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Engaging Women Engineering Undergraduates as Peer Facilitators in Participatory Action Research Focus Groups

Dr. Susan Thomson Tripathy, University of Massachusetts Lowell

Dr. Susan Thomson Tripathy received a Ph.D. in Anthropology from Harvard University in 1989. Her doctoral research was funded by a Fulbright-Hays Doctoral Dissertation grant, and utilized ethnographic fieldwork in rural Bihar, India, to analyze the politics and artistic development of a local dance form. From 1995-2007, Tripathy taught behavioral sciences at Middlesex Community College (MCC), where she was an active participant and researcher in MCC's extensive community service-learning program. In 2007, she became the Director of Research at Germaine Lawrence, a residential treatment center for adolescent girls in Arlington MA, focusing on program evaluation and outcomes after discharge. Since 2011, Dr. Tripathy has been teaching in the Sociology department at University of Massachusetts Lowell. She received teaching awards for applied and experiential learning in 2013 and 2014, was promoted to Associate Teaching Professor in 2018, and received the UMass Lowell Teaching Excellence Award in Sociology in 2018. From 2016-2019, Dr. Tripathy was the Director of the Bachelor of Liberal Arts program, an interdisciplinary major with an enrollment of 250 undergraduate students. During 2018-2020, she collaborated with Dr. Kavitha Chandra to utilize participatory action research (PAR) as an evaluation approach for the Research, Academics, and Mentoring Pathways (RAMP) summer program for first-year women engineering students.

Prof. Kavitha Chandra, University of Massachusetts Lowell

Kavitha Chandra is the Associate Dean for Undergraduate Programs and Professor of Electrical and Computer Engineering in the Francis College of Engineering at the University of Massachusetts Lowell. She directs the Research, Academics and Mentoring Pathways (RAMP) to Success program that aims to establish successful pathways to graduate school and interdisciplinary careers for new undergraduate students. Dr. Chandra's research interests include design of data-driven stochastic models for applications in acoustics, communication networks and predictive analytics in education.

Dr. Hsien-Yuan Hsu, University of Massachusetts Lowell

Dr. Hsien-Yuan Hsu is an Assistant Professor in Research and Evaluation in the College of Education at the University of Massachusetts Lowell. Dr. Hsu received his PhD in Educational Psychology from Texas A&M University and has a background of statistics education. He works closely with researchers in STEM to pursue high quality of STEM education for future researchers. He is currently participating in an NSF-funded grant (#1923452) to spearhead research into middle school students' digital literacies and assessment. Recently, Dr. Hsu has received a seed grant at UML to investigate how undergraduate engineering students' digital inequalities and self-directed learning characteristics (e.g., self-efficacy) affect their learning outcomes in a virtual laboratory environment during the COVID-19 pandemic. Dr. Hsu's research interests include advanced quantitative design and analysis and their applications in STEM education, large-scale assessment data (e.g., PISA), and engineering students' perception of faculty encouragement and mentoring.

Dr. Yanfen Li, University of Massachusetts Lowell

Yanfen Li is an Assistant Teaching Professor at the University of Massachusetts Lowell. She received her PhD in Bioengineering from the University of Illinois at Urbana Champaign. Her current research is in engineering education with a focus on curriculum development and retention of female and minority students in engineering.

Diane Reichlen, University of Massachusetts Lowell

Diane Reichlen is a successful engineering executive with extensive experience in motivating and inspiring engineers to be innovative, collaborative, and to use critical thinking skills. She has over 20 years of experience leading engineering teams in Computer Information Technology and Management. Diane

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was VP of Engineering at Dell Technologies from 2013 to 2018, where she led all quality engineering activities for their market leading Enterprise Storage and Software Solutions. Prior to Dell, Diane held several leadership positions for cybersecurity engineering teams. She served as VP of Engineering at CA Technologies from 2007 to 2013 where she led the Identity Management engineering team for their Security Software and Products organization. Prior to CA, Diane served as Director of Engineering at Symantec from 1997 to 2007. At Symantec she led the Norton 360 engineering team and was responsible for all engineering activities related to the delivery of Symantec's consumer security suite which included software to protect against viruses, spyware, malware, phishing, trojan horses and other online threats. She also directed the activities of the development team who converted a software Firewall/VPN product into a market leading Unified Threat Management appliance which included Antivirus and Content Filtering.

Diane Reichlen is effective at creating and mobilizing large, geographically dispersed teams to meet the demands of competitive and aggressive engineering deliverables. Strengths include the ability to recognize the unique talents each engineer has, and how best to exploit those talents in order to bring success.

Diane holds a bachelor's degree in Mathematics and Computer Science from Boston College.

Diane is on LinkedIn at www.linkedin.com/in/dianereichlen

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ABSTRACT

This study is part of a longitudinal research project examining the design of summer bridge and subsequent undergraduate engineering programs at a public university in New England, with the long-term view of how these programs can create more supportive, inclusive environments for women to become engaged as leaders in their educational pathways and future careers. A summer bridge program prepares first-year women engineering students for the academic and cultural opportunities and challenges they may face. Through an immersion in focus groups constructed for participatory action research (PAR), students learn to use their voices for change and also to lead in taking action to improve their experiences in the program. This summer experience is leveraged in the academic year by additional training for a small group of women participants from the summer program to facilitate focus groups open to all undergraduate students in the college of engineering. Using PAR and an asset-based approach emphasizing listening and learning from student voices, this study suggests how engaging women as peer facilitators in PAR focus groups builds leadership and communication skills, as well as increases understanding of student perceptions and experiences in their engineering majors. Further, using the results of a survey administered to all engineering students in their Junior and Senior years on their experiences in their majors, the responses from participants in the summer program are compared with those from students who did not have this opportunity. Women engineering students in the summer program were statistically more likely to see themselves as having stronger critical thinking and communication skills than women who did not participate in this program, but differences between these two groups in perceptions of sense of belonging and leadership skills were not statistically significant.

1.0 Introduction and Background

This study presents the design and outcomes of a summer bridge program and subsequent academic year extra-curricular activities in undergraduate engineering programs at a public university in New England. The research is part of a long-term view of how these programs can create more supportive, inclusive environments for women to become engaged as leaders in their educational pathways and future careers. It further explores if these programs and activities also promote the students' sense of belonging in their engineering department and college.

In 2018, the authors designed and implemented the Research, Academics and Mentoring Pathways (RAMP) to Success, a summer bridge program to prepare new women undergraduate students to transition from high school to the College of Engineering (CoE) at the University of Massachusetts Lowell. This six-week program takes place during July and August after students have made decisions on colleges they will attend. In 2020, RAMP was expanded to include students of all genders, but is still comprised predominantly of women. While the focus of RAMP remains on improving the experience of women in engineering, a small number of men (seven out of a total 23 participants, four of whom were men of color) were included in 2020 to

create a cohort of allies that support the program objectives and to explore their own experiences of marginalization. In the last three years, fifty-six students have successfully completed RAMP and fifty-four of these students continue to be enrolled across the six different engineering majors in the CoE. In RAMP, students learn to overcome the challenges of taking college courses by enrolling in Calculus 1 and the Introduction to Engineering design course, earning six credits towards their degree. They are also introduced to industry professionals and through weekly meetings begin to learn about technical, communication, and management skills and those attributes that lead to leadership roles. Research skills are introduced through engineering design projects, wherein students learn to solve problems as a team. A more detailed description of RAMP has been presented by Tripathy et al. [1], [2].

A goal of this summer bridge program is for students to better understand the culture, curriculum, educational practices, and norms of engineering programs and workplaces and learn to navigate and overcome some of the barriers that continue to exist in these environments. For faculty designing these programs it is important to understand how effective the program components are in accomplishing these objectives and in particular how these barriers may manifest differently for different students. To this end, we are studying solutions that can proactively engage and empower students in identifying and removing those roadblocks in their degree pathway. The integration of bi-weekly focus groups (FGs) for participatory action research (PAR) in RAMP has been found effective in connecting and assessing multiple program elements from the students' perspective. This has led to an improvement in program design over the last four years and been successful in bringing together women students from across all engineering majors as a community who want to be engaged in creating the change needed to improve their experiences and success in the field. Fig. 1 captures the students' trajectory during the six-week RAMP program.

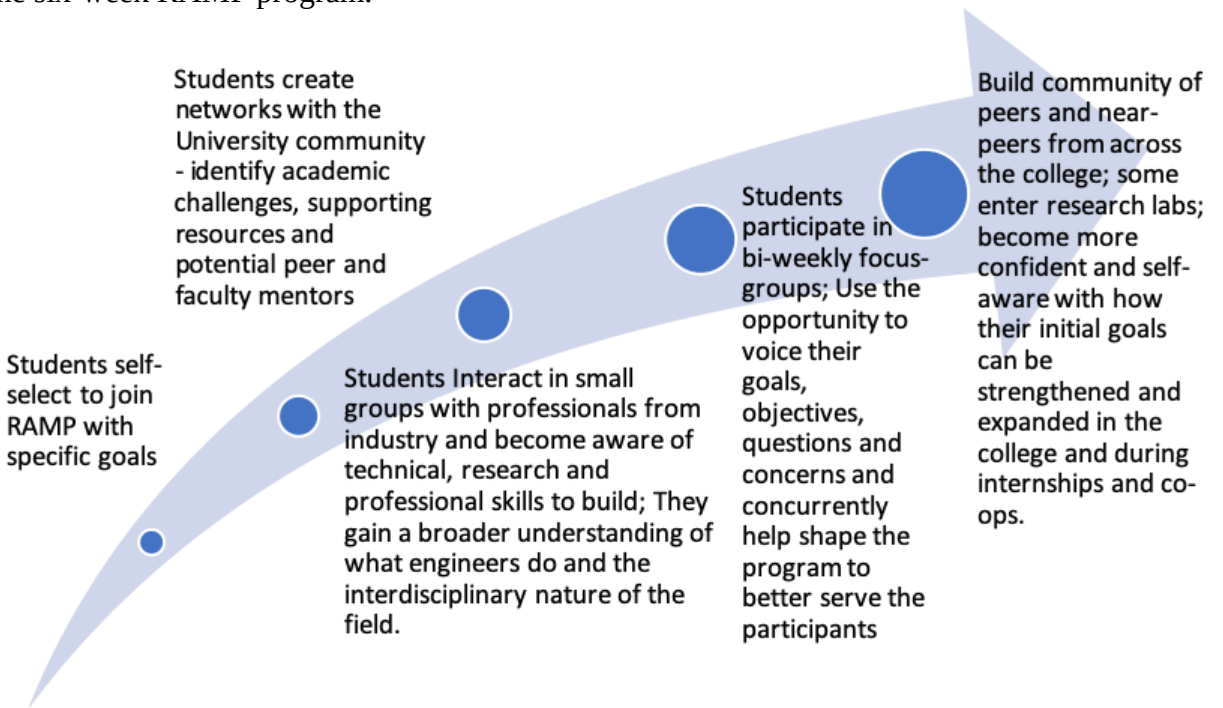

Fig.1: Six-week July to August summer program trajectory for participants in RAMP.

Women engineering students face significant barriers to empowerment due to persistent marginalization, isolation, microaggressions, and stereotypes, both from peers and faculty members, which jeopardizes their well-being and sense of belonging [3]. As noted in Wallerstein & Auerbach, "Part of what enables people to develop psychological empowerment is their connection to others, their sense of community with others, and their empathy with others—in other words, developing a 'social identity" [4]. There are also many problematic experiences that are particular to women of color. Research findings have shown that women of color struggle and leave STEM programs due to social or interpersonal factors and not experiencing a sense of social belonging [5]–[9]. The negative perceptions of campus gender and racial climate [6], [10]–[13] and personal experiences with bias or discrimination and climates of intimidation in STEM programs [14] have also been found to be key barriers that these students have to overcome to persist in the program. Research by Seron, Silbey, Cech, & Rubineau analyzed twice monthly diary entries of 41 women undergraduate students in engineering programs at four different colleges/universities as they progressed from first year to senior year [15]. This analysis reveals how women are aware of their marginal status and provide "clear and strong criticisms of their experiences." But these critiques are muted by the core values of engineering culture, meritocracy, and individualism. We consider in our work the application of PAR FGs that are recognized as a vehicle for transformation and change [16] and examine if this enables participants to move beyond the "muted criticism" that Seron et al. describe.

A novel component of RAMP that has been sustained since its inception is the role students play in improving its design and implementation. This takes place through bi-weekly FGs designed using the model of PAR, which emphasizes both equal participation – everyone's voice is heard – and developing action steps for constructive change [17], [18]. An average-sized cohort of twenty-five students enrolled in RAMP each year are divided into two groups who meet during lunch breaks and address topics that range from their short and long-term goals in the field to their current experiences in the program. Based on the recommendations of participants, in 2019 and 2020 these FGs were facilitated by students who had graduated from RAMP in previous years and who volunteered to be peer-facilitators.

In this study we examine the outcomes of PAR FGs that were implemented during the academic year (Fall 2020) for which all students from the Junior and Senior years were invited to participate. These FGs were facilitated by women also in the Junior and Senior years of their degree pathway who had participated in RAMP in prior years. As facilitators, students can acquire critical skills of engaging a group in dialog, addressing controversial issues, and potentially begin to better identify and broaden their role in their engineering environment. Using qualitative FG data and quantitative data from surveys we study the students' perceptions of themselves as leaders and also investigate if these FGs generate a sense of empowerment among the participants. We propose that FGs could also be designed to serve as safe social spaces or "counterspaces" [3] that provide supportive ways to connect with others and build a sense of belonging and identity in engineering majors.

Schell and Hughes [19] look at the relationship between leadership roles and the formation of an engineering identity. They note there are few opportunities for undergraduates to see themselves as engineering leaders either in a typical engineering curriculum or in the process of developing an engineering identity. Their study proposes a leadership identity development

model that requires four environmental conditions: (1) a set of influential individuals who shape the students' perception of leadership; (2) peers and social networks developed with them that help build a sense of belonging to the field; (3) meaningful involvement in curricular and co-curricular activities; and (4) opportunities for reflective learning regarding their leadership experiences. As seen in the graphic of Fig. 1 that depicts the central elements of RAMP, this program supports the first two of these conditions through students interacting with professionals from industry, building a community of peers who look like them, and creating social networks with faculty, staff, and administrators in the new environment they are transitioning into.

The facilitation of FGs by women (including both women of color and White women) and their reflections on this activity as discussed in this study are among the co-curricular programs being designed to promote leadership roles and the formation of engineering identities. It is also of interest to see as noted in [19] if such opportunities allow students to recognize that leadership need not be positional but can be exercised in a relational context by anyone who may be influencing others or working to improve the environment. These leadership roles can be significant in empowering students to become engaged with educators and administrators in making decisions and changes that improve their environment.

Section 2 describes the research program, participants, and methods used in the online surveys and FGs. Section 3 summarizes the results derived from the qualitative and quantitative research methods applied. Section 4 provides conclusions and limitations of our study and Section 5 discusses future work.

2.0. Description of the Research Project: Programs, Participants, and Methods

To assess the experiences and perceptions of students from RAMP and Juniors and Seniors in the College of Engineering, we used a combination of quantitative and qualitative methods. Drawing questions from the APPLES survey [23] that explores engineering students' experiences and the survey by Leibowitz et al. [24] that addresses sense of belonging, academic engagement, and self-efficacy, an online survey was developed and sent by email during September 2020 to all 608 Juniors and 1090 Seniors in the College of Engineering. 173 students responded, 142 of whom completed the survey (8.4% of the 1,698 Juniors and Seniors).

With regard to qualitative methods, we utilized a PAR framework to investigate how FGs open to Junior and Senior engineering students of all genders and facilitated by women undergraduate engineering students can promote the social positioning of these women in their departments and in the college, help develop their leadership skills, and also evolve as safe spaces for all participants to discuss their experiences and provide suggestions for improvement. PAR is ideally suited for these purposes, since it emphasizes including the voice of all stakeholders in the research process and in developing action steps for constructive change. As a research framework, PAR encompasses a wide variety of both qualitative and quantitative research methods, such as focus groups, surveys, mapping, photovoice, interviews, and others [17], [25], [26], and has been used in STEM educational settings [20], [27], [28].

The engagement of undergraduates as facilitators in PAR has been examined by Weinberg et al. and Trott et al. in a series of papers [20]–[22]. In these studies, undergraduate students undertaking research experiences facilitated PAR on a community related research, but

they were not themselves members of the community. The studies show that student facilitators developed new perspectives and skill sets that extended beyond their previous STEM research experiences.

Following the administration of the online survey, we invited former RAMP participants to volunteer as facilitators of FGs in a two-part event named "Your Voice Matters," conducted in November 2020 with Juniors and Seniors from the College of Engineering. Seven women volunteered to be peer facilitators. One of these volunteers was not able to attend both of the FGs, and so continued as a participant rather than as a facilitator. With regard to race/ethnicity of the facilitators, one was Middle-Eastern, one was White, two were Asian, and two were Black. Four were from Electrical Engineering and Computer Engineering, one from Chemical Engineering, and one from Biomedical Engineering. Three of the facilitators had previous experience facilitating RAMP FGs, and the other three had been participants in RAMP FGs. All Juniors and Seniors in the College of Engineering were invited via email to participate in "Your Voice Matters." Eight engineering students accepted this invitation, including five White men, one Middle-Eastern woman, one Black woman, and one Latina. Engineering majors of the FG participants included three from Mechanical Engineering, two from Electrical Engineering and Computer Engineering, two from Civil Engineering, and one from Chemical Engineering.

To serve as facilitators, students were trained in: (a) explaining the purpose of the FGs and the PAR process of listening to all voices and developing action steps for change; (b) building rapport through creative ice-breakers; (c) encouraging all FG members to voice their thoughts and concerns; (d) listening without judgement and establishing trust; (e) responding to comments with appropriate follow-up questions; (f) setting ground rules for all FG participants to follow; (g) diagramming activities using MIRO whiteboards; and (h) summarizing final thoughts. The data from these FGs, which included audio and video of the discussions and comments via MIRO, was transcribed and analyzed thematically by the research team. Peer-facilitators were also encouraged to share their own thoughts and experiences, but to do so after the other members of the FG had spoken, to minimize influencing participants' thoughts.

Findings from the RAMP FGs during the first implementation in 2018 stressed the importance of having peer facilitators rather than a faculty facilitator. Making this change in the RAMP program in successive years has yielded improved student evaluations of the program. For this reason, we continued using peer facilitators during the academic year as well. In this research, we investigate how PAR FGs facilitated by women undergraduates can promote the social positioning of these students in their departments and in the college, help develop their leadership skills, and also evolve as safe spaces for all participants. This approach of training women engineering students, the majority of whom are women of color, to moderate FGs differs from the FGs used in conventional research, where the facilitator is often not themselves a stakeholder in the issues being investigated.

After the training was completed, two one-hour FGs were organized via Zoom to give the fourteen students (6 facilitators, 8 participants) an opportunity to discuss their values, goals, and experiences in the CoE and to allow both research faculty and peer facilitators to listen and learn from student voices.

The design of the November FGs was drawn from workshops held during the Community Based Participatory Research (CBPR) Summer Institute at the University of New Mexico in August, 2020 [29], [30]. Our peer facilitators modified the focus group activities for use via MIRO whiteboards on Zoom and also contributed to the overall design of the sessions. At the conclusion of these FGs, an anonymous online survey was completed by participants and peer-facilitators to provide feedback about their experiences in the FGs. The sessions were recorded and transcribed via Zoom.

The first FG activity was the River of Life, adapting an activity developed by Wallerstein [31], [32] for use with students in an educational setting. Using interactive MIRO boards and a "journey down the river" metaphor, participants were asked to comment on four questions: 1) What motivated you to join your engineering major? 2) What barriers and difficulties have you encountered along the way? 3) What has been most helpful on your journey? 4) Considering your experiences and goals, what would you like to see reinforced, changed, or improved at the CoE?

The second FG uses a method developed by Paulo Freire, which includes dialogue around codifications or "codes" [33]. According to this method, a code is "a concrete physical representation of a particularly critical issue" [4] and can be represented through a story, role play, or visual. Students were presented with two photos representing familiar yet challenging situations they might experience or observe in the CoE. The first photo was two "Beaver Dome" cartoons with the captions "I don't fit in" and "I'm the only one who doesn't understand this" taken from the archive in [34]. The second was a photo of three men and one woman in what appears to be a work setting. They are seated together in a line of chairs against the wall, with the 3 men grouped together, and the woman on the edge. The woman's posture is noticeably different than the men, who are looking at her with what appear to be questioning expressions. This photo [35] is ambiguous in meaning, which makes it helpful to spark discussion regarding possible interpretations.

After examining these photos, students then engaged in a SHOWeD dialogue [4], [36] with the other FG participants to respond to the following questions:
Descriptive: (1) What did you **see** here? (2) What's really **happening**? How are people feeling?
Personal: 3) How does the story relate to **our lives**?
Analysis: 4) **Why** does this problem occur?
Action: 5) What would help **empower** us? 6) What can we **do** about the problem?

The goal of this exercise is to stimulate discussion about difficult issues and develop ideas for action steps to improve challenging or harmful situations.

Through the roles of the peer-facilitators and the overall emphasis on "Your Voice Matters" in these exercises, we are using an asset-based approach. In other words, by listening carefully to student voices and responding to their suggestions, we are recognizing the value of their perspectives, and intend to use their experiences and insights to create a more welcoming and supportive learning environment in the CoE. An asset-based approach emphasizes the strengths and abilities that women bring to the table, rather than emphasizing deficits and the need to "fix" these students to conform to dominant norms in engineering culture [37]. This

approach also corresponds with community cultural wealth theory by drawing attention to "the array of cultural knowledge, skills, abilities and contacts possessed by socially marginalized groups that often go unrecognized and unacknowledged" [38].

Following the completion of the FGs, transcripts were coded for key themes by one of the researchers. This analysis was discussed with all members of the research team. Our research team is interdisciplinary, including faculty and administrators from engineering, education, industry, and sociology, and includes a variety of race/ethnic backgrounds: one South Asian woman, one East Asian woman, one East Asian man, and two White women.

3.0 Data Analysis

The data analyzed flows sequentially from the responses of first-year participants in RAMP, followed by survey data from respondents in the Junior and Senior years described in Section 3.1. Data from FGs conducted with Juniors and Seniors is summarized in Section 3.2. Finally, analyzing data from surveys of the students who facilitated and participated in the FGs, in Section 3.3 we present key findings drawn from student comments on their experiences. There are several different indicators that arise from aggregated study of these data. In this paper, we focus on the perceptions of the FG facilitators.

3.1 Student Survey Data Analysis

The final sample size of students from the Junior and Senior cohort who responded to the survey was 142, including 18 (12.68%) women from RAMP, 45 (31.69%) non-RAMP women, and 79 (55.63%) non-RAMP men. The respondents self-reported as White (62.68%), Black or African American (5.63%), Hispanic or Latino/a/x (6.34%), Asian or Asian American (16.20%), and multiracial (9.15%). Outcomes of interest were student perception of: (a) sense of belonging, (b) leadership ability, (c) self-confidence, (d) communication skills, (e) critical thinking skills, and (f) ability to help others. All outcomes were measured on a three-point ordinal scale (agree/neutral/disagree for sense of belonging; above average/average/below average for remaining outcomes).

Ordinal logistic regression [39] was applied for data analysis because our outcomes had ordinal responses with more than two categories. A cumulative logit model for an ordinal response is expressed as follows:

$$\text{logit}[P(y \leq j)] = \alpha_j + \beta_1 x_1 + \beta_2 x_2 + \ldots + + \beta_p x_p, \; j = 1, 2, \ldots, c\text{-}1,$$

where $P(y \leq j)$ denotes the probability that the response falls in category j or below (i.e., cumulative probability), c is the number of categories in an ordinal outcome, α_j is the intercept parameter for each cumulative probability, the parameter β describes the effect of predictor x on y. Two group comparison variables (i.e. dummy variables) were created to examine the difference in outcomes for (a) RAMP vs. non-RAMP women, and (b) RAMP students vs. men. Student demographics including race/ethnicity, income level, academic attainment (GPA), first-generation student or not, transfer students or not, and a Junior or Senior student, were used as

covariates in the analysis. The statistical significance level (alpha) was set to .05. Regression coefficients (*coef.*), corresponding *SEs*, and *p*-values are reported below for indicators of interest.

Results show the sense of belonging of RAMP students was not statistically different from that of non-RAMP women (*coef.* = -0.61, *SE* = 0.60, *p*-value = .30) and men (*coef.* = -0.52, *SE* = 0.55, *p*-value = .35). Similarly, RAMP students' perception of leadership ability was not statistically different from non-RAMP women (*coef.* = 0.66, *SE* = 0.64, *p*-value = .30) and men (*coef.* = 0.68, *SE* = 0.59, *p*-value = .25). In other words, RAMP students' sense of belonging and perceived leadership ability were at the same level as those of non-RAMP women and men.

Furthermore, we found RAMP students were statistically more likely to see themselves as above average in communication skills compared to non-RAMP women (*coef.* = 1.91, *SE* = 0.70, *p*-value = .01) and men (*coef.* = 2.15, *SE* = 0.66, *p*-value = .00). In addition, RAMP students perceived statistically stronger critical thinking skills compared to non-RAMP women (*coef.* = 1.56, *SE* = 0.69, *p*-value = .02); and perceived stronger ability to help others compared to men (*coef.* = 2.75, *SE* = 1.12, *p*-value = .01). On the other hand, we found RAMP students were statistically less likely to see themselves as above average in self-confidence in comparison to men (*coef.* = -1.30, *SE* = 0.56, *p*-value = .02).

3.2 A Summary of Thematic Analysis of the Fall'20 Student FGs Facilitated by Trained RAMP Participants

Thematic analysis of the FG conversations suggests that students viewed these opportunities both as places to share experiences with their peers and also as a way to bring about change in the CoE by engaging in research about student experiences. The coding of seven hours of audio, video, and text data recorded during the two FGs identified the following major themes in the conversations: (i) Reactions to FGs; (ii) Challenges; (iii) Ways to Counter Challenges; (iv) Process of Creating Change. The following observations identify the role of the peer facilitators in helping guide these discussions.

Reactions to FGs: Responding to how the shared concerns of students would lead to real change, facilitators provided participants more information on the research process based on their prior experiences using PAR to bring about change in RAMP. The action-oriented component of PAR is clearly one that students sought to better understand and lends to the importance of training peer-facilitators to be able to clearly articulate how these actions would be enabled. This also requires working with CoE faculty and administration to develop avenues for change. Overall, the FGs were viewed as safe spaces where students could connect with each other and have their voices heard in a non-judgmental, supportive environment.

Challenges and Ways to Counter Challenges: One of the interesting dynamics that emerged from the FG data was how peer facilitators were able to promote a discussion of the challenges felt by students with different backgrounds and experiences (such as: veteran, transfer, international, visible and invisible disabilities, trauma, language barriers) and relate these to their own experiences of stereotypes and microaggressions as women of color or White women. For example, White men in the group expressed their own experience of stereotype threats as engineering students in liberal-arts classes. For these men, participating in a group that was not

typically all-men was found to be welcome and supportive of being able to talk about their difficulties. Because all of the peer facilitators were women, and a majority were women of color, their leadership role in facilitating the FGs also reversed the White, masculine gender hierarchy that is typical in engineering culture.

Process of Creating Changes: The FG participants identified many different areas for improvement ranging from the curriculum requirements of non-engineering courses and engineering capstone projects to the need for engineering instructors to be less negative and more informed about the best way to create equitable team projects and articulate their outcomes. One of the key recommendations was that students saw the need for and welcomed more such opportunities to vocalize their concerns and collaborate together in a safe space. It was evident that the peer-facilitators were clearly able to convey the goals of the FGs and encourage an open-conversation.

3.3 Data Analysis of Open-Ended Questions on Surveys of FG Participants and Peer Facilitators

3.3.1 Survey One: Evaluations of the FGs by Student Participants and Peer Facilitators

Immediately following the second Fall 2020 FG, we conducted an online survey of both student participants and peer facilitators. Through open-ended questions, we asked students to reflect on what they liked best about the activity and what they thought should be improved. Twelve out of fourteen students responded, including six peer facilitators and six student participants.

Reflections on what was liked about the FGs: Student participant responses tended to be fairly brief but mentioned that they liked: (i) talking with students from different majors; (ii) discussing about ways to improve the College of Engineering; (iii) the "open dialogue/freedom of speech," and "being heard—or at least having the opportunity to feel that way."

Peer facilitator responses regarding what they appreciated were more detailed included "being able to speak freely with peers and meet new people" and "getting different perspectives and information off my chest." One facilitator also mentioned that it "helped me see that I wasn't the only person struggling or the only one having issues." Facilitators felt the conversations were productive and allowed them to "delve into these issues that are often overlooked." Finally, "listening to everyone's relatable experiences/opinions was enlightening and definitely was fun!"

Responses to what could be improved about the FGs: The following suggestions were offered by student participants: (i) explain the intent of the FGs more clearly; (ii) encourage more students to participate; and (iii) include free giveaways and/or food. One student participant also responded, "At the moment, nothing that I can think of. Keep up the good work!"

Peer facilitators suggested the following improvements: (i) try to increase the number of students, have "more open-forum meetings where students bring their own questions/problems"; (ii) increase the length of the FGs by an additional ½ hour since they frequently ran out of time;

(iii) have more activities to encourage students to talk. One peer facilitator also mentioned that if the groups were larger, there would be less time to use the MIRO whiteboards, but that students tended to go into more into detail in their verbal explanations.

3.3.2 Survey Two: Peer Facilitators' Perceptions of Skills Learned and Benefits of the FGs

About one month after the two FGs were completed, we conducted an anonymous online survey with the peer facilitators (5/6 responded). Responses from open-ended questions about facilitators' perceptions of skills learned and benefits of being a peer facilitator are summarized below.

Skills Learned: 4/5 facilitators responded that they learned new skills from facilitating the groups. With regard to what skills they learned, facilitators mentioned "the practice to lead the flow of the discussion while simultaneously extracting honest opinions," and that the experience "improved on skills I already had, e.g. improvising and leading meetings." Additional skills mentioned included communication, leadership, team building, public speaking, assertiveness, confidence, open-mindedness, patience, listening, and teamwork.

3/5 facilitators felt the experience of facilitating the groups opened up new ideas of future skills they would like to learn. One facilitator commented: "I realized that I quite enjoy leading a team. In the past I would shy away from stepping out and just tried to blend with the group. But now, I feel much more confident in myself and feel like this will be an extremely great skill to have going forward."

Others added that the experience helped them learn "how to lead focus groups better" and "improve public speaking skills." One facilitator commented that this experience helped her realize she wanted to improve her ability to balance both listening and speaking.

Benefits of being a Peer Facilitator: Three of the peer facilitators had previously been facilitators in RAMP; two of them had facilitated for two years (2019, 2020), and one for one year (2020). So before asking about their experience with the Fall 2020 FGs, we asked what they felt they got out of their facilitation experience during RAMP. One facilitator mentioned "I felt like it was a great way for me to improve on my communication skill especially in a group environment" and another commented that it was helpful to meet people from different backgrounds whom she "otherwise would not have met . . . their backgrounds and inspirations were motivating factors that made me want to work harder and dream bigger with no set boundary on what I can do. It pushed me along the way."

With regard to what they thought they got out of facilitating in the Fall 2020 focus groups, facilitators remarked on "the organic and honest conversations," "learning to be more empathetic and open-minded," and appreciated the opportunity to connect with other students and get a sense of how they are dealing with the pandemic and other issues. Two facilitators further commented that the experience helped them to feel less alone or recognize that any difficulties they may have experienced were similar to those of others: "I was able to see that my experience in the college of engineering was not necessarily unique; others felt as though they

didn't fit in and I wasn't alone in that. The conversations were great. It was also nice being part of the process in changing things."

What facilitators learned about students in their group: 5/5 shared what they learned about the students, mentioning that students didn't feel they could ask for help, may sometimes be "afraid to state their opinion because of the crowd around or if it is unpopular," were "great listeners" and "not judgmental." Finally, one student summarized what she learned as follows: "We are all struggling in some way or another. And all participating students were willing to support each other, although they were practically strangers before the focus groups."

Overall, 5/5 peer facilitators felt the focus groups were beneficial to the student participants. Benefits included allowing the students to learn from each other and from the peer facilitators, as well as reflect on their achievements, successes, and any barriers they encountered. Facilitators also mentioned the value of providing constructive criticism about student experiences in the CoE: "It made them realize what is lacking in terms of their needs from the school as well as what they want to see more of, and thus I definitely believe they left on a note of hope of improvement."

Was the opportunity for peer facilitators to share their own experiences helpful?: 5/5 peer facilitators said they appreciated the opportunity to "get my opinion out" and "express my thoughts along with my peers." As one facilitator stated, "both parts of the experience were enjoyable and eye-opening." Another commented: "I enjoyed being a facilitator as much as a participant as I was able to think about the discussion myself as well as relate to the conversation. Whatever the outcome of the focus groups, I hope that participants can be able to drive and contribute to the outcoming solutions."

4.0 Discussion

This research study investigated how PAR focus groups may be used to empower women engineering students to identify ways to make the college environment more supportive of their identities, values, interests, and goals. A particular interest was to provide continuity of engagement of these students from the RAMP summer bridge program to the following academic years. This was undertaken by training a group of women who were RAMP participants to serve as FG facilitators for a broader group of participants, including students of all genders, drawn from the Junior and Senior cohort in the College of Engineering. Using a combination of qualitative data from FGs and responses to surveys, we examined the skills these students exhibited while conducting the FGs as well as skills and perceptions they self-reported in anonymous online surveys.

Review of the survey responses of FG facilitators reveals that they identified multiple specific facilitation skills they gained, such as listening, communicating effectively, encouraging active participation, and public speaking, as well as broader personal skills such as confidence, leadership, and assertiveness. They also felt the FGs were of benefit to the student participants and were motivated and inspired by hearing about the backgrounds and experiences of the students they met in these groups. In this way, the PAR focus groups provided a mutual learning process, with peer facilitators and student participants learning from each other's comments and

experiences. Finally, peer facilitators also saw these focus groups as a way to bring about constructive change in the CoE.

The survey results from 142 Juniors and Seniors provided a means to assess if RAMP participants identified themselves with specific skills in contrast with non-RAMP participants. However, it is difficult to assess what aspects of RAMP may have promoted the differences noted in this analysis (i.e., perception of better communication and critical thinking skills, ability to help others). Since students experience RAMP holistically, how to isolate the effects of the FGs needs to be explored further.

With regard to limitations, the small number of FG facilitators in this study limits our ability to generalize the utility of FG facilitation for acquiring specific skills such as leadership, communication skills, and empowerment. Similarly, our ability to make generalizations based on the intersectional identities of the facilitators is also limited by this number, although the data generated was very informative for identifying student perceptions of changes needed in the CoE. To increase the number of participants, we will further investigate how FGs may be embedded in courses and as part of student club activities to involve larger groups of students both as peer facilitators and FG participants.

5.0 Conclusion

Historically, engineering culture in colleges of engineering and in the engineering profession as a whole has been dominated by White men. Despite contemporary efforts to remedy this injustice, colleges of engineering still struggle with lack of equity and unsupportive environments for women engineering students, especially for women of color. By providing a select group of women engineering students, a majority of whom are women of color, the opportunity to experience leadership through facilitating PAR focus groups aimed at listening to student voices, identifying inequities, and offering suggestions for constructive change, our work is focused on ending the systemic sexism and racism that these students have endured and creating a more supportive, inclusive, and welcoming engineering environment.

In future research studies we will continue to examine the design of the FGs and how they can be facilitated to serve as counterspaces for students with multiple intersectional identities (race, gender, class, veteran status, disability, transfer status, etc.) to voice the assets they bring to the table as well as the challenges they may be facing. To move forward with this goal, an intersectional analysis of how engineering students share their experiences in the College of Engineering will be the subject of a future paper. We will also use the findings from the FGs to involve students, faculty, and administrators in bringing about the changes that students seek in the College of Engineering.

References

[1] S. T. Tripathy, K. Chandra, and D. Reichlen, “Participatory Action Research (PAR) as formative assessment of a STEM summer bridge program,” *ASEE Annu. Conf. Expo. Conf. Proc.*, 2020, doi: 10.18260/1-2--33957.

[2] K. Chandra and S. Tripathy, “Research, Academics and Mentoring Pathways (RAMP) to

Success," 2019. https://www.uml.edu/docs/RAMP2018-Final-Report_tcm18-309285.pdf (accessed Mar. 06, 2021).
[3] M. Ong, J. M. Smith, and L. T. Ko, "Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success," *J. Res. Sci. Teach.*, 2017, doi: 10.1002/tea.21417.
[4] N. Wallerstein and E. Auerbach Edmonton, *Problem-Posing at Work: Popular Educator's Guide*. Edmonton, Alberta: Grass Roots Press, 2004.
[5] H. B. Carlone and A. Johnson, "Understanding the science experiences of successful women of color: Science identity as an analytic lens," *J. Res. Sci. Teach.*, vol. 44, no. 8, pp. 1011–1245, 2007, doi: 10.1002/tea.20237.
[6] M. Ong, "The status of women of color in computer science," *Commun. ACM*, vol. 54, no. 7, pp. 32–34, Jul. 2011, doi: 10.1145/1965724.1965737.
[7] S. V. Brown, "The preparation of minorities for academic careers in science and engineering: How well are we doing?," in *Access denied: Race, ethnicity, and the scientific enterprise*, J. Campbell, George, R. Denes, and C. Morrison, Eds. New York: Oxford University Press, 2000.
[8] R. Varma, "Women in information technology: A case study of undergraduate students in a minority-serving institution," *Bull. Sci. Technol. Soc.*, vol. 22, no. 4, pp. 274–282, 2002, doi: 10.1177/027046760202200400 3.
[9] R. Varma, Prasad. D, and D. Kapur, "Confronting the 'socialization' barrier: Cross ethnic differences in undergraduate women's preference for IT education.," in *Women and information technology: Research on underrepresentation*, J. Cohoon and W. Aspray, Eds. Cambridge, MA: MIT Press, 2006, pp. 301–322.
[10] M. J. Chang, J. Sharkness, S. Hurtado, and C. B. Newman, "What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups," *J. Res. Sci. Teach.*, 2014, doi: 10.1002/tea.21146.
[11] G. A. Garcia and S. Hurtado, "Predicting Latina/o STEM persistence at HSIs and non-HSIs," *Proc. from Am. Educ. Res. Assoc. 2011 Annu. Meet.*, 2011.
[12] S. Hurtado, N. L. Cabrera, M. H. Lin, L. Arellano, and L. L. Espinosa, "Diversifying science: Underrepresented student experiences in structured research programs," *Res. High. Educ.*, vol. 50, no. 2, pp. 189–214, 2009, doi: 10.1007/s11162-008-9114-7.
[13] T. J. Yosso, W. A. Smith, M. Ceja, and D. G. Solórzano, "Critical race theory, racial microaggressions, and campus racial climate for latina/o undergraduates," *Harv. Educ. Rev.*, vol. 79, no. 4, pp. 659–690, 2009, doi: 10.17763/haer.79.4.m6867014157m707l.
[14] R. T. Palmer, D. C. Maramba, and T. E. Dancy, "A qualitative investigation of factors promoting the retention and persistence of students of color in STEM," *J. Negro Educ.*, vol. 80, no. 4, pp. 491–504, 2011.
[15] C. Seron, S. Silbey, E. Cech, and B. Rubineau, "'I am Not a Feminist, but. . .': Hegemony of a Meritocratic Ideology and the Limits of Critique Among Women in Engineering," *Work Occup.*, vol. 45, no. 2, pp. 131–167, May 2018, doi: 10.1177/0730888418759774.
[16] L. F. Chiu, "Transformational Potential of Focus Group Practice in Participatory Action Research," *Action Res.*, vol. 1, no. 2, 2003, doi: 10.1177/14767503030012006.
[17] C. MacDonald, "Understanding Participatory Action Research: A Qualitative Research Methodology Option," *Can. J. Action Res.*, vol. 13, no. 2, 2012.
[18] N. Wallerstein and B. Duran, "Theoretical, Historical, and Practice Roots of CBPR," in *Community Based Participatory Research for Health*, N. Wallerstein, B. Duran, J. Oetzel,

and M. Minkler, Eds. San Francisco: Jossey-Bass, 2018, pp. 17–29.
[19] W. J. Schell and B. E. Hughes, "An approach to understand the role of identity in engineering leadership," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2017, doi: 10.18260/1-2--27550.
[20] A. E. Weinberg, C. D. Trott, and L. B. Sample McMeeking, "Who produces knowledge? Transforming undergraduate students' views of science through participatory action research," *Sci. Educ.*, vol. 102, no. 6, pp. 1155–1175, 2018, doi: 10.1002/sce.21453.
[21] C. D. Trott, A. E. Weinberg, and L. B. S. McMeeking, "Prefiguring sustainability through participatory action research experiences for undergraduates: Reflections and recommendations for student development," *Sustain.*, vol. 10, no. 9, p. 3332, 2018, doi: 10.3390/su10093332.
[22] C. D. Trott, L. B. Sample McMeeking, and A. E. Weinberg, "Participatory action research experiences for undergraduates: forging critical connections through community engagement," *Stud. High. Educ.*, vol. 45, no. 11, pp. 2260–2273, 2019, doi: 10.1080/03075079.2019.1602759.
[23] S. Sheppard, S. Gilmartin, H. L. Chen, G. Lichtenstein, Ö. Eris, and M. Lande, "Exploring the engineering student experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES) (TR-10-01)," *Center for the Advancement of Engineering Education*, 2010. http://www.engr.washington.edu/caee/APPLES_report.html (accessed Apr. 03, 2021).
[24] J. Leibowitz, C. F. Lovitt, and C. Seager, "Development and Validation of a Survey to Assess Belonging, Academic Engagement, and Self-Efficacy in STEM RLCs.," *Learn. Communities Res. Pract.*, vol. 8, no. 1, 2020.
[25] A. McIntyre, *Participatory Action Research, Qualitative Research Methods Series 52*. Los Angeles: Sage Publications, 2008.
[26] M. J. Amon, "Looking through the glass ceiling: A qualitative study of STEM women's career narratives," *Front. Psychol.*, vol. 8, no. 236, Feb. 2017, doi: 10.3389/fpsyg.2017.00236.
[27] A. Delgado and J. V. Paragulla, "Improving teaching and learning in systems programming courses using participatory action research," *IEEE CACIDI 2016 –IEEE Conf. Comput. Sci.*, pp. 1–5, Dec. 2016, doi: 10.1109/CACIDI.2016.7786000.
[28] L. Hahn and V. Werpetinski, "Work in progress - Using participatory action research to investigate student learning in Engineers Without Borders," in *2010 IEEE Frontiers in Education Conference (FIE)*, 2010, pp. T2D-1-T2D-3, doi: 10.1109/FIE.2010.5673112.
[29] "Center for Participatory Research | The University of New Mexico." https://cpr.unm.edu/ (accessed Mar. 07, 2021).
[30] N. Wallerstein, B. Duran, J. G. Oetzel, and M. Minkler, Eds., *Community-Based Participatory Research for Health: Advancing Social and Health Equity*, 3rd ed. San Francisco: Jossey Bass, 2017.
[31] S. Sanchez-Youngman and N. Wallerstein, "Partnership River of Life," in *Community-Based Participatory Research for Health: Advancing Social and Health Equity*, 3rd ed., N. Wallerstein, B. Duran, J. Oetzel, and M. Minkler, Eds. San Francisco: Jossey-Bass, 2017, pp. 375–378.
[32] "Engage for Equity – A partnered website hosted by the Center for Participatory Research." https://engageforequity.org/ (accessed Mar. 07, 2021).
[33] P. Freire, *Pedagogy of the Oppressed*. New York, New York: Bloomsbury Academic,

1970.
[34] "MindHandHeart Cartoons ." https://mindhandheart.mit.edu/resources/mindhandheart-cartoons (accessed Mar. 07, 2021).
[35] Flaherty Colleen, "New study finds discrimination against women and racial minorities in hiring in the sciences," Jun. 07, 2019. https://www.insidehighered.com/news/2019/06/07/new-study-finds-discrimination-against-women-and-racial-minorities-hiring-sciences (accessed Mar. 07, 2021).
[36] R. Shaffer, *Beyond the dispensary*. Nairobi, Kenya: African Medical and Research Foundation, 1985.
[37] M. Ong, N. Jaumot-Pascual, and L. T. Ko, "Research literature on women of color in undergraduate engineering education: A systematic thematic synthesis," *J. Eng. Educ.*, vol. 109, no. 3, pp. 581–615, 2020, doi: 10.1002/jee.20345.
[38] T. J. Yosso, "Whose culture has capital? A critical race theory discussion of community cultural wealth," *Race Ethn. Educ.*, vol. 8, no. 1, pp. 69–91, 2005, doi: 10.1080/1361332052000341006.
[39] A. Agresti, *Statistical Methods for the Social Sciences*, 5th ed. Boston, MA: Pearson, 2018.