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Equity in Engineering Education: The Experiences of Non-Traditional Students in Introductory Engineering Courses with Peer Learning Support

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Introduction

This paper seeks to examine one aspect of the pilot research study entitled, "Engagement in Engineering Pathways: An Initiative to Retain Non-Traditional Students in Engineering" funded by the National Science Foundation Improving Undergraduate STEM Education grant program (Award No. 1712008). This three-year study examines the effect of the use of Peer-Led Team Learning (PLTL) on students' academic performance, STEM experiences, and persistence in engineering programs [2]. The data collected is from May 2018- May 2020. The present study population is undergraduate engineering students at a multi-campus, federally designated Hispanic-serving, public, two-year college in the southeastern U.S. This paper will specifically address the effects of the PLTL on the student's STEM experiences.

Methods

Data were collected from focus groups and roundtable discussions held in May 2019 and October 2019. The responses were compared to those who did not participate in the PLTL activities. Along with the focus groups conducted in May 2019, quantitative data was collected from students who completed the STEM experiences questionnaire and pre-and post-survey data. The study included participants enrolled in four face-to-face introductory engineering courses required by engineering majors- statics, dynamics, engineering networks, and principles of electrical engineering courses. The courses followed a face-to-face format with class primarily reserved for lecture and practice within a one-hour per week recitation session with peer-led learning. The PLTL provides a systematic process to increase group engagement through personalized team learning strategies embedded in the introductory engineering courses [1]. These practices offered an opportunity to reach a diverse population of engineering students, particularly underrepresented and female students, from a variety of majors within an engineering context. This context situates the statics and dynamics engineering courses in a unique position for educational interventions to potentially affect higher numbers of underrepresented students than in any other domain within engineering education due to the high attrition rates of students who struggle with the applied math required in the courses.

Results

The majority of the students participating in the study identified with a group underrepresented in STEM and engineering. The overall project included 518 participants enrolled in the engineering courses over the three year.

Table 1 displays the demographics of the 518 participants in the study.

Table 1
Demographics of participants in the 3 Years Pilot Study

Demographics	%
Hispanic	41.31%
Caucasian	26.06%
Asian	7.14%
African American	9.85%
Others	15.64%

Female student participants represented 20.8% (108/518) of the overall student headcount. The majority of individuals in the four courses identified as Hispanic, a group significantly underrepresented in engineering.

Quantitative survey data were collected from students and analyzed to determine average responses and to see whether there was any statistical significance between pre- and post-survey responses from students enrolled in the courses with PLTL sessions from May 2018-2020. Qualitative data were collected through focus group activities with the students who participated in PLTL sessions.

May 2019 Focus Group

During the May 2019 focus group, a diverse group of female students were asked to provide feedback on 16 questions that offered insights on the type of support they wished for. The student's perspectives showed that PLTL support had opportunities to further support and advance female students in engineering pathways. Four students participated in the focus group. To themes emerged from the question, "Do you know other women at Valencia who were pursuing an Engineering degree but then stopped?" The themes of challenges that impacted female students' abilities to persist were feelings of marginalization, intimidation and the need for more time to finish.

During the response to the question about knowing other women at Valencia who pursued engineering degrees then stopped, one student mentioned that she did not feel that her voice was heard amongst the large groups of men in the program. The other three female students did not agree fully about their voices being heard and two felt intimidated while in their classes. One student mentioned that she was not intimidated by the fact that there were more male students in the classroom, but she was worried about that (feelings of intimidation) once entering the workforce. Students in the focus group also discussed the length of time it takes to finish their degree and how the delayed graduation can also be detrimental to situations like family planning

and impact school and work-life balance. It was mentioned the additional time created fatigue as they understood they needed to obtain additional work experiences outside of the classroom to give them access to full-time employment in the engineering fields after graduation such as internships or research opportunities.

Students also responded to the question "*Do you think there are barriers to women with careers in engineering*?" with response options of agree, disagree, or neutral, one student said 'disagree', two remained 'neutral' and one 'agreed'. One student mentioned that "*Females will always have to prove themselves*." Another student said that "*Society is conditioned to look at some jobs as more fitting for females than others*." The student also stated that "*Engineering is seen as male work*."

When asked, "*What else could we do to help you to succeed in your courses*?" the primary theme 'provide support' emerged. Students indicated two categories of support. The students said types of "*activities more geared towards promoting women in the field*" would help them succeed in their courses. They also said, "*Greater engagement opportunities like women speakers*", were needed for them to succeed in their courses.

Students also discussed support related to academic learning such as tutoring, specifically in engineering. When asked, "*What else could we do to help you to transfer or continue moving towards your career as an engineer*? Students indicated 'more information' and 'access to engagement opportunities' as two strategies the institution could offer to support their career goals in engineering. A student said, "*Information on what it means to be a female student at a 4-year school*" can be offered to assist them with the transfer process from a two-year engineering program to a bachelor's program or into the workplace as an engineer. Another student said, "*Support outside of the classroom would be key to success*" in engineering.

Students were also asked, "*What would you tell a new faculty member…in order to help students, women, succeed in STEM classes*?" This was an important question in addition to the psychological questions about motivation and questions about general support strategies that would facilitate continued success in engineering. Two themes emerged from the questions about information to tell a new faculty member that included their 'pedagogical style' and 'increased access to faculty outside the classroom'. A student said, "*The pedagogical style should allow ample time for students to work through problems before moving on*." Another student said faculty should, "*Answer questions posed and not pass it off on tutors to answer*." Another student suggested, "*Adjust pedagogy to take all learning styles into consideration before just writing on the board*."

Students also discussed their opinions on faculty making themselves accessible outside the classroom. One student said they, "*don't feel there are enough opportunities to turn what they are learning in the classroom into practice.*" The student recommended that faculty can increase student success by, "*providing more opportunities for tutoring both outside the classroom and online*." In addition to providing access to online learning support, particularly for commuter students, one student stated that it was helpful for faculty to "*provide practice tests ... opportunities for group reviews*.

October 2019 Experiences Questionnaire

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 PLTL 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 offer a reflection of participants' experiences. The questionnaire was built from Talley and Ortiz's [3] research on the constructs of interest and motivation that are associated with the persistence of female students who are undergraduates in STEM fields. Questions of the focus group were developed to explore both internal processes for motivation in STEM and external sources of motivation such as institutional systems of support, family, or peer support. The questions also explored the development of interest in STEM fields.

Students were directed to "Tell us more about your experiences… as a student in STEM fields. Please mark the boxes, letting us know which you have experienced and also how important each is to you – and let us know if you think we should provide more experiences like this." 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 of in the engineering program at the institution. Items about pedagogy are noted and focused on the kinds of teaching practices intended in the grant proposal as compared to the experiences that students are reporting on the questionnaire.

Findings show that most students have experienced faculty members making connections between course content and the real world. Most students perceive that they have experienced learning ways to make a difference through a career in STEM and have time to network and make connections with each other. What students wished they had more of was an introduction to people working in STEM fields.

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 (i.e. community) tools needed for studying, feeling comfortable using the necessary tools for studying, and learning steps necessary for safety in the class or in labs. Most students indicated using hands-on equipment and technology in STEM and have worked in pairs or small groups to discuss information and ideas. Students wished they had activities that encourage 'risk-taking' or that allow them to be more creative; opportunities to talk about their own STEM work; and opportunities to reflect on a problem and discuss the problem with a partner using the active-based learning strategy think-pair-share. Students who completed the participation experiences questionnaire also reported 1) they learned ways to make a difference through a career in STEM; 2) learned steps necessary for safety in the class; 3) worked in pairs or small groups to discuss information or ideas; and 4) discussed case studies in order to understand ideas or events.

One of the major goals of the project was to increase engagement and support for female and underrepresented minority students who do not have a network of peers and faculty as role

models that they can identify within engineering disciplines. The data collection offers a description of students sharing their interest in a future engineering career and the need to stay connected to a support network and individuals in the industry to help them succeed. To solve some of these known experiences of students, the E-PATH project provided interventional methods of support through collaborative learning with upper division peer leaders who could serve as role models.

Findings

The female students who participated in the May 2019 focus groups shared their perceptions of feeling intimidated, primarily from being in courses with significantly more men than females. They also offered numerous strategies that could support them towards success through the engineering pathway. These strategies included inviting female engineers to present and improving faculty interactions inside and outside the classroom.

In the October 2019 focus groups of female students, the students responded to the experiences questions on whether they had a certain experience if the experience was important, and whether they wished they had more of the experience. In sum, more students often reported experiencing items related to the goals of the grant, as compared to the students who did not participate in the PLTL activities. Of the items related to STEM pedagogy, students more often reported experiencing them as compared to students that did not participate in the activities. The five most often reported experiences were: (a) feel comfortable using the tools needed for studies; (b) staff/faculty members making connections-course content and real-world (i.e. community); (c) access to the tools needed for studies; (d) learned steps necessary for safety in the class or in labs; (e) 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 PLTL activities compared to the students who did not participate in the study. Items (b) "real-world connections" and (e) "making difference through STEM" showed a notable increase, which may reflect changes made to instruction. Also, the students involved in the PLTL activities noted that they wished there were more: (a) peer mentors or other students to meet with regularly to discuss my plans/feedback and (b) workshops or other activities that teach strategies and provide resources to strengthen STEM skills.

As a result of the focus group, the team noted that most students experienced faculty members making connections and course content to the real world which was a goal of the grant for both the faculty members involved and the peer leaders. Also, most students perceive that they have experienced learning ways to make a difference through a career in STEM which was an important element of the peer-led activities along with increased opportunities to connect and have time to network with other students. Based on the findings, the team noted a need to increase students' access to individuals in the industry working in STEM fields.

As for the results of the pre- and post-survey questions offered to students who enrolled in the courses with the PLTL sessions at the end and the beginning of course, the students were asked opinions about their experiences and to measure comfort and commitment to engineering. For most students, the average post response was higher than the average pre-survey response on the

question assessing comfort with asking questions in class. As a result of the participation in the PLTL, 80% of the students who completed the survey stated they were comfortable applying mathematical and physical concepts to real-world problems and 96% of the students felt that their analytical and critical thinking skills had improved.

The average post-survey response to the question asking whether students felt comfortable applying mathematical and physical concepts to real-world problems showed females had the highest averages. Their responses indicated that they felt nearly 'very comfortable' applying mathematical and physical concepts to real-world problems. This finding suggests that females who have a greater network to peers have higher levels of commitment to engineering pathways and confidence in their ability to apply the course material to their future career field.

Conclusion

These PLTL experiences have demonstrated success and are strategies that other instructors can use to support the success of students, particularly female and underrepresented minority students, in introductory engineering courses. The peer leaders were provided with professional development to incorporate active learning strategies into the recitation sessions with peer learning. The findings from this study reveal an in-depth account of the experiences of females enrolled in the PLTL sessions in the introductory engineering courses statics, dynamics, engineering networks, and principles of electrical engineering. The female students in this study believe their experiences in STEM activities such as PLTL activities offer further connections to peers and to real-life scenarios that align with their future careers in engineering. The perceptions of the female students in the study show that these connections influence the development of their career interests and their motivation to persist and be successful in engineering. This study includes a substantial Hispanic point of view (with over 40% of participants identifying as minority or multi-racial students) with a large female representation. The survey and focus group experiences questionnaire used for this study were based on validated instruments but used adapted language to address the specific goals of this grant as well as included additional questions.

Further use of these tools is recommended to validate their results, including use with diverse student groups including Veterans and adult learners. The researchers recognize the study was limited to the small number of participants who self-selected and volunteered to share their experiences in focus group sessions. Therefore, the findings may not reflect all of the voices of the students who participated in the PLTL sessions. The focus groups also represented a random and diverse group of students from different age groups and ethnic backgrounds. This may have created pressure to conform based on one dominant group member or led some other members of the group not to share their opinions openly. Therefore, the researchers recommend that this first collection of data be used as a pilot test to identify underlying components and to employ a mixed-methods approach to triangulate between the results of questionnaire results that are quantitative and the qualitative insights of the focus group. The data analysis from the focus groups reveals the diverse experiences and motivators of female undergraduate students to persist and succeed in engineering, specifically at two-year colleges.

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