Exploring the Use of Peer Mentors in Calculus to Support Retention Efforts in Engineering

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Abstract – *This paper describes the preliminary results of using advanced engineering students as peer mentors in delivering calculus course content to students who express interest in engineering as an academic major. The data were used to inform the design and delivery of supplemental study sessions for calculus courses that are intended to improve retention rates in engineering. The overall study is funded by a National Science Foundation (NSF) Course Curriculum and Laboratory Improvement (CCLI) grant.*

Keywords: engineering peer mentors, student success, retention

1 Introduction

Research on retention in science, technology, engineering, and mathematics (STEM) fields emphasizes that students are often academically unprepared or underprepared for the rigors of engineering [1]. Many of the students that switch away from engineering cite math, specifically calculus, as one of the most influential factors in their decision [2]. Students who switch to another major may have deficiencies in their mathematical background or study skills and are not prepared for the rigors of college calculus. Additionally, students may not understand the importance of calculus as an engineering tool.

We seek to provide ways for institutions to capitalize on opportunities to educate the next generation of engineers. A traditional engineering curriculum requires students to endure a year of math and science courses before being immersed in engineering. Others have identified the need to include engineering content and equations in calculus courses [2][3][4]. Given what is known about the calculus barrier to engineering study, we focused our efforts on embedding real-world engineering problems into calculus courses.

A significant obstacle to teaching a calculus course with engineering content is having sufficient support for both the mathematics and engineering content. One solution to this problem is to have a mathematics professor teach the lecture portion of the calculus course and use upperclass-level mentors to help the students learn the engineering content. To that end, the purpose of this project is to explore the use of advanced engineering students as peer mentors in delivering calculus course content to students who express interest in engineering as an academic major. This study is a work in progress, and part of a larger study where we design and deliver supplemental study sessions for calculus courses that are intended to improve retention rates in engineering. The overall study is funded by a National Science Foundation (NSF) Course Curriculum and Laboratory Improvement (CCLI) grant (Project DUE-0942270).

2 Peer Mentoring and Reciprocal Peer Coaching

Peer mentoring and reciprocal peer coaching are integral components of our project; we expect the engineering peer mentors to provide real-time, instructive feedback as well as guidance on efficient study habits to students enrolled in calculus and considering engineering as an academic major. Moreover, we use peer mentors to connect students to campus resources as well as to each other. Peer mentoring is regarded as a successful intervention to address issues of student retention in academic programs [5]. Peer mentoring is defined as "a helping relationship in which two individuals of similar age and/or experience come together … in the pursuit of fulfilling some combination of functions that are career-related and psychosocial" [6]. For students in engineering, the act of pairing incoming students with peer mentors benefits students in a variety of ways, including reduction of feeling of isolation, improved academic performance, and an increase in minority student persistence [7][8].

Reciprocal peer coaching, a form of peer-assisted learning, shares many characteristics with peer mentoring, as it "encourages individual students in small groups to coach each other … so that the outcome of the process is more rounded understanding and a more skillful execution of the task in hand than if the student was learning in isolation" [9]. Reciprocal peer coaching encourages and motivates students to work toward a common goal; there is also an opportunity for students to give and receive feedback in a small group setting, a learning environment that is less "risky" than the traditional classroom setting.

The students who served as peer mentors in this project participated in training exercises prior to facilitating group sessions. The mentors received information on group facilitation and leadership, in addition to instructions as to how to distribute the module problems and schedule the small group meetings. The mentors were also guided by a member of the research team on how to create a safe learning environment and meet the needs of individuals with different learning styles. A summary of mentor responsibilities includes:

- Schedule mentor sessions with students.
- Facilitate group discussions
- Provide general support for learning engineering content
- Serve as a resource to help students connect with each other, and to engineering as a discipline
- Provide feedback to project faculty on students' levels of participation in sessions
- Provide process-related feedback to project faculty on the modules and mentor sessions

At each session, the mentor was instructed to:

- Create an atmosphere that is comfortable for learning
- Select a student to share her/his process for solving the problems in the module.
- Encourage other students in attendance to comment in a positive manner and ask questions as they go through the process.
- Guide the students in a discussion that will help them find the most efficient, correct method for solving the problem.

3 Methodology

In this project, students use real-world engineering examples, provided in learning modules, to learn calculus concepts. Students work on the problems with experienced, upper-level engineering students as mentors in specified study sessions that take place outside of class. The full study began in the fall 2011 semester with students enrolled in Calculus I.

Students were informed of the opportunity to participate in the study prior to enrolling in Calculus I. To encourage participation in the study, we highlighted the fact that real-world engineering problems would be incorporated into the class as well as the opportunity to work with an experienced, upper-level engineering student in specified mentor-led study sessions. We offered students an opportunity to use their work at the mentor-led study sessions to count toward earning extra homework-related points. Students who enrolled in the course but chose not to participate were still invited to the mentor study sessions so as to avoid bias or penalty for choosing not to participate in the study.

The mentor-led study sessions were small group discussions of engineering problems that can be solved by applying concepts from Calculus I. Students in the study were organized into small groups to work on the module problems. Groups were constructed using the Comprehensive Assessment for Team-Member Effectiveness (CATME) Team-maker tool, developed and maintained with support from the National Science Foundation [10]. The problems were organized into learning modules that were distributed by the peer mentor. There were 8 modules and corresponding mentoring sessions, spaced evenly throughout the semester. Each mentoring session lasted approximately one to one and a half hours; no session exceeded two hours.

Members of each small group met with the mentor to discuss the modules within two weeks of receiving the modules. At these meetings, group members took turns presenting solutions to the module problems. When not presenting, students were strongly encouraged to engage in discussion. Students were expected to attend a minimum of five mentoring sessions. Participants in the study were asked to provide feedback on their experiences at the end of the semester by completing the Modules and Mentors (MM) survey.

The Modules and Mentors (MM) Survey was designed to learn about students' experiences in their calculus classes related to the engineering concept problems and working with their engineering peer mentors. There were 18 total questions on the survey, nine of which concerned students' feedback on working with the peer mentor and their interactions with other students in the peer-led study sessions. In addition, participants responded to questions that focused on their self-reported comfort and confidence levels with calculus, as well as on connecting calculus knowledge to the study of engineering.

The Modules and Mentors survey instrument was reviewed and approved by the Institutional Review Board (IRB) at the University where it was administered. Upon certification that the study met the human research subject protections and obligations as required by law and University policy, the survey was distributed online to students who were enrolled in Calculus I in the fall 2011 semester and participated in the mentor-led supplemental study sessions at a large research university located in the Midwest (n=46). Students' completion of the survey was voluntary. As such, the response rate was approximately 21.7% (n=10).

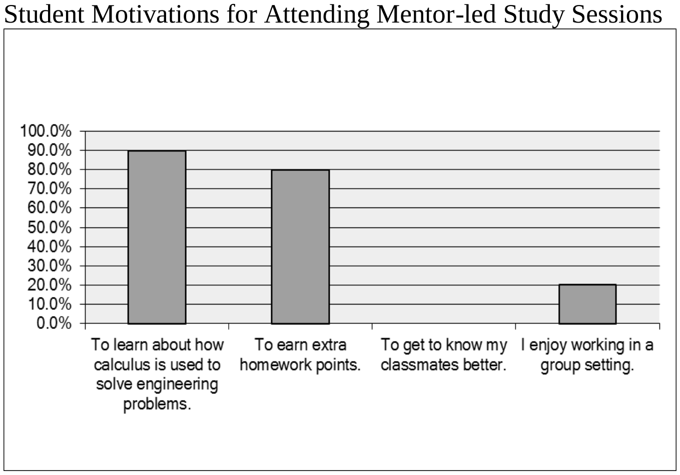
4 Results

The results of the content-based questions on the Modules and Mentors survey are organized into three sections: 1) motivations; 2) perceptions on the human components and; 3) confidence levels. The first section concerning motivations includes participant self-reporting of why they chose to attend the mentor-led study sessions. The second section, perceptions on the human components, asked students to report information about the degree of helpfulness they experienced by working with a peer mentor as well as the feeling of connectedness to other math and engineering students. The third section addresses participant self-reported confidence levels in mathematical abilities, engineering, and their comfort, as well as students' perceptions in using calculus to solve engineering problems.

4.1 Motivations

All of the students who responded to the survey attended six to eight (75.0-100.0%) of the mentor-led study sessions. Nine out of 10 respondents indicated that they attended to "learn how calculus is used to solve engineering problems". The majority of students (80.0%) were also motivated to attend by the opportunity to "earn extra homework points" for class. Although two students noted that they preferred to learn in a group setting, no students indicated their reason for attending was to "get to know [their] classmates better". See Table 1 for a graphic representation of student motivations for attending the mentor-led study sessions.

Table 1
Student Motivations for Attending Mentor-led Study Sessions



4.2 Perspectives on human components

For purposes of this paper, we were primarily interested in learning how students were impacted by the human components of the study: working with engineering peer mentors. As previously stated, the peer mentor led each study session and facilitated group work toward exploring and finding solutions to the engineering-related calculus problems. In the fall 2011 study, participating students felt that working with the engineering peer mentor was "helpful" (40.0%), "very helpful" (20.0%), or "somewhat helpful" (20.0%) in learning calculus (see Table 2).

Table 2
Student Perceptions of Helpfulness of Working with an Engineering Peer Mentor

	%
Not at all helpful	10.0%
Somewhat helpful	20.0%
Helpful	40.0%
Very helpful	20.0%
Extremely helpful	10.0%

In the same semester, 40.0% of participating students felt "connected" to other students in math and engineering after taking Calculus I and participating in the mentor-led study sessions (see Table 3).

Table 3
Student Perceptions of Connectedness to Other Students in Math and Engineering

	%
Not at all connected	20.0%
Somewhat connected	40.0%
Connected	40.0%

4.3 Confidence levels

Students remained "confident" (50.0%) and "somewhat confident" (30.0%) in their mathematical abilities following completion of their participation in the mentor-led study sessions (see Table 4). Concerning their confidence in engineering subject matter, 40.0% of students expressed they were "somewhat confident" and 20.0% felt confident in their ability to succeed in engineering (see Table 5). Table 6 further illustrates students' comfort and confidence levels in using calculus to solve engineering problems. Table 7 highlights perceptions of using calculus to solve engineering problems, specifically concerning the frequency with which students felt calculus is necessary to solve engineering problems. Responses to this question indicate that the majority of participants (60%) felt that calculus is always required to solve engineering problems. No participants reported that they did not see a connection at all between calculus and engineering.

Table 4
Self-reported Student Confidence Levels in Mathematical Abilities

	%
Not at all confident	0.0%
Somewhat confident	10.0%
Confident	50.0%
Very confident	10.0%
Extremely confident	30.0%

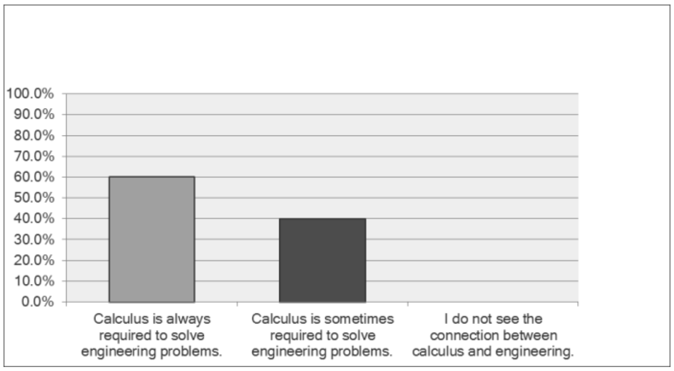
Table 5
Self-reported Confidence Levels in Engineering

	%
Not at all confident	10.0%
Somewhat confident	40.0%
Confident	20.0%
Very confident	20.0%
Extremely confident	10.0%

Table 6
Student Comfort Levels in Using Calculus to Solve Engineering Problems

	%
Not at all comfortable	0.0%
Somewhat comfortable	20.0%
Comfortable	60.0%
Very comfortable	10.0%
Extremely comfortable	10.0%

Table 7
Student Perceptions of Using Calculus to Solve Engineering Problems



5 Discussion

The opportunity for students to participate in reciprocal peer coaching and to get direct instructive feedback on their problem-solving methodology is not always possible in a traditional calculus course. Working in a small group setting seems to be of some benefit to students in our study, but the perception of helpfulness of working with a peer mentor was not as strong as expected. Student performance and attitudes about calculus and the study of engineering may benefit from a revision to the peer mentor training seminar where the role of mentors in the student learning process will be emphasized.

Less than half of the students who participated in the fall 2011 study indicated a stronger connection with other students in math and/or engineering after completing the Calculus I course and participating in the mentor-led study sessions. Combined with a lack of respondents who indicated a desire to meet others as impetus for attending the study sessions, it does not appear that peer connections are a priority for students in this iteration of the study. Peer connections should be emphasized as an important component in the pursuit of engineering student success in all academic areas, particularly in calculus. There may be an opportunity to better facilitate peer interaction in the small groups setting, led by the engineering peer mentor, by considering group construction. Pairing mentors with a compatible group of mentees that share commonalities has been shown to be very beneficial [11]. In future semesters, we will strive to assign each group a mentor from their specific engineering discipline. In addition, special efforts will be made to match mentees of an underrepresented group with a mentor of a similar group.

Participating students felt more confident in their mathematical skills as well as in their abilities to succeed in engineering. Moreover, students made a connection between calculus and engineering. This was an important outcome for those who took part in this study, specifically from their interactions with upperclass-level engineering students, and participation in the study sessions. We anticipate expanding the data analysis portion of this project once the full study is complete, to include determination of correlation coefficients and some predictive analysis of students' likelihood to remain in engineering.

6 Conclusions

The use of engineering peer mentors is a key component in supporting students' comfort, confidence, and acquisition of the requisite calculus knowledge, skills, and abilities. Moreover, the program's goal is student persistence and improved institutional efforts concerning retention of STEM students. As consideration of the mentor-led study sessions continues, so does the pursuit of creating a framework for best practices of peer mentoring programs that may be used by other institutions.

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