

Dr. Macon: Thank you for joining us to view our session on our NSF grant funded project to deploy and examine peer learning in introductory engineering courses. Our team is at the conclusion of a fourth year extension on a three year project to assess the effectiveness of peer-led recitation in engineering courses in terms of performance, retention, and student efficacy, particularly for Hispanic female and other underrepresented student populations. We will share our project goals and findings.

Dr. Macon: Intro. Please allow me to introduce my colleagues and collaborators. Dr. Mohua Kar is Program Chair and Professor of Engineering at Valencia College, and our Principal Investigator Dr. Kimberly Luthi is our Research Analyst and Collaborator, and a Professor in Graduate studies within the College of Aeronautics at Embry-Riddle Aeronautical University. I am Dr. Lisa Macon, Program Chair and Professor Computer Science at Valencia College, and Co-PI on this project.

Dr. Macon: The session will examine one aspect of the three-year pilot study entitled, Engagement in Engineering Pathways, funded by the National Science Foundation Improving Undergraduate STEM education grant program. The presentation will offer an overview of support interventions that lead to increased academic performance outcomes related to female persistence in engineering education. The study examined the effects of problem-based activities offered through peer led strategies on undergraduate engineering students at a multi-campus, federally-designated Hispanic-serving, public institution in the southeast United States. This session will provide an overview of the findings and the culturally responsive analysis of best practices in engaging underrepresented minority students and females through the inclusion peers with shared cultural backgrounds and experiences. Through the use of peer leaders, the researchers found that PLTL in introductory engineering courses, to include statics and dynamics, increased student commitment to engineering and STEM pathways, specifically students historically underrepresented in engineering. The session will offer guidelines on best practices in the inclusion of learning modules that are adaptable across STEM disciplines in introductory courses.

The study specifically addressed conditions in which the support interventions affected the commitment of Hispanic women to engineering pathways. The courses are taught in large class sections, two sections per semester, with an instructor and one recitation leader. This structure addresses an important construct through peer learning that we found to be a significant factor in academic success and persistence in STEM education. The courses follow a face-to-face instructional model with class primarily reserved for lecture and the one-hour a week recitation lab reserved for peer-led practice of applied mathematics within real-world engineering concepts. Over the three-year period, the project has moved toward the goal of increasing student success and course pass rates. The investigate team also found the interventions provided the necessary support structures so that non-traditional students, particularly minority female students, can progress in engineering and engineering technology disciplines.

Dr. Macon: Goals, expected outcomes and key takeaways: The goal of our research and practice is to provide a better understanding of these

impacts, and promote the identity development and commitment within STEM and engineering. The expected outcome was to provide guidelines on best practices so that other STEM educators are equipped to support students, specifically non-traditional students, experiencing challenges as they progress in STEM pathways. Findings from this study are expected to advance the development of an equitable national engineering workforce that promotes the full participation of all women, specifically Hispanic women, at all levels within academia and the workforce. The key takeaways provided insight into best practices including faculty guidance on implementing peer-led team learning exercises within engineering courses that have potential to increase underrepresented students' commitment to the engineering pathways. Much attention has been focused on addressing these trends, yet little research, particularly within the area of engineering education, has addressed the tangential impact of PLTL on those faculty members who support students, but may not be professionally trained to provide such support.

Dr. Luthi: Hi. This is Kimberly Luthi. I wanted to give you a summary of our research. Our research really looked to understand if peer led team learning and engagement in problem based activities increased commitment to engineering pathways and academic success, specifically in non-traditional student groups. As peer led team learning comes to age, we realized there was a number of STEM orientated programmatic initiatives available to students such as academic tutoring, math help, peer led learning, but not necessarily within the classroom, in these types of active learning activities. So we noticed that some of the students were really struggling with applying mathematical concepts to real life scenarios. Specifically, within their introductory engineering courses. Statics, Dynamics, and Electrical Networking. So, a lot of the fundamental components of these engineering courses really were built upon for the students ability to complete the degree and we just noticed that students, especially non-traditional students in engineering being females and under represented minorities such as Hispanic students just struggled to continue on in that pathway after they faced some of these early challenges in their degree program so they were learning strategies embedded in these courses again that were available external to the course but we saw a really good opportunity to address some of these issues that affected high numbers of underrepresented students and within the engineering Program. With these unique interventions that could be done through the peer led team learning and we used a variety of mixed method qualitative and quantitative data collection, analysis to answer the research questions and help guide some of the recommendations you'll see in our presentation today.

Dr. Macon: The study utilized peer-led, team-based learning activities in recitation sessions within post-secondary, undergraduate, introductory engineering courses to examine underrepresented and female students' abilities to translate cognitive knowledge into demonstrable, performance-based proficiencies. Within the target non-traditional student populations, our investigative research revealed data showing low retention, low grades, low participation, and low self-confidence in mathematical and problem-solving abilities.

Dr. Macon: When discussing possible mitigating solutions for these issues, our team of faculty, staff, and administrators wondered if peer-led team learning activities might improve not only performance among these

populations, but also retention and self-efficacy. So, we examined the research question: Does participation in PLTL activities support underrepresented and female students' performance in introductory engineering courses and retention in engineering pathways?

Dr. Macon: Our study was based on the sample population to include 518 undergraduate students enrolled in four introductory engineering courses and the recitation lab that included the peer-led team learning support. We evaluated student proficiencies such as their problem-solving, analysis, synthesis, and reasoning skills in the contexts of engineering education performance-based activities. Data was collected on participants enrolled in statics courses in year one, statics and dynamics courses in year two, and statics, dynamics, engineering networks, and principles of electrical engineering courses in year three of the grant. The courses followed a face-to-face format with class primarily reserved for lecture and practice within a one-hour per week recitation lab with peer-led learning. Out of class work consisted of active learning activities as well as academic learning support tools such as online quizzes based on the textbook and lecture notes, and real-life, project-based engineering scenarios for longer-term team assignments.

Dr. Macon: Peer leaders and faculty involved in the project engaged in trainings on how the peer-led team learning activities supported learning and education in science and helps students build a solid engineering foundation. We also encouraged peer leaders to help others develop a curiosity for STEM and engineering through peer engagement.

Dr. Macon: Faculty members teaching the courses completed an Active Teaching in Engineering Workshop to learn how to effectively leverage the peer leaders and develop a deeper comprehension and familiarity with specific active-based instructional strategies used within the peer-led activities such as 3-minute review, mnemonics and analogies, and round-robin brainstorming activities (Blaz, 2018). The activities required students to practice collaborative work with others to solve a problem and work towards a common goal to mirror problems faced in the industry (Bransford, 2007).

Dr. Luthi: The majority of the students participating in the study identified with a group underrepresented in STEM and engineering, specifically Hispanic student groups. The study included 518 participants enrolled in four introductory engineering courses over the three years. Female student participants represented 20.8% (108/518) of the overall student headcount enrolled at the beginning of the courses. We will discuss in the next slides the demographics of the participants as well as the breakdown of the demographics of the experimental group and control group for each course.

Dr. Luthi: Data was collected from three surveys conducted each term: a pre- and post-survey of students in the courses and a mid-term survey. The initial survey was administered at the beginning of the academic term and prior to their final exam. All students in the courses were invited to complete a post-survey to determine any changes in their career and educational goals, inquire about student's experiences and level of

engagement in the course, and their perception of the faculty and peer support during the semester. The survey questions were guided by the study's theoretical framework (Brandura, 2012) and used to determine a student's commitment to engineering pathways and levels of self-efficacy. The measurement tool used was a modified version of theory-based scale developed by Klobas, et. Al., (2007) to measure self-efficacy for learning among university students. The instruments had a validity and reliability ratings of 0.80 and higher.

The survey included a Likert-like scale to include assessment measures for motivation and commitment to engineering pathways as well as demographic information collection. Several demographic and background data points were collected through the instrument to compare the effect of the use of PLTL among different sub-groups. These demographics and background data points included, gender, age, race, grade level, major, and current GPA. The researchers also held focus group and administered an experiences questionnaire to a smaller sub-set of students. The structured the focus group questions and experiences questionnaire were developed from the focus questions employed by Talley and Ortiz (2017). The questionnaire contained the "self-efficacy for learning and performance" and subscales within the validated MSI (Barbuto and Scholl, 1998). The additional statements related to the subscale of the MSI to include intrinsic process and external self-concept as well as a student's explanation of their interest development in STEM (Talley & Ortiz, 2017).

We also used Grades. The researchers used grades and pass rates as part of the quantitative performance indicators. The student pass rate was 62.74% (325 of the 518 students that passed the courses). The female student pass rate was 58.49% (62/106) compared to the male students' pass rate 63.83% (263/ 412). The slides to come will show you the breakdown of the academic performance of the students.

Dr. Macon: By examining the table, you can see that over the course of the experiment, there were varying results. However, for 3 of the four experimental classes, a positive difference in academic performance was observed, with the largest improvement in passing rate observed in our Introduction to Electrical Engineering course.

Dr. Macon: The researchers noted an overall increase in pass rates with the experimental group. Although the study included institutional measures on students engaged in all four courses across the three-year grant period, the researchers found the findings from the statics course of particular interest due to the content of material covered and the higher percentage of students (73%) enrolled in the statics courses out of the three courses incorporated in the study.

The highest pass rates in the statics courses were seen in the Hispanic male students in the experimental group at 79.61% followed by Hispanic female students at 73.58%. The next highest pass rates for the statics course were seen in the Caucasian male experimental group. Although the overall grade distribution pass rate was lower for the experimental group in the dynamics course, female Hispanic students had the second highest pass rate of those who participated in the PLTL activities. Additionally, female Hispanic students had the highest pass rates in both Electrical Engineering and Electrical Networks courses.

Dr. Macon: One of the project goals was to increase commitment to engineering pathways. As previously, discussed, a student's academic major was used to track a student's commitment to engineering pathways

after participating in the PLTL activities. The researchers reviewed the major of students enrolled in the statics courses recitation labs within three years of taking the course. The researchers were not able to obtain institutional transfer data on all participants in the experimental group, however, the following data was collected on the students whose information was reported to the National Student Clearinghouse. 88% (208 of the 264) of the students in the experimental group who enrolled in and successfully passed the statics course remained in an engineering pathway at the institution and/or declared an engineering upon transfer to a four-year institution and 10% (23 out of 264) left engineering but remained in a STEM-pathway. 84% (71 of 85) of the students that took dynamics stayed in engineering and 12% (10 of 85) left engineering but remained in a STEM-pathway. 100% (18 of 18) of the students that took electrical networks remained in engineering. The totals represent the student headcount and not the registrations per course since some students enrolled in each sequential course and not all students enrolled in statics due to prior credit.

Dr. Luthi: The majority of students participating in the study identified with a group under represented in STEM engineering specifically Hispanic student groups. The study included 518 participants enrolled in floor introductory engineering courses over the three years. Female student participants represented 20.8% 108 of the 518 of the overall student headcount at the beginning of each course. We will discuss in next slides the demographics, of the participants, as well as the breakdown the demographics within the experimental group and control group for each course.

Dr. Luthi: As a result of participation in the activities, 86% of the students felt that their analytical and critical thinking skills had improved by a great or moderate extent. In addition to the pre- and post- survey, students were provided a mid-term survey that measured students' opinions on the extent to which the activities helped improve class performance. As we stated 80% of the students surveyed, agreed that the activities helped improve their class performance. As we stated, 80% of the students surveyed agree the activities to help improve their class performance. Additional information was collected on the average student responses so, for example, how do you feel. Do you feel comfortable and applying mathematical and physical concepts to the real world problems? So female students average responses was higher indicating that female students were more comfortable or comfortable and applying mathematical and physical concepts to real world problems compared to their male counterparts on the post survey responses.

Dr. Luthi: In October 2019, seven students who participated in the study completed an experiences questionnaire. The responses were compared to those of four students in STEM disciplines who did not participate in the peer lead team learning activities. This questionnaire allowed students to report current experiences and experiences they wished to have more of in the engineering program as well as STEM programs in general. Although the sample size that completed the questionnaire is small, the results due offer a reflection of participants' experiences. Students were

directed to "Tell us more about your experiences... as a student in STEM fields. So they marked the boxes letting us know if they had experiences had certain experiences and also how important the experience was to them, and if they would like more experiences like that. The results offered insight into the experiences that are most important to the students and that were most frequently reported. Students described the experiences they wished to have more with in the engineering program at the institution. The seven students often reported experiencing related to the goals of the grant, as compared to the four students who did not participate in the peer lead team learning. So the items related to STEM pedagogy, students more often reported experiencing them as compared to those that did not have the peer lead team learning.

So The five most often reported experiences were: feel comfortable using the tools needed for studies; staff / faculty members making connections-course content and real world and community; they had access to the tools needed for studies; and they learned steps necessary for safety in the class or in labs; and they learned ways to make a difference through a career in STEM. Almost all of these items showed a positive increase in the students who participated in the peer lead team learning activities compared to the four students who had not participated team lead team learning activities. Items "real-world connections" and "making difference through STEM" showed a notable increase, which may reflect changes made to instruction. The students involved in the peer lead team learning activities noted that they wished there were more: peer mentors or other students to meet with regularly to discuss my plans and offer feedback and they also requested workshops or other activities that teach strategies and provide resources to strengthen STEM skills. The most notable difference the majority of students reported experiences in having access to the staff and faculty members that made connections between the course content and real word experience. This allowed them to be more creative in the classroom have opportunities to talk about their own work in STEM and engineering and opportunities to reflect on a problem and discuss the problem with a partner, using this active based learning strategies, for example, think pair share.

Dr. Luthi: So in conclusion, as a result of participation, the peer led team learning exercises 80% of students were comfortable applying mathematical and physical concepts to real world problems. And 96% of the students felt that their analytical in their critical thinking skills had improved.

These were notable results in seeing that students felt more comfortable and applying their mathematical and their physical concepts to real world problems, and we should saw higher averages in female students who responded to the survey.

So this increased level self efficacy, academic success, and commitment to engineering can be contributed to their experiences in participating in these peer led team learning exercises.

And this included they learn ways to make a difference, through a career in STEM, learn steps necessary to be safe in the classroom, and contribute to the classroom and also work in pairs and small groups to form ideas.

So these peer led team learning exercises have now demonstrated success as strategies that can be used in these introductory engineering courses.

And the peer leaders provided also professional development, to incorporate active learning strategies into the labs but also into their own professional development we're working with other students. These active learning strategies that can be shared and used in small collaborative groups and offer opportunities for students to ask questions and demonstrate their problem solving skills. The peer leaders also incorporated active learning strategies to increase their students confidence and decrease the nervousness and anxiety around these introductory classes. So as researchers, we found that the strategies introduced through these peers, such as decreasing nervousness increasing confidence. And hosting Problem Solving practicing sessions with other students improved their performance on all the content based exams, as well as their overall course grade and commitment to engineering pathways. These PLTL experiences have demonstrated success and our strategies that other instructors can use in introductory engineering courses.

Dr. Macon: These PLTL experiences have demonstrated success and are strategies that other instructors can use in introductory engineering courses. The peer leaders were provided with professional development to incorporate active learning strategies into the recitation labs. These active learning strategies included small collaborative groups, inquiry and asking questions, and demonstration of problem-solving strategies. Furthermore, the peer leaders incorporated active learning strategies to increase students' confidence and decrease their nervousness or anxiety. The researchers found that the strategies introduced through the peers such as decreasing nervousness, increasing confidence, and hosting problem-solving practice sessions improved students' performance on content-based exams as well as overall course grade. Again, to wrap up, this study was designed to address barriers to underrepresented minority students' persistence and retention in engineering. The researchers noted that based on findings in the literature female and underrepresented students are more likely to persist if they have higher levels of self-efficacy for learning and a network of peers and faculty as role models that they can identify with in engineering disciplines. We found this to be true in the evidence we presented today.

Dr. Luthi: Alright that sums it up. Thank you for joining us for today's session. Please feel free to email us with any follow-up questions or if you have an interest in future research collaboration.