Assessing the Impact of Peer Mentoring on Performance in a Fundamentals of Engineering Course

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Abstract
This Work in Progress Paper will assess the impact of peer mentoring on the performance of students in Fundamentals of Engineering course. First Year Experience Programs are designed to build the foundation for incoming freshmen students at college level. Fundamentals of Engineering courses offered as part of these programs teach required problem solving and technical skills and forms the basis for admission into engineering majors. Students often find these courses to be challenging and overwhelming. Many students experience difficulty in transitioning from high school to college because the goals and expectations vary significantly. Although several learning pedagogies such as active learning, flipped classroom and interactive discussion groups have been implemented by instructors to make student’s experience more rewarding and impactful, there is still a need to explore strategies to further enhance students’ performance and overall success. The goal of this study is to address the research question: Will providing peer mentoring sessions help improve the performance in Fundamentals of Engineering course offered at a regional campus? The concepts covered in the course integrate the scientific principles and mathematical problem solving with practical applications utilizing engineering tools. Data analysis in Excel, application based programming in MATLAB and software design project are three main components of the course. Although most of the application assignments encourage teamwork, students find it difficult to learn and implement the functionality of tools and lack confidence in accomplishing the tasks in a timely manner. The rationale behind peer mentoring approach is to provide support and a medium for students to interact with peers who have successfully completed the coursework. It also helps students learn from other’s experiences to avoid possible mistakes, thereby developing a sense of confidence and motivation. In this paper, we describe peer mentoring learning strategy to assess the performance of students in Fundamentals of Engineering course at a regional campus. The peer mentoring sessions are offered by the STEM enrichment center where the students are paired with the mentors. The study is being conducted during autumn and spring semesters and it is a work in progress.

Introduction
First Year Experience Programs are designed to build the foundation for incoming freshmen students at college level. Higher Education institutions emphasize on first year program because the foundations built during the first year are a key to student’s success. There are about four different pathways for the First Year Experience in Engineering Program at this institution: Standard, Honors, Scholars and Transfers. The Standards Program is the focus of this paper as it the only pathway offered at the regional campuses. The two courses sequence offered in this program are: Fundamentals of Engineering I and Fundamentals of Engineering II. These courses have two main components: lectures and hands-on labs. The topics covered in lecture provide skills for problem solving, critical thinking, ethical decision making, teamwork, communication and presentation. The laboratory experiments provide a broad overview of engineering disciplines. These courses also help many undecided (exploring) freshmen to narrow down the
list of engineering majors and declare a major of their interest. Students often find these courses to be challenging and overwhelming. It is known that enrollment, admission, advising and many other processes pose challenges for the freshmen students before getting into the classrooms. In addition, the social and psychological aspect of beginning college has a huge impact on students. Many students experience difficulty in transitioning from high school to college because the goals and expectations vary significantly. In order to address these concerns and challenges, higher education institutions have been working hard to make the first year experience amiable and pleasant for the students. Several learning pedagogies have been implemented by instructors such as active learning, flipped classroom and interactive discussion groups. In-class activities and forming teams are part of the active learning techniques that help students overcome the fear and anxiety and allow them to openly discuss and share ideas. However, there is still a need to explore strategies to further enhance students’ performance and overall success. Mentoring has been described in the prior studies as a process in which a more-experienced individual (mentor) guides a less-experienced individual (mentee) in a professional and academic setting [1, 2]. It is evident through research that the peer mentoring helps mentees in transitioning into post-secondary education, building confidence, providing support to address academic challenges and assisting with networking and social interactions [3, 4, 5, 6]. Peer mentoring has become a common approach for achieving outcomes not only for mentors and mentees [7, 8, 9] but also in retaining minority and female students in engineering and other science fields [10,11]. Peer mentoring helps not only mentors learning the material from a mentee but also helps mentee build teaching, communication and leadership skills [10, 11, 12].

The role and benefits of the peer mentoring process has been investigated in the literature. Many peer mentoring strategies has been developed by the researchers to assess the performance not only in engineering but also in other disciplines. Most successful programs in the past utilized strategies that include: training the mentors and mentees, mentor-mentee matching, mentee-mentor expectation worksheets, and social activities [9]. Utilizing teaching assistants as peer mentors is another approach but due to other responsibilities such as grading, lab preparation and office hours, teaching assistants are not able to provide effective peer mentoring. In some literature work, the peer mentors are tutors who are not involved with a specific course and some are need-based tutors who are not always available to mentor. Some of the challenges were the availability of suitable mentors when needed by mentees and being able to retain knowledge of the course.

This paper presents a unique approach to utilize peers for mentoring the first year engineering students. Peer mentors are recruited based on the selection criteria. Instructors evaluate the performance of the students who successfully completed the course in the past two semesters for potential mentor roles. The selection criteria differs from the prior studies in regards to determining the candidates. In this study, the time and grade thresholds will be used to determine the eligibility for the mentors. Two mentoring session options will be explored: 1) Mentors paired with mentees depending on availability. 2) Mentors conducting scheduled sessions whether the students sign up or not. The STEM enrichment center is one of the campus’s programs that aims for student success and offers tutoring services. Most successful peer mentoring programs provide credit hours for mentoring work [13], or pay hourly wage their
work [9] or simply to provide an opportunity to gain experience. In this study, we chose to hire the mentors through the STEM enrichment center and pay them an hourly wage. The goal of this study is to address the research question: Will providing peer mentoring sessions help improve the performance in Fundamentals of Engineering course offered at a regional campus? As mentioned earlier, this regional campus offers the Standards Program Pathway under which the two courses offered are: Fundamentals of Engineering I and Fundamentals of Engineering II. Two to three sections of the course are offered in each semester and the author is the instructor and facilitator of the course at this regional campus. The class sizes are small and the enrollment varies from autumn to spring semester. In autumn, the classes reach the maximum capacity while in spring there is low enrollment. A regular freshmen is expected to enroll in Fundamentals of Engineering I in the first semester since there is no prerequisite for the course and Fundamentals II in the following semester. Student who are either repeating the course or transferring from other campuses or programs might enroll in the first course of the sequence in spring semester.

In this paper, the student performance is evaluated based on the motivation to attend the peer mentoring sessions and how those sessions help improve the student performance in class. The performance is assessed based on student grades in application assignments, midterm and final exams, though the author realizes that grades are not the only factor to study the performance. Student self-assessments, mentor and mentee surveys and team evaluations are going to be conducted as part of the future work to assess the impact of peer mentoring on performance.

Course Design

Fundamentals of Engineering I is the first of the two course sequence which serves as a pre-
requisite for admission into engineering majors. It is a two credit hour course which provides a broad overview of engineering topics. The coursework involves problem solving, engineering design process, written and oral communication, ethics in engineering, teamwork and engineering tools that aid in critical thinking, planning and data analysis. Data analysis in Excel, Programming in MATLAB and Software Design Project are three main components of the course. First-year engineering courses cover a variety of learning objectives outlined in ABET that address not only technical and professional outcomes [6] but also outcomes related to teamwork. Teamwork is another important part of the course, which is heavily weighted for grading purposes. Teams are formed in the beginning of the semester using a random process of grouping students. There are application assignments each week that cover the concepts taught in lecture to assess the student’s ability to apply the knowledge to real world scenarios. Most of the application assignments encourage teamwork, however the difficulty lies in understanding the functionality of tools and accomplishing the tasks efficiently in a timely manner. Individual and team participation in course is directly related to the overall performance. Application assignments are distributed evenly between Excel and MATLAB topics. Excel concepts involve creation of arrays, arithmetic operations and use of built-in functions. Graphing techniques are taught that allow students to be able to plot single and multiple sets of data. Programming in MATLAB section allows students to supplement the concepts covered in Excel section using algorithm and code development. The midterm exams follow similar format as the application
assignments. The final exams are comprehensive and includes all the topics covered in the course.

Teams of up to four students are formed in the beginning of the semester to allow students to build the bonding and skills to interact with each other. Teams distribute the tasks evenly among the members and work closely each week to complete the tasks. The Lab exercises are built in such a way that students learn to work individually and also as a team. This set up helps to build a sense of responsibility of their own work and also a sense of dependability when it comes to team work. The Software Design Project is the end-of the course project, which is allocated for the last four weeks of the semesters. Students utilize programming skills to design a computer-based game following the problem solving approach. In addition to critical thinking and problem solving skills, students learn technical communication and marketing skills while working on project documentation. Instructors are responsible to ensure the timely execution of the tasks by using the gradebook to record each task and assign complete/incomplete grades. This structure of the design project allows students to realize their roles and responsibilities and the significance of deadlines in a project. The team evaluations are conducted at the end of the course and provides an opportunity for students to assess their performance. These evaluations also serve as a feedback for instructors on how to efficiently form teams in future.

**Selection of Peer Mentors**

In this section, the selection of peer mentors including the criteria, organization of sessions and communication methods are discussed. This paper explores a unique approach of utilizing peer mentors who have successfully completed the coursework through an evaluation process. The instructors of the course are capable of assessing the overall performance of the students and provides a suggestion to invite selected candidates for the possible mentor role. The pedagogical approach, expectations, intended outcomes, and other details has been described in some detail. Students who successfully completed the course and earned a grade of B or better are recruited to serve as peer mentors. Student who have outperformed on the software design project are the possible candidates as these students have demonstrated excellent engineering and technical skills. Since teamwork is a heavily weighted component of the software design project and also the overall course, students with excellent grades on software design project have worked very well on communication and people skills. Not all students with good grades are good communicators, therefore the communication skills are considered as the key factor in determining the candidates. In addition to grade requirement, there is a time requirement factored into the selection process. Students completing the coursework in the last two semesters are considered for this study. The reason for considering only the last two semesters is due to the fact that courses get revised more often to maintain rigor. Students who have covered similar material would serve as better mentors that those who have covered obsolete material. Instructors have a better understanding of student’s knowledge, skills, abilities and commitment to the process. Therefore, there is a higher possibility of recruiting strong students as peer mentors. An email invitation is sent to the qualified students to learn about their interests and motivation to become mentors and their availability. Most of the students showed interest but some are unable to participate due to class conflict and other commitments. Interested students respond back to the
email with their availability and are hired as peer mentors. The Academic Enrichment had been a long standing program at the campus that provided tutoring services for all subjects and recently it has expanded to STEM areas with enhanced support to enrich the science and engineering programs and is now called the Academic Success Program. Usually, the mentors are compensated for the mentoring work either by providing credit hours or by paying hourly wage. In our study, we chose to pay our mentors. Academic Success Program coordinators train the peer mentors on policies for the code of conduct and procedures on recording timesheet and payment. Two mentoring session options will be explored: 1) Mentors are paired with mentees depending solely on availability. Since most of the teams in the course meet once a week, this arrangement allows teams to schedule a fixed time with the mentor during the week. 2) Mentors are scheduled to conduct sessions regularly whether or not the students sign up. This arrangement allows students to show up for assistance when needed. This multi scheduling approach is efficient both in terms of serving mentees and also respecting the mentor’s time, other responsibilities and commitments. For the first option, a sign-up sheet is circulated or shared among the students interested in attending a mentoring session. The sign-up sheet is shared with the students in all the sections, mentors, instructors and the Academic Success Program coordinators. After reviewing the responses, the mentoring sessions are scheduled by mentors and mentees show up for help. In the second option, mentors are scheduled based on their availability. Since this option might not be efficient for all students due to class conflict, less number of students are expected in the scheduled sessions.

The selection of topics covered in the peer mentoring sessions depend on the weekly content covered in lecture and is directly related to the student’s ability to complete the application assignments successfully thereby assessing their performance throughout the semester. Similarly, the sessions close to the midterm exams are focused on the review of all the topics included in the exams. Mentees are invited to meet with the mentors in teams so as to help address their concerns regarding the design project.

Peer mentoring sessions are available to students from all sections. Due to the different topics covered in this class: Data Analysis in Excel, Programming in MATLAB and Software Design Project, mentoring sessions have been categorized respectively. Category 1: Assistance with Excel concepts and graphing techniques. Category 2: Assistance with MATLAB programming. Category 3: Assistance with the software design project. Due to the small class sizes at the regional campus, there is some flexibility in scheduling mentoring sessions, however, student availability pose to be a constraint. Most of the students find it difficult to attend mentoring sessions due to heavy course load in the first semester and lack of time management. This could serve as a factor to impact the performance and might require further study on course load and other academic and social constraints in the first year.
Analysis of Performance

In the literature, most of the data comes from surveys from mentors and mentees [7] collected at the end of the semester. In this study, the data obtained from the mentors and mentees is mostly the log of student attendance and the grades in each of the three components of the course. Student performance is measured based on the grades achieved on individual application assignments throughout the course. Students are evaluated in the beginning of the semester based on the first couple of assignments to determine a baseline for their performance. A threshold is then determined to identify the students needing assistance with the coursework. Students are encouraged to attend peer mentoring sessions and often paired with a mentor by the instructor. Since attendance is not required for peer mentoring sessions, students do not feel motivated to attend the sessions. As the semester progresses, the students attending these sessions are assessed regularly with each assignment to observe the performance. For Category 1, since it is the beginning of the semester, students seem to be in a relaxed mode until the assignments begin to get challenging. The data presented in Table 1 shows the percent of students participating in the mentoring sessions for three different categories. It shows that only 9.8% of students attended mentoring session for assistance with Excel based concepts. For Category 2, a new topic was covered in this section, MATLAB programming. Some students come in with some experience with programming and coding. But, majority of students come with no programming background. Understanding the lecture presentations is not difficult for students, but applying the concepts to solve problems seem to pose challenges. Although, the course material covers many examples and programming demonstrations, students find it difficult to absorb the plethora of information. When application assignments gets challenging, it begins to impact their grades. Students spend more time relating the examples to the problems in application assignments to compare rather than applying the concepts directly to solve the problems. From Table 1, about 22% of students reached out to the mentors for assistance with MATLAB programming. It is evident that there are more students for Category 2. By the time the Software Design Project begins, students become familiar with the array operations, loops, conditional statements and built-in functions in MATLAB with the help of application assignments and therefore seems to be prepared to design a computer-based game. With the help of brainstorming sessions during the lecture, teams begin to take on the challenge for the design project. Researching ideas, reading articles and journals help teams to begin programming. Team are encouraged to attend mentoring sessions but due to the substantial amount of work involved in the project, less number of students were able to attend the sessions. From Table 1, about 17% of students utilized mentoring for the Software design project.

It is observed that students begin to explore the resources such as the peer mentoring sessions available to them during the first half of the semester but wait until the first midterm. Once the grades are returned, students begin to actively participate and utilize those resources. This is obvious from the Table 1. For the Software design project, it is observed that student participation is reduced close to the end. One major factor for this distribution is the end of the semester coursework and responsibilities for all other courses. Preparation for final exams and other relevant work for other enrolled courses has an impact on the student participation in the peer mentoring sessions.
Table 1. Percent of Student Participation in Mentoring Sessions

The student performance is measured based on the overall grades in the course. Table 2 shows the final grade comparison for students attending the peer mentoring session (PMS) and students not attending the peer mentoring sessions (Non-PMS). Attending at least one session qualified the student to be in the PMS group.

Table 2. Final Grade Distribution for Peer Mentoring and Non-Peer Mentoring Sessions

The data shows that the sample size for PMS group was smaller as not all student attended the sessions. For those students attending the sessions, there was no significant difference between A and B grades although there were less C and D/F grades. This warrants more data to prove that the peer mentoring sessions improve the overall grade hence impacting the performance of the students in Fundamentals of Engineering I course.
Conclusion and Future Work

The results presented in this paper validates the results from prior studies that the peer mentoring sessions are helpful in enhancing the performance of the students in first year engineering programs. The results presented in this paper also warrants for further research to be conducted in identifying the key factors in assessing the impact of mentoring on student learning and performance. Since the only element considered in this study to assess the performance were the student grades, the author realizes that there is a need to consider other factors such as mentor and mentee surveys and assessment of mentoring sessions by the Academic Success Program coordinators. The author plans to utilize survey questions from prior studies [14] to set a baseline and build upon new questionnaire to assess the impact of the mentoring sessions. The role of the Academic Success Center is important in this study and ensures the stability of this approach since the mentors are hired through the center. Since it was a work in progress paper, the author will continue to work on this project to collect more data to show statistical significance of the approach. In future, a more sophisticated approach can be used to schedule the sessions using Google Docs that will allow students to sign up for the sessions that work best with their schedules. The instructors will also be able to communicate effectively with peer mentors with this approach.

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References


