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Analysis of Impacts on Peer Mentors in an Undergraduate Peer Mentoring and Tutoring Program

Dr. Hua Li, Texas A&M University - Kingsville

Dr. Hua Li, a Professor in Mechanical and Industrial Engineering at Texas A&M University-Kingsville, is interested in sustainable manufacturing, renewable energy, sustainability assessment, and engineering education. Dr. Li has served as P.I. and Co-P.I. in various projects funded by different federal agencies.

Prof. Kai Jin, Texas A&M University - Kingsville

Dr. Kai Jin is a Professor of Industrial Engineering and Co-PI of the MERIT project. Her research interests include Sustainable Energy, Green Manufacturing, Quality Control, and Multi Objective Decision Making and Optimization as well as Engineering Educa

Dr. Michael Preuss, Exquiri Consulting, LLC

Michael Preuss, EdD, is the Co-founder and Lead Consultant for Exquiri Consulting, LLC. His primary focus is providing assistance to grant project teams in planning and development, through research and external evaluation, and as publication support. Most of his work is completed for Minority-Serving Institutions and he publishes regarding findings on a regular basis.

Dr. Mahesh Hosur, Texas A&M University-Kingsville

Mahesh Hosur, PhD Associate Dean, Research and Graduate Affairs Mahesh Hosur received his education from India with a Bachelor of Engineering (B.E.) degree in Civil Engineering from Karnatak University (1985), Master of Technology (M. Tech.) degree in A

Dr. Afzel Noore, Texas A&M University - Kingsville

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Abstract

While engineering majors' low retention and graduation rates are still national problems in the U.S., peer mentoring and tutoring have proven to be one of the effective ways to engage students and improve retention and graduation rates. Engineering students enter college with certain expectations about engineering that hardly materialize in traditional curricula where students face gateway courses such as calculus, physics, and chemistry that are taught outside of engineering. An engaging peer mentoring and tutoring program for gateway courses in engineering education can help bridge this gap. Over the last four years at Texas A&M University-Kingsville, a collaborative approach has been used to create a strong connection and collaboration between faculty from the Colleges of Arts & Sciences and Engineering to facilitate an undergraduate peer mentoring and tutoring program intended to aid students in engineering gateway courses. While most literature focuses on the impacts on student mentees in peer mentoring and tutoring programs, the authors investigated the impacts on student peer mentors in an undergraduate peer mentoring and tutoring program. This paper analyzes the survey responses collected in the last four years from more than 30 peer mentors. Survey questions cover those peer mentors' perspectives on the training they received regarding mentoring and tutoring skills, impacts on the mentees, and impacts on themselves. Different questions were asked under each area with a total of 23 questions in the survey. The results show that peer mentoring and tutoring activities have positive impacts on the student mentors in various domains.

Project Background

The retention and graduation rates of STEM majors are national problems [1], [2], [3]. The College of Engineering (CoE) at Texas A&M University-Kingsville (TAMUK) has seen a decrease in enrollment of undergraduate students and retention rate of the first-time-in-college degree-seeking engineering students in the last several years. The students in the CoE come from different backgrounds with the majority of Hispanic students having different needs and different levels of preparedness for college, based on their high school education and the resources available to the rural schools from which many TAMUK students come. Many students are first-generation students from families at or below the federal poverty level, and they contemplate supporting themselves by working through college. These students view their educational experience in the context of their background and perspectives that make their transition to 4-year college challenging and complex. Often, they are not confident about their choice of an engineering major due to a need to set new academic expectations while completing social and psychological transitions made necessary by cultural barriers related to their perceptions, family background, and life experiences. Overcoming these challenges requires a coordinated and concerted effort of proactive student success support services offered by the institution, college, mentors, advisors, and faculty.

As part of the efforts to increase enrollment, retention, and student performance at the CoE, a peer mentoring program has been implemented with support from an NSF grant, which is designed to infuse STEM gateway courses with engineering concepts and assist students' transition from freshman/sophomore to upper level. The peer mentoring was completed in

parallel with introduction of engineering-relevant, hands-on projects in the gateway course curriculum. The peer mentors were available for all elements of course curricula including the hands-on activities. Literature indicates that design and hands-on activities and entrepreneurial thinking can increase students' interests in engineering fields [4], [5], [6] and peer mentors aid in positive academic outcomes and retention in engineering [10], [11]. While most literature focuses on the impacts on student mentees in peer mentoring and tutoring programs, the authors investigated the impact on student peer mentors in the NSF project's peer mentoring program. This paper analyzes the survey responses collected in the last four years from more than 30 peer mentors in the peer mentoring program.

Project Design

Engineering students enter the CoE with certain expectations about engineering that hardly materialize in traditional curricula where students face gateway courses such as calculus, physics, and chemistry that are taught outside of engineering. Peer mentoring and tutoring are effective for the development of skill sets for struggling STEM students [7], including engineering students [10], [11]. Thus, an engaging peer mentoring and tutoring program for gateway courses in engineering education has potential to be advantageous. Hands-on activities bring abstract concepts to life and are a common practice in engineering education [4], [5], [6]. To facilitate tutoring and hands-on learning in gateway courses, a collaborative approach to gateway courses was enacted between faculty from the Colleges of Arts & Sciences and Engineering at Texas A&M University-Kingsville. The intention was to create strong connections and collaborative activity around the use of hands-on learning and peer mentoring in the courses. The enhanced mentoring program was enacted in the gateway courses in the first two years of engineering curriculum that is taught outside of the engineering college by Arts & Sciences faculty. Faculty members from Engineering and Arts & Sciences worked together to create customized hands-on learning modules involving engineering concepts for selected gateway courses. Junior and senior students were recruited to mentor and tutor students in the courses. Both engineering faculty and gateway course instructors trained the peer mentors on how to use the enhanced course modules to mentor and tutor the students. The customized and enhanced learning modules use different engineering concepts/examples to explain a number of difficult constructs identified in the gateway courses. The combination of the mentoring program and hands-on activities were intended to increase students' understanding, awareness and interest in engineering, help them to prepare for engineering courses at the junior and senior levels, and eventually increase the likelihood of their retention and graduation. In the last four years, different STEM gateway courses were targeted in the enhanced mentoring program as shown in Table 1.

Each course had 1 to 5 peer mentors depending on the enrollment. The peer mentors were introduced to the enhanced learning modules developed through collaboration between course instructors and engineering faculty at the beginning of each semester. Peer mentors normally met with the course instructors on a weekly basis to discuss the progress of the peer mentoring and tutoring. Additional mentoring and tutoring materials were sometimes given to peer mentors depending on students' needs. Peer mentors provided mentoring and tutoring services to students outside class time using the enhanced learning modules and additional materials provided by the instructors. Some peer mentors sat in the class with the students if their schedules allowed. At the

end of each semester, peer mentors were interviewed by an external evaluator and asked to complete surveys.

Table 1: Targeted STEM gateway courses in the enhanced mentoring program

Semester	STEM Gateway Courses
Fall 2021	University Physics I & II, General Inorganic Chemistry I, College Algebra, Calculus II
Spring 2022	University Physics I & II, General Inorganic Chemistry I & II, General Introduction to Chemistry, College Algebra, Trigonometry, Calculus II
Fall 2022	University Physics I, General Inorganic Chemistry I, College Algebra, Calculus II
Spring 2023	General Inorganic Chemistry I, College Algebra, Trigonometry
Fall 2023	University Physics I, General Inorganic Chemistry I, College Algebra
Spring 2024	University Physics I, General Inorganic Chemistry I, College Algebra
Fall 2024	University Physics I, General Inorganic Chemistry I, College Algebra, Calculus I

Project Results

The authors analyzed results from interviews and surveys completed by over 30 peer mentors in the last four years. Outcomes from the surveys completed are presented in Table 2. A total of 32 usable submissions were received across four years. This includes limited duplication in headcount as some peer mentors persisted for two years and several of those submitted survey responses both years they were active in the program. The repeated submissions were allowed as each party had an additional year of experience upon which to draw when completing their second survey and making the requested assessments. The students who served as peer mentors were asked to respond to three categories of questions. First, they were asked about their experience as peer mentors then about the impact they felt the peer mentoring had on mentees, and finally about the impacts serving as peer mentors had on them.

The survey results indicate peer mentors felt that they had been adequately coordinated, supported, and compensated as well as having access to the class faculty and engaging in appropriate levels of interaction with them. This confirms the pattern described above was generally adequate to the needs of the students working as peer mentors. Yet, about one-fifth of the peer mentors felt that too little time had been spent training them while over half felt too little time was spent in direct interaction with students. In fact, one informant stated in a follow-on query that s/he had received no training. As is the case in most programming with a broad implementation footprint, there would have been individual variation in the general approach taken. There also would have been a range of preferences for level and types of support or interaction among the students recruited to be peer mentors. These circumstances appear to be reflected in the survey results including one party noting not being trained which could be based on having a different understanding of what training should involve for someone in his/her position or that something interfered with his/her opportunity to be trained. Interest in additional time interacting with students, as the informants also noted, was impacted by the need to operate exclusively online due to COVID-19 in the first two years but that perception persisted to a more limited extent following the pandemic. It is likely that some mentors encountered students who required more assistance

than many of their peers or that the mentor himself/herself was more oriented toward interactive and individualized patterns of instruction.

The peer mentors felt that their work had impacted the students in classes although there was a range of responses as indicated by the breadth of some of the standard deviations (up to a value of 2.69 on a ten-point scale). The variance may be a product of different professors teaching sections of the courses as each faculty member has idiosyncratic patterns or other factors like the student population in the course. Yet, the majority opinion was that peer mentoring impacted student relationships, confidence, understanding, sense of belonging, academic success, interest in continuing to study engineering, and plans for the future. The academic outcome information for the courses supported the peer mentors' opinion for two of the gateway courses as grade distribution patterns improved (i.e., more As, Bs, and Cs and fewer Ds, Fs, and withdrawals).

Table 2: Combined Peer Mentor Survey Responses from 2020-2021 through 2023-2024

Query	*n*	Too Little	About Right	Too Much
Please rate each of the following items using the three-point scale.				
1. Training received to be a peer mentor.	32	6	26	-
2. Coordination of the peer mentors by the supervising faculty.	32	2	30	-
3. Interaction with faculty teaching the course.	32	-	31	1
4. Interaction with students in the course.	31	17	13	1
5. Support received when you asked questions, sought assistance, faced a problem.	31	-	30	1
6. Your level of compensation.	32	1	30	1
Please rate the level of impact you believe you had on the students mentored/tutored in the areas listed.				
Query	*n*	Mean	Mode	Stan. Dev.
1. Developing relationships with other students.	30	7.03	8	2.43
2. Confidence in their ability.	31	8.00	8	1.68
3. Improved understanding of concepts.	29	8.50	10	1.54
4. Sense of acceptance/belonging at TAMUK.	30	7.87	10	2.59
5. Academic success (e.g., test grades, passing classes).	31	8.48	10	1.50
6. Interest in continuing to study engineering.	31	7.90	10	2.38
7. Reformulation/revision of their plans for their future.	31	7.26	10	2.69
Please rate the level of impact mentoring/tutoring had on you in each area listed.				
1. Developing relationships with other students.	32	7.34	10	2.64
2. Confidence in your ability.	31	8.58	10	1.24
3. Improved understanding of concepts.	31	8.39	10	1.50
4. Sense of acceptance/belonging at TAMUK.	30	7.93	10	2.21
5. Academic success (e.g., test grades, passing classes).	31	8.00	10	2.34
6. Interest in continuing to study engineering.	30	7.90	10	2.47
7. Recognition of skills possessed.	30	8.60	10	1.33
8. Reinforcing past learning.	27	8.63	10	1.52
9. Developing new skills.	29	8.54	10	1.92
10. Reformulate/revise plans for your future.	30	7.93	10	2.28

The information above is reported as context for the learning experienced by the peer mentors and to demonstrate an additional form of practice or learning they were provided. The self-reflection and assessment required to respond to these queries was an opportunity to refine or advance thinking regarding patterns of training and instruction, the needs of learners, appropriate levels and patterns of commitment in those processes, and potential outcomes from mentoring. That process had the potential to foment additional growth [8] [9] and confirmation of convictions

or perspectives on the part of the peer mentors even though it could also have been completed in a perfunctory pattern. The variation in survey responses and the patterns present in the interview responses (Table 3) indicate that the students did engage in and achieve growth or reinforcement of values and perspectives in the process- and self-assessment required to act as a peer mentor and the subsequent evaluation process related to their activity.

Providing academic assistance to others can involve relationship building and result in deeper learning on the part of the tutor. Ten queries were included about the personal impact of operating as a peer mentor. The responses were all positive. The results could be used in recruiting materials for the position as the peer mentors felt, even in an entirely online setting, they had developed relationships, increased their confidence, improved their understanding of course topics, reinforced past learning, increased their sense of belonging at Texas A&M University Kingsville, had greater academic success, recognized skills they already possessed and developed new skills, increased their interest in studying engineering, and were provided material relevant to reformulation of their plans for the future. A similar result was found in the interviews. When offered an opportunity to comment on the mentoring program, all the interviewees stated that their experience had been very positive and each indicated an interest in continuing as a peer mentor in the coming year.

The peer mentors recruited to work with students were themselves active students at Texas A&M University-Kingsville. Through the spring of 2024, there was a total of 41 students filling this role. As active students and participants in the project, albeit as advanced students providing mentoring, their outcomes and progress were tracked. The items tracked were retention at the institution, graduation, advancement to graduate study, retention in graduate study, completion of a graduate degree, and initiation of a PhD program. Graduate students were also interested in the opportunity and several of the undergraduate peer mentors completed baccalaureate study and enrolled as graduate students while simultaneously continuing as peer mentors. This represents an expansion of originally expected process which envisioned juniors and seniors as peer mentors. Information summarizing outcomes and milestones for the peer mentors are listed below.

- There were 33 peer mentors who began as undergraduates. The other eight began engagement as graduate students.
- Out of the 33 undergraduate mentors, 32 were retained, and all eight of the graduate students acting as peer mentors were retained.
- There were 27 of the undergraduates acting as peer mentors who have completed baccalaureate degrees, 81.8% out of 33 undergraduate peer mentors, with all but one of the others persisting in the study.
- Of the eight students who began involvement as peer mentors when graduate students, all have been retained in studying at TAMUK, and six have completed degrees (75%).
- Seven of the undergraduates acting as peer mentors initiated graduate degree study at TAMUK. All seven have persisted with four achieving MS degrees to date.
- One student started as an undergraduate acting as a peer mentor, graduated, enrolled in a graduate program, completed a master's degree, and has enrolled in a PhD program at Texas A&M University-Kingsville.

These outcomes are exemplary as they represent substantially greater persistence and on-time graduation rates than for peers within the CoE at TAMUK. In Fall 2024, the full-time first-time-in-college who graduate within four years at CoE is around 22%, while the full-time first-time-in-college who graduate within six years at CoE is around 42%. In addition, the retention

rate of full-time first-time undergraduate after one academic year at CoE in Fall 2024 is around 64%. Table 3 contains a summary of comments made by peer mentor in interviews related to the impact of the enhanced mentoring program on them and the mentored students.

Table 3: Peer mentor interview comments regarding impacts of the enhanced mentoring program.

Topic	Comments
Responsibility with the project.	Informants were able to describe in detail specific and project relevant sets of responsibility including the sequence and scope of activity completed in each area. That indicates, at a minimum, understanding of and more than casual engagement with the process.
Time allotted adequate to tasks?	All informants felt the time that had been allotted for completion of their responsibilities was adequate. Several noted that processes were fast paced but that their peers and the faculty working on the project were responsive and supportive.
Contributions toward easing transition anxiety for new community college transfers.	Peer mentors reported personal contact, relationship building, guidance regarding actions to take, and referrals to on campus service centers as means by which they helped with transition anxiety.
Impacts on mentees.	Peer mentors noted that the students had been exposed to communication, teamwork, problem-solving, and time management challenges as in-class project team members. The peer mentors felt the students who had been part of the robotics implementation had experienced learning regarding team processes and had begun to develop social networks that would prove beneficial to them as they continued to pursue a degree at TAMUK. They reported increased confidence in pursuing an engineering degree among mentees and, as a related construct, increases in sense of belonging in the engineering field.
Impacts on mentors.	Peer mentors noted having expanded their personal networks to include students from the course in which they assisted and that continuing to offer these students encouragement and assistance in informal ways was a means of easing their transfer into engineering study. They also felt personal advancement in confidence and belonging. Their confidence increased because they were able to lead teams, implement processes they had been taught, provide guidance to others, trouble shoot, and develop programming in collaboration with a professor. This, in turn, confirmed for them that they were pursuing the right degree path and, for one, helped refine career goals within the field of engineering. The peer mentors felt they had experienced personal growth in relating to supervising faculty, expanded their repertoire of social skills (e.g., team leadership, team trouble shooting), and had taken on an informal and continuing role as a sounding board for and guide to some of the students from the course in which the robotics project was implemented. They improved their understanding of course topics, reinforced past learning, increased their sense of belonging at TAMUK, increased their levels of academic success, recognized skills they already possessed and developed new skills, increased their interest in studying engineering, and were provided material relevant to reformulation of their plans for the future.
Choose to participate again?	All the peer mentors indicated they would elect to be peer mentors again given their experience with the NSF project.

Continuous Improvements and Lessons Learned

During the interview, peer mentors responded to a question asking what might have improved the likelihood of success as a peer mentor. Respondents indicated that listening to the course lectures, being added to the Blackboard site for the course, receiving examples of the level of detail faculty wish to have submitted in student responses and proofs, scheduling bi-weekly review sessions so students see the tutoring as part of course offerings, and returning to face-to-face interaction (the last during the COVID pandemic) were means of improving the likelihood that they would be successful mentors for their peers. These comments also provided some insights into why some of the mentors felt additional training was needed.

Peer mentors were also asked whether they had experienced technical or logistic challenges related to their duties. Informants noted a limited number of difficulties had occurred when starting mentoring activity in classes taught by faculty they had not worked with in the past and, most notably, in completing a rapid transition to online mentoring when COVID pandemic restrictions on in-person instruction were imposed. They also stated that these were overcome through communication with the faculty, assistance from the project team, and various forms of personal initiative and ingenuity.

The material described above was produced as part of the external evaluation of the NSF-funded undertaking. Reflecting on it and their experience, the authors suggest the following actions in addition to those above. These practical measures could increase the impact of the peer mentoring program on peer mentors and the students they serve.

- Finalize the selection of peer mentors before the semester starts so the peer mentors can be introduced to the students on the first day of class. This could improve initial connection between peer mentors and mentees.
- Peer mentoring training should be offered at the beginning of the semester focusing on establishing connection with mentees. Bi-weekly meetings should be scheduled with peer mentors to answer any questions from them. Additional training should be offered in the middle of each class focusing on retaining mentees. A final reflection meeting at the end of each semester would be helpful for peer mentors to reflect on what they learned through peer mentoring processes. The questions asked of the peer mentors that resulted in the content of this article can serve as an example of possible topics to address.
- Course instructors should encourage students to meet with peer mentors and take advantage of peer mentoring. The positional authority of the instructor has the potential to influence student participation, can reduce pressure on peer mentors to advertise their services, and would likely improve attendance of students during the mentoring and tutoring sessions.

Conclusions

There are different factors identified as the challenges that preclude the success of Latinx STEM students, including lack of a culture of support, lack of educational resources, academic deficiencies, poor sense of belonging, and lack of STEM information to enter STEM fields. An enhanced peer mentoring and tutoring program that recruited peer mentors with similar cultural backgrounds as the mentees, both groups mainly Hispanics, demonstrated significant impacts on both mentors and mentees. Introducing engineering applications into the mentoring and tutoring

materials of the gateway courses helped improve grade distributions and increase the retention rate of engineering students in their first two years in their engineering majors. In that process, significant personal learning, skill development or reinforcement, and perspective altering experiences were achieved for the peer mentors. The potential for upperclassmen and graduate students to benefit in these ways from acting as peer mentors should be included in plans to enact mentoring programs potentially even as a part of a graduate student program.

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