early warning method of identifying students in most need of targeted intervention. The questions from the College Self-Efficacy Inventory are listed in the Appendix.

Results and Discussion

Class demographics in ENGR 2100 were 87.5% male and 12.5% female, with 70.4% of students classified as White, 15.5% as Black or African American, and 9.9% Hispanic. All ENGR 2100 students are under the age of 25 with all but three under the age of 20. The estimated cost of attendance (COA) for undergraduate resident students at WMU is $27,298 for the 2019-2020 academic year. Across ENGR 2100, 29.0% of students reported a combination of expected family contribution (EFC) and scholarships/grants of less than one quarter of the COA ($6,825).

Just over 60% of students reported EFC plus scholarships totally less than half of the COA ($13,649).

Thirty-four students completed the survey at the start of the semester (47.2% response rate) and nine students completed both the start-of-semester and end-of-semester surveys (12.5% response rate). One student completed only the end-of-semester survey. Of students completing the start-of-semester survey, three were Hispanic (8.8%), five were Black or African American (14.7%), and the balance were White (76.5%). White students were somewhat overrepresented compared to the overall ENGR 2100 demographics. Four of the start-of-semester respondents were female (11.8%), slightly less than the portion of female students in ENGR 2100 as a whole. All students responding the end-of-semester survey were White, and two were women (20%).

Use of the additional tutoring session in the ENGR 2100 classroom was generally low. Because the typical login infrastructure used in the SSC locations was not available, we were not able to capture exact counts for each period. However, observations from the instructor indicated that many students in the preceding ENGR 2100 typically left before the tutor arrived and few students from the other sections typically attended. A small number of students did make use of the available resource and, anecdotally, reported that they felt it helped them better understand topics in Algebra II. Three of the students who completed the end-of-semester survey reported having participated in the in-class tutoring (including the student who did not complete the start-of-semester survey). All of them reported that the sessions helped them complete their assignments on-time and prepare for exams. One student also expressed that the sessions generally helped improve understanding. Based on this limited data, it appears that the in-class tutoring is meeting its goals for students who make use of it. It is clear, however, that additional changes are needed to encourage more ENGR 2100 students to actively use the available tutoring resources.

Statistical analysis (one-way ANOVA) was performed to determine if start-of-semester self-efficacy significantly affected students' first semester GPA or retention to the second semester. Self-efficacy topics were grouped, as suggested in [10] as "Course Efficacy" – the first seven items in the efficacy survey, "Roommate Efficacy" – the next four items, and "Social Efficacy" – the final eight items. Responses for all questions within a category were averaged and then binned according to 0 – 2.49 = 1, 2.5 – 4.99 = 2, 5 – 7.49 = 3, and 7.5 – 10 = 4. No statistically significant effect of any of these categories individually was found on first semester GPA or students' retention to the College for the spring semester. The number of under-represented minority students in the sample was small (three Hispanic and five Black or African American vs 26 White). It is not clear if this played a role in the fact that we did not see similar impacts of self-efficacy on student success as reported by Solberg *et al*. [10].

Analysis of the end-of-semester survey showed relatively stable values of 'Course Efficacy' for most respondents (the ratings of only two of nine students changed, one by +1, one by -1). Changes were more likely in 'Roommate Efficacy' (three students changed, all by -1) and 'Social Efficacy' (four students changed, two by -1, one by +1 and one by +2). Three of the nine students showed no changes in any efficacy category, including the only student who responded to both surveys and ended the semester with a GPA below 2.0 (GPA = 1.80). One student reported a decrease of 'Course Efficacy' and 'Roommate Efficacy' of -1 but an increase in

'Social Efficacy' of +2. No other student reported a change in all three categories. The small number of students who responded to both surveys prevents any meaningful analysis of the self-efficacy changes that were reported.

Relative to the planned time spent on various activities (start-of-semester survey) vs. the reported time from the end-of-semester survey, no clear links to student success could be detected. In most categories, there was little difference between students' expected time allocations and their actual schedule. Some students did report more time spent studying with groups than they expected, but others reported less. In the start-of-semester survey, approximately 85% of students reported expecting to spend at least one hour per week studying with a group outside of class (and not part of a tutoring session). This number was relatively stable in end-of-semester survey, with 80% of respondents reporting having spent at least one hour per week with a study group. Again, the limited pool of students completing both surveys makes meaningful analysis difficult.

Conclusions

Few meaningful conclusions can be drawn from the data collected so far. The self-efficacy survey results are not statistically significant relative to students' first semester GPA or retention to the College. There are also no clear trends relative to student expectations as to how they will need to spend their time and the outcome of the semester. We are hopeful that an additional semester of academic success data (Spring 2020 performance, retention to Fall 2020) may elucidate relationships that are not clear at this point. It is also possible that any relationships between the variables are more nuanced than our ANOVA analysis was able to determine.

The most positive take-away from the current work was the need to rethink the cohort schedule for PREP students to make the intrusive tutoring more useful for all students. It is clear that students who are not already in the classroom are not likely to use in-classroom tutoring at any higher rate than the 'regular' SSC tutoring. As a result, we have decided to reduce the number of sections of ENGR 2100 offered Fall 2020 to two and to offer in-class tutoring following each. We are also considering administering the self-efficacy and time management surveys again but potentially enhancing the rewards for participation to increase the sample size.

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Appendix

3. How confident are you that you could successfully complete the following tasks?

	Not at all confident					Somewhat confident					Extremely confident
Research a term paper for a course	○	○	○	○	○	○	○	○	○	○	○
Write a paper for a course	○	○	○	○	○	○	○	○	○	○	○
Do well on your exams	○	○	○	○	○	○	○	○	○	○	○
Take good class notes	○	○	○	○	○	○	○	○	○	○	○
Keep up-to-date with your coursework	○	○	○	○	○	○	○	○	○	○	○
Manage time effectively	○	○	○	○	○	○	○	○	○	○	○
Understand your textbooks	○	○	○	○	○	○	○	○	○	○	○
Get along with your roommate(s)/suite mate(s)	○	○	○	○	○	○	○	○	○	○	○
Socialize with your roommate(s)/suite mate(s)	○	○	○	○	○	○	○	○	○	○	○
Divide space in your apartment/room/suite	○	○	○	○	○	○	○	○	○	○	○
Divide chores with your roommate(s)/suite mate(s)	○	○	○	○	○	○	○	○	○	○	○
Participate in class discussions	○	○	○	○	○	○	○	○	○	○	○
Ask a question in class	○	○	○	○	○	○	○	○	○	○	○
Get a date when you want one	○	○	○	○	○	○	○	○	○	○	○
Talk to your instructors	○	○	○	○	○	○	○	○	○	○	○
Talk to a university staff member	○	○	○	○	○	○	○	○	○	○	○
Ask an instructor a question	○	○	○	○	○	○	○	○	○	○	○
Make new friends at college	○	○	○	○	○	○	○	○	○	○	○
Join a registered student organization (RSO)	○	○	○	○	○	○	○	○	○	○	○

4. How many hours per week do you expect to spend on each of the following?

	0	1-5	6-10	11-15	16-20	21-25	26-30	31-35	35+
Attending class	◯	◯	◯	◯	◯	◯	◯	◯	◯
Using a Student Success Center (SSC) either alone or with a group	◯	◯	◯	◯	◯	◯	◯	◯	◯
Meeting with a tutor outside of a Student Success Center (SSC)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Studying alone outside of class (not in an SSC)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Studying with a group outside of class (not in an SSC)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Working on-campus	◯	◯	◯	◯	◯	◯	◯	◯	◯
Working off-campus	◯	◯	◯	◯	◯	◯	◯	◯	◯
Speak with instructors outside of class (office hours, etc.)	◯	◯	◯	◯	◯	◯	◯	◯	◯