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Engaging Future Engineers through Active Participation in Diversity, Equity, Inclusion, and Belonging.

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Abstract

It is important for future engineers to understand themselves in relation to the many cultural influences they may encounter during their career, and to confront their own biases when interacting with colleagues whose cultural backgrounds are different from their own. This paper describes and evaluates a series of nine diversity, equity, and inclusion (DEI) workshops developed and implemented during the summer of 2022 for high school and entering first-year college students enrolled in the Research, Academics, and Mentoring Pathways (RAMP) six-week engineering summer bridge program at University of Massachusetts Lowell. The workshops incorporated activities designed to create an environment fostering respect, belonging, and acceptance to make teamwork more inclusive and effective.

Each workshop was based on collaborative learning and used a broad range of strategies to engage students as active participants in learning about diversity, equity, and inclusion within the context of teamwork. To develop the workshops, the facilitators aligned the activities with key themes from chapters in the book *From Athletics to Engineering: 8 Ways to Support Diversity, Equity, and Inclusion for All* [1].

The summer bridge program was evaluated using quantitative and qualitative data collected throughout the program and upon its conclusion tracking students' reactions and levels of engagement in each of the program components. This included a pre-survey, mid-semester survey, post-survey, and weekly journal prompts on Google Classroom. We also used the Universality-Diversity scale [2] to measure any pre-post changes in students' attitudes towards diversity. With regard to the workshops, an analysis of student responses indicated a high level of satisfaction and sense of accomplishment. Students reported they enjoyed getting to know each other better and that the DEI activities were interactive, educational, and engaging.

1.0 Introduction

It is important for future engineers to understand themselves in relation to the many cultural influences they may encounter during their career, and to confront their own biases when interacting with colleagues whose cultural backgrounds are different from their own. This paper describes and evaluates a series of nine workshops focused on diversity, equity, inclusion, and belonging that were integrated into the Research, Academics, and Mentoring Pathways (RAMP) six-week engineering summer bridge program at the University of Massachusetts Lowell (UML). The participants include twenty-three first year students transitioning from high school to engineering degree programs and eight high school students who were rising juniors and seniors.

The RAMP program is open to students of all genders and race/ethnic/socioeconomic backgrounds. It is designed to give students an early start in their engineering majors and help build a community of students, faculty, and staff across different engineering disciplines. For

high school students this is an opportunity to further explore their interest in engineering while building networks with students and mentors in the university.

Workshops, programs, and other initiatives to bring awareness to issues related to diversity, equity, and inclusion (DEI) in an organization (a workplace or an academic institution) have been around since the 1960s [3], [4], with questionable outcomes [5], [6]. However, during the summer of 2020, amidst the global pandemic, certain events such as the methods used by law enforcement officials in the treatment of Black American citizens, anti-Asian hate crime, and the exclusion of other minority groups prompted leaders and administrators to re-examine and restructure their DEI policies. Many organizations issued announcements, dedicated resources and pledged to make significant efforts to incorporate diversity, equity and inclusion initiatives into their cultures [7]. It was evident that simply talking about DEI in the workplace was not enough—it needs to be embedded as a core value of the organization to govern how it operates and how members of that organization ought to behave [8].

2.0 Defining Diversity, Equity, Inclusion, and Belonging

Diversity refers to differences [9] within a group or a population. With respect to people, these differences may include racial and gender identities, cultural and socio-economic status, ways of thinking, likes, dislikes, religious beliefs, sexual orientation, and personal experiences. It may also include age, body shape or size, disability, and many other characteristics. Diversity is an attribute of groups, not of individuals. An organization's efforts to address diversity have often focused on representation and promoting fairness [10], but this is just a superficial aspect. Diversity alone is not sufficient.

Equity is not the same as equality, so it is not about treating everyone the same and providing the same resources and ignoring differences. Equity is about accepting and embracing these differences and giving individuals what they need to succeed. A central goal of equity is fair treatment: "It is an action-based practice that requires organizations to identify and eliminate barriers that have historically prevented the full participation of all groups" [11].

Inclusion is the process of intentionally taking actions that allow employees to have a voice and valuing their contributions. Policies centered around inclusion foster a safe work environment free from oppression where employees can speak without fear.

Belonging is an emotional need to "affiliate with and be accepted by members of a group" [12]. When there is a sense of acceptance, individuals feel supported and included.

2.1 Importance of DEI in Engineering

Engineers invent, design, and apply systematic and creative approaches to problem solving. Working in teams, engineers face challenges and succeed in problem-solving. Hence, issues related to diversity, equity, and inclusion as well as belonging are critical for teamwork. Harding and Squires describe inclusive engineering as when the "engineering team and its leadership . . . welcome a diverse range of talent, and where necessary [take] deliberate action to provide equity" and the systems are as "accommodating as possible of the differences within the entire

stakeholder community" [13]. They argued that if these criteria are not met, then the outcomes may be one of low productivity or a production or design of a system that may not meet the needs of diverse global communities they serve [13]. In addition to diverse teams benefiting the communities, recent research shows that homogenous teams, i.e., teams with individuals with the same cultural background, education, life experience, and thinking are less effective in solving problems compared to more diverse teams [14, 15].

3.0 Overview of the RAMP program

The RAMP program is a six-week summer bridge program in the Francis College of Engineering for incoming first-year engineering majors and high school students. The main goal of this program is to increase the enrollment, retention, and accomplishment of students who are underrepresented in engineering fields and create pathways to successful graduation. RAMP was first offered in 2018 with an enrollment of 22 young women, all entering first year engineering students. Since then, it has been offered every summer for the past five years, and has broadened to include students of all genders, races/ethnicities, as well as a small cohort of high school students. A key goal for the RAMP program is providing participants with leadership skills early in their degree program and opportunities to exercise these skills during their tenure in the college.

Students in the RAMP program get a head start in engineering by building skills in computing, research, technical writing, and communication This summer program also helps them get accustomed to a college environment before entering as full-time students in the fall. Students are placed in a math course appropriate to their level, and take Introduction to Engineering, both for college credit. They also participate in two 90-minute DEI workshops twice a week. Throughout the program, students receive mentoring from faculty members and peer mentors, and participate in team research projects on a variety of topics. In 2022, these topics included acoustics, magnetic gears, environmental engineering, life-cycle analysis, and renewable plastics. The program culminates with the presentation of these team projects for the whole RAMP community of peers, near-peer mentors, faculty members, and industry participants.

4.0 Motivating Student Participation in DEI Sessions

Incorporating DEI sessions into the RAMP program required careful consideration of how to motivate students to participate, given research showing that requiring people to participate in these programs can limit their effectiveness [6]. With this in mind, rather than rely on external motivators such as grades or course credit, we decided fostering intrinsic motivation would be a better approach to encourage students to go outside of their comfort zones in group discussions, understand the connection between DEI and successful teamwork, become aware of environmental factors such as discrimination and systemic racism in academia and in workplaces, and internalize key lessons from DEI activities.

According to Fishbach & Wooley, intrinsic motivation is the "key for persistence at work. When they are internally motivated, people experience work activities as an end in itself . . . the result is increased interest and enjoyment in work activities" [16, p.339]. They further claim, "any variable that strengthens the association between the activity and the end goal will result in

stronger intrinsic motivation" [16, p. 343].

People are intrinsically motivated when their actions and behaviors are governed by internal rewards, i.e., the inherent satisfaction of completing a task [17] [18]. Ryan and Deci (2000) described intrinsic motivation as the "tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn" [19, p.70]. Hence, intrinsic motivation is deeply embedded in Self Determination Theory (SDT), as developed by Ryan and Deci [19] in the 1970s.

Self Determination Theory is based on three "innate psychological needs that are the basis for self-motivation and personality integration, as well as for the conditions that foster those positive processes" [19, p.68]. The first of these needs is 'competence.' This refers to an individual's knowledge, skills, and the ability necessary to succeed. The second need is 'relatedness.' This refers to the connectedness individuals have with one another [20]. Human beings have an inherent need to belong and have a sense of community and shared purpose [21]. The third and the last of these needs is autonomy. This refers to the freedom to fully endorse one's own actions, decisions, and initiatives [22].

In addition to these three psychological needs, Ryan and Deci [19] posit that environmental factors can also hinder or undermine self-motivation, social functioning, and personal well-being. With this in mind, we believe that issues related to diversity, equity, inclusion, and belonging among individuals within college classrooms and the workplace may contribute to these environmental factors, and hence need to be identified, explored, and resolved.

In this paper, we will demonstrate how a series of workshops were designed to create satisfying, hands-on activities fostering students' intrinsic motivation to increase their awareness and ability to address DEI issues in engineering education, as well as in engineering workplaces. Overall, we will answer the question: Can a DEI workshop series created for high school and entering college students from diverse backgrounds be considered engaging, helpful, and satisfactory by a majority of students?

5.0 Construction of the Workshops

We incorporated nine DEI workshops for students participating in the RAMP program. The activities for each workshop, which were facilitated by two of the authors of this paper, Lewis and Tripathy, were centered around the contents of the book *From Athletics to Engineering - 8 Ways to Support Diversity, Equity, and Inclusion for All* by Johnson and Webber [1]. The book, published following the aftermath of the killing of George Floyd, shares the authors' experiences in "coaching, mentoring, and leadership" [1, p.19] in eight short chapters that they assert can support diversity, equity, and inclusion at the workplace, and in the community. We chose this book as a resource for two reasons. First, it is not very lengthy and therefore easy for the students to read and digest. This book had also served in weekly reading and discussion in the previous year's RAMP program and the facilitators were familiar with the material. Second, the authors share their life experiences in athletics and in academia in each chapter. They present their personal triumphs and challenges, their career trajectories, and their interactions with others whose thinking and agendas were different. In addition, the chapters of the book are clearly laid

out and provide some profound advice and strategies that can be put into practice. The authors had also shared their goals and objectives for writing this book in a virtual conversation with last year's RAMP cohort.

5.1 Interactive Activities and Readings for Building Diverse Teams

Students were assigned two chapters from Johnson and Webber's book [1] to read each week and asked to write responses to four prompts for each chapter. The prompts given were:

- What message is conveyed to you in this chapter?
- Write down three things as bullet points that you find the most valuable from this chapter.
- List two things you want to discuss in our discussions.
- Give one concern you have.

Responses were submitted on Google Classroom, a platform that was familiar to the students. Each week included two DEI workshops except for week one, which had just one workshop. At the start of each week's first workshop, student responses to the chapter prompts were used as discussion points before engaging students in interactive activities addressing key concepts in DEI and teamwork.

When deciding on the activities to bring awareness to diversity, equity, and inclusion in teamwork, we focused on ways to promote the students' individuality and create a sense of belonging respectful of personal differences. The schedule of workshop themes, readings, and activities is presented in Table I, and examples of student work are shown in Fig. 1 and Fig. 2.

Fig. 1. Week 2: A group collage.

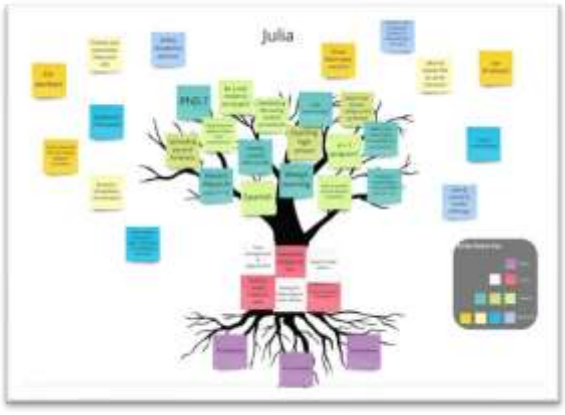

Fig. 2. Week 5: A student's core value tree

TABLE I

Workshop Themes, Readings & Activities

Workshop Themes	**Readings from [1]**	**Activities**
Week 1: Sharing Personal Goals, Expectations, Building Teams		Students experience global inequities through a simulated trading game revealing the importance of collaboration and teamwork (*The International Trading Game* [23]).
Week 2: Getting to know each other, personal identities and DEI: What does this mean to you?	*Chapter 1* (It Starts with Us) *Chapter 2* (Love your Neighbor)	Students create and share poster collages about what DEI means to them personally and to their group. They also discuss intersectionality and personal backgrounds.
Week 3: How to keep your career in orbit and recognizing/responding to microaggressions	*Chapter 3* (Talk about It) *Chapter 5* (Expand your Comfort Zone)	In groups, students share career plans/goals, and create role-plays about recognizing and responding to microaggressions.
Week 4: The effects of personal biases and building diverse teams	*Chapter 4* (Check your Biases & Blindspots) *Chapter 6* (Build Diverse Teams)	*The Parable of the Polygons—A Playable Post on the Shape of Society* [24] allows students to visualize the long-term societal impact of personal biases, and a team tower-building activity illustrates the value of diverse teams.
Week 5: Identifying and aligning core values with actions; key-takeaways from the workshop series	*Chapter 7* (Collaborate) *Chapter 8* (Align actions with Goals and Values)	Students draw "core value trees" to identify and reflect on their core values and align with actions (adaptation of B.Carr's "Live your Core Values" exercise [25]). The workshop series concludes with a spontaneous talent show and student summaries of key take-aways.

6.0 Evaluation of the Workshops

Student Demographics:

During Summer 2022, we recruited 23 entering first year engineering majors and eight high school students to participate in the RAMP program. The first-year engineering majors were recruited through applications published on the RAMP website, phone conversations, and information provided about RAMP in the Dean's letter to early-accepted applicants to engineering majors. High school students were recruited by emailing teachers in high schools partnering with the UML Francis College of Engineering, referrals from instructors, and an information session for students and families.

For students entering the College of Engineering, choice of majors was as follows: Electrical Engineering (6, 26%), Biomedical Engineering (6, 26%), Civil Engineering (4, 17%), Mechanical Engineering (3, 13%), Undeclared (2, 9%), Environmental Engineering (1, 4%) and Computer Engineering (1, 4%).

Fifteen entering college students identified as female and eight as male. Eight students (35%) identified as Hispanic/Latino, six as White (26%), five as Asian (22%), and three as Black/African American (13%). One student did not specify race/ethnicity (4%).

For the high school students, five identified as female (62.5%) and three as male (37.5%). Race/ethnic data was not available for the high school students.

Evaluation Method:

Our evaluation method included the design, administration, and analysis of three online surveys via Qualtrics and online journal entries via Google Classroom. These instruments were used to collect both qualitative and quantitative data and were designed to elicit student perspectives on their experiences in the RAMP program. Qualitative data included the online journal entries and open- ended questions on a mid-semester online survey. Quantitative data included pre- and post- online surveys using Likert-scale questions that asked students to rank different aspects of the RAMP program regarding satisfaction and learning accomplishments. We also utilized the Universality-Diversity scale [2] to measure any changes in students' attitudes towards diversity after participating in the DEI sessions.

As required by our university's institutional review board (IRB), students over age 18 provided consent to be photographed/videotaped for publication purposes and for our research team to collect and analyze their responses during the RAMP program activities and evaluation process. For students under the age of 18, their parents/guardians provided this consent.

Qualitative Data:

Each week, students had the opportunity to provide feedback about their experiences in RAMP via online journal prompts in Google Classroom. Open-ended questions included the following: What did you enjoy doing this week and why? What did you find challenging this week? Do you have any recommendations or suggestions for improving your experiences?

The number of students responding to the journal prompts varied from a high of 21 students during week three to a low of eight students during week five, with an average of 16.6 journal responses per week.

Students also had the opportunity to respond to open-ended questions about their experiences in RAMP during a mid-program online survey. Regarding the DEI sessions, students were asked, "Please indicate one thing you like and one thing that could be improved about the DEI sessions." Space was also available to provide general feedback on program activities.

Student feedback in the weekly journal entries and mid-semester online survey was mostly positive. Students characterized the RAMP program DEI sessions as fun, educational, interactive, inclusive, open-minded, collaborative (involving teamwork), challenging, hands-on, safe, relaxing (especially after math classes), and creative. In addition, the sessions were seen as an opportunity for students to get to know each other better.

With regard to challenges or aspects of the DEI sessions students felt could be improved, three students mentioned they were uncomfortable or disliked doing the skits and other activities, two students mentioned that having more time for the activities would be helpful, one student felt one of our worksheets for the microaggression skits was outdated (i.e., pre-legalization of gay marriage), and one student mentioned that they wished other students spoke more. All these suggestions were considered and when possible (such as the comments about needing more time), changes were made in the program to address these concerns. In some cases, such as the comments made about the skits, changes will be considered for next year's RAMP program.

In the weekly journal entries, students also commented specifically on what they learned in particular workshop sessions. For the first workshop, the trading game activity, one student mentioned the value of students figuring things out first on their own, before more explanation is given: *"I think working through the activity first helped me get a better idea of what we were talking about in the end because I had gone through the whole process of it myself."* For the poster collages on the theme, "What does diversity, equity, and inclusion" mean to you, one student observed: *"I found it interesting that no one put the same things down and everyone's theme was different."* And regarding the skits about biases and the polygon game, one student had this comment: *"The skit about biases taught me that there were many types of biases, and the polygon game made it easier to understand how to achieve diversity."* For another student, the outdoor tower-building activity provided an opportunity to practice teamwork and see the benefits of collaboration and diverse perspectives:

> *My favorite thing to do this week was the DEI class where we had to build the tallest building. I really liked this because we all had different views on how we could build the tallest and strongest building. It took us a little while to agree,*

however, when we did agree on what to do, our structure won overall.

Finally, during the last DEI session, our lunch was delayed. So, while we were waiting, one of the instructors invited students to participate in an impromptu "RAMP program Talent Show," which was highly appreciated. In one student's words: *"I do think y'all should have 'RAMP's Got Talent' every year. It allows us to learn more about each other and it is also a nice break from straight class work."*

One issue that came up in the workshops was whether students should choose who they sat with at the group tables, or if these groups should be assigned by the instructors. Some students mentioned they liked getting to know new people, whereas others felt uncomfortable with this. In the words of one student:

> *I found it challenging accomplishing tasks and activities in a group because it is hard for me to work with different people that I don't usually work with. I would suggest to keep partnering with my friends and classmates that I know very well to help improve my experiences.*

From an instructor viewpoint, encouraging the students to go beyond their comfort zones and work with new people was helpful in keeping all students engaged and avoiding situations where most of the students knew each other at a table but one or two were left out. So we decided to vary how groups were formed—sometimes assigning them, and sometimes allowing students to choose. In this way, students learned that we listened to their perspectives.

Quantitative Data:

To triangulate the qualitative data collected through journal entries and open-ended survey questions, we collected and analyzed quantitative data regarding the students' perceived impact of the DEI sessions. In the online post-survey, using a Likert-style scale, we asked students to rank eight aspects of the RAMP program with regard to the following two questions: 1) How satisfied were you with the following RAMP program activities? and 2) What have you accomplished by participating in the RAMP program?

For the first question, the RAMP program activities ranked included the following: Calculus class, Calculus tutoring, Introduction to Engineering, Industry partner meetings, Near-peer mentors, Writing computer programs, DEI sessions, and Research project experience. 19/31 students responded to this question (61%). On a scale of five, from "very dissatisfied" (1) to "very satisfied" (5), the DEI sessions were ranked the highest, with a mean of 4.7. The next highest ranked activity was near-peer mentors, with a mean of 4.5 (see Fig. 3 below).

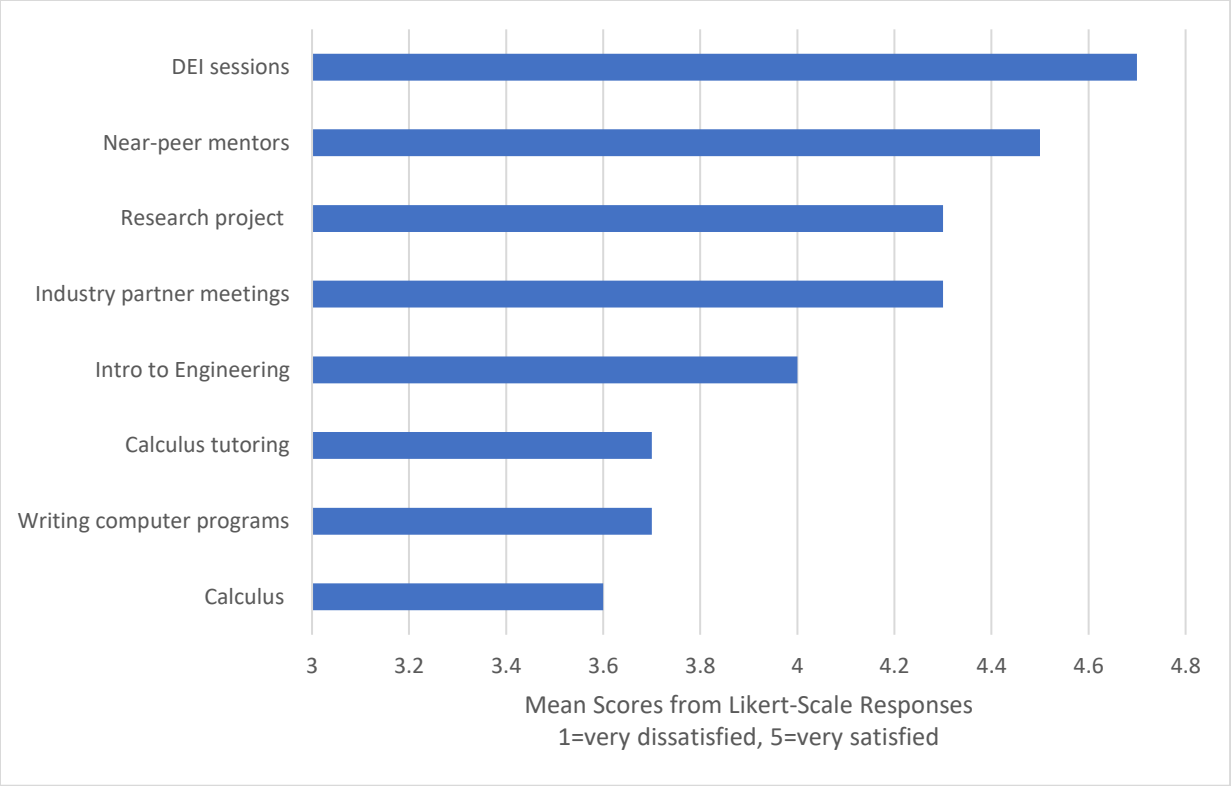

Fig. 3. Student satisfaction with RAMP program activities (N=19)

For the second question, students were asked to rank eleven possible accomplishments they may have made during the RAMP program on a scale of four points, from "not accomplished" (1) to "well accomplished" (4). This list of accomplishments was generated from responses about expected accomplishments made by the students during the pre-survey, and included the following: learned more about engineering programs, college life, engineering industries, how to become an engineer, the life of an engineer, the importance of DEI; got a head start on academic work; improved my study skills; made connections with professors, industry partners; made friends with other students. 13/31 students responded to this question (42%). In the Likert-style rankings of these accomplishments, "the importance of DEI" was ranked the highest, with a mean of 3.8. The next two highest ranked accomplishments were "got a head start on academic work" (3.7) and "learned about college life" (3.7) (see Fig. 4 below).

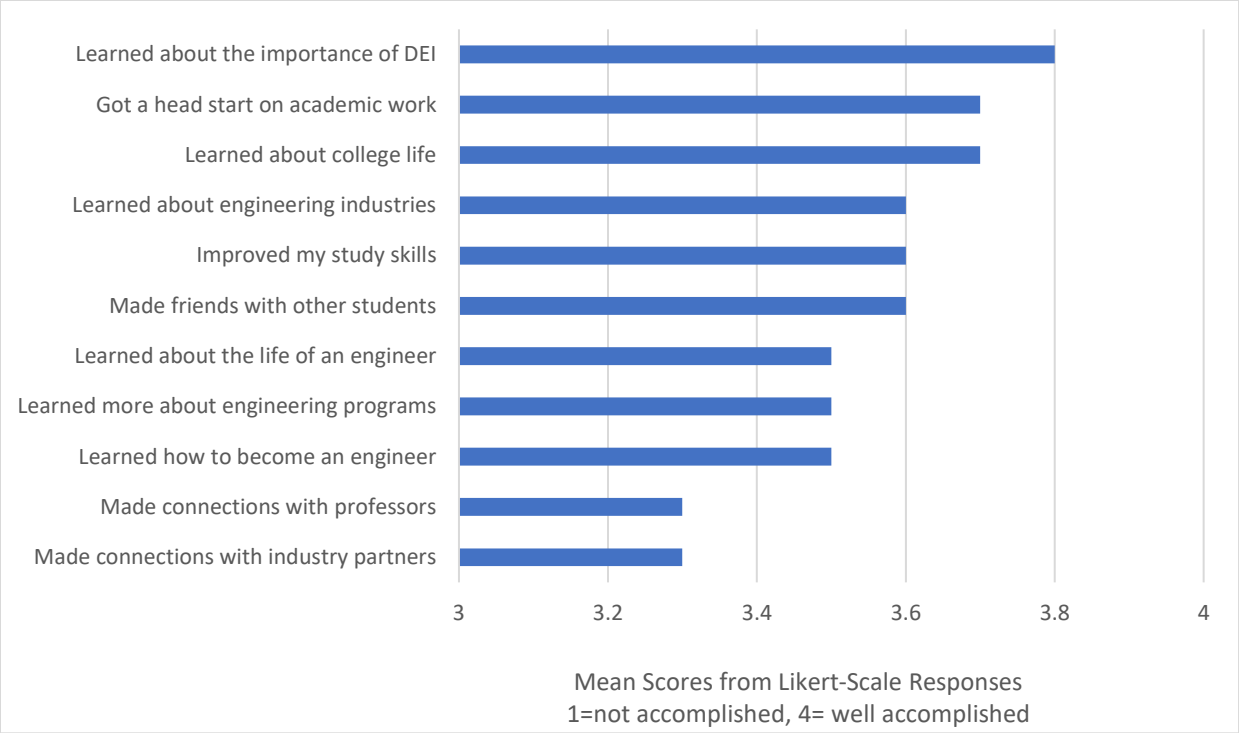

Fig. 4. Student perception of their accomplishments during RAMP (N=13)

The ranked responses to these two questions align with the positive student responses regarding what they learned in the DEI sessions noted in the qualitative data analysis. This analysis further suggests that these sessions may have fostered intrinsic motivation by engaging students in activities they considered to be satisfying, helpful in learning about DEI, and interactive with other students.

To assess any changes in attitudes towards diversity after participating in the DEI sessions, we used the short form of the Universality-Diversity scale [2] on both a pre-survey (administered before participation in the DEI classes) and post-survey (administered after the DEI classes). This scale includes questions assessing the following characteristics: interest in learning about different cultures, countries, and ethnicities; relativistic appreciation of differences and similarities; and discomfort with people from different ethnic/racial backgrounds. The scale is comprised of 15 Likert-style questions.

Eight out of a total of 31 students (26%) completed the Universality-Diversity scale [2] on both the pre-survey and post-survey, limiting the significance of this comparison. However, for these eight students, comparison of the pre-survey and post-survey mean responses to the scale questions shows a statistically significant increase (paired two-sample t-test, $P = 0.00052$) for the first ten questions (indicating greater interest in learning about different cultures, countries, ethnicities and greater relativistic appreciation of differences and similarities), but did not show a statistically significant change for the last five questions (indicating comfort levels with people from different ethnic/racial backgrounds). We hope to repeat this pre-post evaluation using this scale with future cohorts of DEI participants in the RAMP program to achieve a better response rate and more meaningful comparison.

Limitations:

Limitations of our evaluation strategy include the low response rate on the online surveys and the variation in the number of responses to the online journal prompts. In addition, given that participation in RAMP is voluntary and our research design did not include a control group, it is possible that students who chose to attend the RAMP program and respond to our evaluations were predisposed to be receptive to learning about DEI (i.e., selection bias).

7. Conclusion

The DEI workshop series that was built into the RAMP six-week summer bridge program in the Francis College of Engineering at the University of Massachusetts Lowell for incoming first-year engineering majors and high school students was met with enthusiasm by a majority of the participants. They enjoyed learning about each other, sharing goals, discovering the value of diverse teams, and discussing anticipated challenges in engineering majors and careers. The high degree of satisfaction and sense of accomplishment reported by students in both the post-survey and the journal entries is important, considering research demonstrating that one of the reasons DEI workshops may not produce long term changes is because participants experience negative reactions such as feeling coerced or confused during the training sessions [6].

This coming year, we plan to follow up with the 2022 RAMP program participants to understand more about the outcome of our workshop series and incorporate what we learn into the design of subsequent DEI workshops during the RAMP 2023 program. We will also investigate how these workshops could be integrated into department and course level activities, particularly for engineering students who did not participate in RAMP. We believe that when students are exposed to DEI training during their education, they feel more comfortable and safer when addressing issues connected to DEI in the workplace later in life. Additionally, when students learn to understand and accept cultural differences with their peers, they learn to interact with a wider range of social groups and feel more confident in themselves and with their social interactions with others. For these reasons, DEI concepts and skills presented in an interactive, engaging way are necessary additions to engineering curricula.

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