ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #45289

Revisiting Assessment Tools Used to Measure the Impact of Summer Program Interventions on Perceptions and Interest in Engineering Among Underrepresented Pre-College Students – A Work in Progress

Zeynep Ambarkutuk, Virginia Polytechnic Institute and State University

Zeynep Ambarkutuk is a doctoral student in the Educational Psychology program at Virginia Tech. Her research interests include motivation, motivation interventions, and the effect of identity and culture on motivation and learning.

Jesika Monet McDaniel, Virginia Tech Department of Engineering Education

Jesika is an accomplished graduate of Virginia Tech, holding degrees from both the College of Engineering and the School of Education. Her passion for education led her to become a dedicated K-12 STEM Educator. In this role, Jesika is committed to introducing and inspiring students from diverse backgrounds and cultures to the intricacies of STEM (Science, Technology, Engineering, and Mathematics).

With a specific focus on encouraging underrepresented students, Jesika has been actively involved in developing and implementing curriculum. Her innovative approach aims to cultivate a love for STEM subjects and motivate students to pursue higher education in these fields. Over the past five years, Jesika has played a pivotal role in directing various summer enrichment programs designed to provide students with hands-on experiences and valuable insights into the world of STEM.

Jesika's work is not just about imparting knowledge; it's about fostering a sense of curiosity and empowerment in her students. Through her dedication and contributions, she continues to make a meaningful impact on the next generation of STEM enthusiasts, particularly those who may not traditionally have had access to such opportunities.

Cynthia Hampton Ph.D., Virginia Polytechnic Institute and State University

Cynthia Hampton is a postdoctoral fellow with the Center for the Enhancement of Engineering Diversity (CEED) at Virginia Tech.

Dr. Kim Lester, Virginia Polytechnic Institute and State University

Dr.Lester serves as the Coordinator of Pre-College Programs at Virginia Tech's Center for the Enhancement of Engineering Diversity. She also worked as a global engagement specialist in the Office of Global Engineering Engagement and Research at Virginia T

Pre-college, Race/Ethnicity, Gender, Engineering

Revisiting Assessment Tools Used to Measure the Impact of Summer Program Interventions on Perceptions and Interest in Engineering Among Underrepresented Pre-College Students – A Work in Progress

Abstract

Students start their education in STEM (Science, Technology, Engineering, and Mathematics) fields with the aim of having STEM-related careers. However, many students who are in such programs, particularly those from historically underrepresented groups, drop out, change majors, or ultimately do not pursue STEM-related careers [1]. It is important to attract and retain students in STEM fields by understanding their experiences in such programs. The expectations for success, sense of belonging, interest, and perceived relevance are critical factors for students to embrace; therefore, interventions that effectively foster these perceptions, particularly early in their education such as during high school, can significantly enhance the success of underrepresented groups in STEM fields. Four such programs exist at a large, four-year institution in the Southeast. The focus of this work is the revision and assessment of the tools to ensure they effectively capture the nuances of participants' experiences and identify any challenges encountered during implementation. For this purpose, the evaluation of these programs included a combination of different assessment tools. The Likert-type surveys employed to capture participants' experiences and attitudes toward engineering, administered pre- and post-camp. Activity surveys assessed perceptions of specific activities and their effectiveness in engaging students. Pre- and post-camp focus groups provided qualitative insights into participants' experiences and camp effectiveness. Preliminary findings highlighted improvements in data collection and cleaning tools, focus group setup, and the use of established frameworks. These assessments helped coordinators refine their methods and enhance student engagement. In this work in-progress that began in the Spring of 2024, we present lessons learned to guide future programs and their evaluations, focusing on both quantitative and qualitative data collection methods.

Introduction

Effectively capturing how science, technology, engineering, and mathematics (STEM) outreach programs shape participants' experiences, perceptions of the program, and attitudes toward engineering requires careful considerations and use of research-based methods. This includes careful planning, attentive implementation, the selection of appropriate tools, and rigorous interpretation of the resulting data. In this study, we explore the necessary changes and considerations for collecting data, capturing relevant insights from participants, and documenting the process to achieve these objectives in four STEM outreach programs held during the summer of 2024.

The increasing demand for skilled professionals in STEM underscores the importance of attracting and retaining students in these fields. According to projections, the workforce needs for engineers are expected to grow significantly, driven by advancements in technology and the evolving nature of the global economy [2]. However, this anticipated growth presents a challenge: women and minorities remain significantly underrepresented in STEM occupations, despite various initiatives aimed at increasing diversity and inclusion [3]. This lack of representation limits the diversity of thought and innovation within these fields. Further, equity-based barriers to access for underrepresented groups remain a constant and increasingly fraught component of attracting and retaining talent to pursue opportunities in STEM.

Research has shown that underrepresented students are more likely to experience challenges that can lead to higher dropout rates or shifts away from STEM careers [1], [4]. These challenges are often rooted in a combination of factors, including stereotype threat, a lack of role models, and an unwelcoming academic climate [5]. Addressing these issues requires a deep understanding of how students perceive their programs and the broader educational environment, and how these perceptions influence their motivation, engagement, and long-term commitment to pursuing a career in computer science or engineering. Additionally, frameworks around "fixing the student" or deficit-based, compared to community cultural wealth approaches that center contributing factors that marginalized groups bring to engineering and computing from their families and communities [6], have increasingly emerged in rhetoric around intervention-based work. To this end, evaluating educational interventions, such as summer camps specifically designed for underrepresented groups, is crucial. These programs offer a unique opportunity to assess what strategies are effective in fostering a supportive learning environment and what areas require further improvement. By examining the experiences of participants in these summer camps, we aim to identify the factors that contribute to their sustained interest in engineering and the barriers that may hinder their progress. Further, STEM intervention programs towards broadening participation face unique challenges such as changing of funding sources over time, inadequate staffing and service delivery, and long-term program sustainability [7].

Educational interventions, particularly those aimed at increasing diversity in STEM fields, often employ iterative design cycles to refine and enhance their effectiveness. These design cycles are grounded in the principles of design-based research (DBR), a methodology that emphasizes the importance of developing and refining educational interventions through iterative processes in real-world settings [8]. DBR integrates the collaborative efforts of researchers and practitioners, allowing them to work together to address complex educational challenges and create practical solutions that can be directly applied in classroom or program settings.

A key feature of DBR is its cyclical nature, where initial designs are tested, evaluated, and revised based on empirical evidence. This approach allows for continuous improvement, ensuring that interventions are not only theoretically sound but also practically effective in fostering student engagement and learning. By involving educators in the research process, DBR ensures that the interventions are grounded in the realities of the classroom, making them more likely to be adopted and sustained over time [9],[10],[11].

Relatedly, broadening participation in STEM has attempted to follow a research-to-practice cycle, in which the results of studies on existing and emerging phenomena are applied in educational settings. An expanded view of these cyclical design-based and research-to-practice principles is one that includes *knowing, documentation, creation,* and *doing* [12]. This expanded view acknowledges that in approaches to broadening participation, a common method is to attempt to create new interventions and strategies without understanding and documenting what is currently in use, as described by London et al. [12] in the context of broadening participation of Black Americans in engineering. In line with this expanded view, the purpose of this paper is to apply the 'know, document, create, and do' frameworks within the context of assessment in the summer programs held in 2024. Therefore, the authors sought to explore the question: *What changes and considerations are necessary for documenting, collecting, and analyzing data in order to capture participant experiences in four programs during the summer of 2024 outreach program cycle?*

Overview of the Programs and Assessment Methods Used

The summer camps at [University's] [Center] include various programs spanning pre-college outreach to graduate student support. In preparation for the summer of 2024 pre-college programs, the authors focused on four distinct programs: a 2-week residential program for rising 11th and 12th grade high school women interested in engineering *(GAMMA Program);* a 2-week residential program for rising 11th and 12th grade Black/African-American high schoolers interested in engineering *(BETA Program)*; a 2-week residential program for rising 11th and 12th grade high school women interested in microchip manufacturing *(MU Program)*; and a 5-week summer bridge program for incoming engineering first-year students *(UPSILON Program).* Each of these programs had its own specific audience and unique differences, tailored to meet the needs of students in engineering.

For the BETA, GAMMA, MU, and UPSILON programs, the authors began discussions in January 2024 to consider increased coverage of qualitative and survey-based data collection. As is the nature of managing outreach programs, the combined tasks of assessing, evaluating, and facilitating interventions can be daunting. Therefore, in revisiting the assessment and evaluation, we looked at what was currently being done and the validated instruments used and needed, including Likert-type scales and open-ended questions, to measure student engagement, motivation, and overall program effectiveness. These instruments provided reliable and consistent data, which was crucial for assessing the impact of the interventions. While validated instruments formed the backbone of our evaluation, we also recognized the need for creating tailored measurement tools that addressed the specific contexts of the programs. These tools were developed in consultation with the program directors. Ensuring high response rates required clear communication with participants and a dedicated period for participants to complete the surveys. Below, we will explain each of these programs and the assessment tools developed and used for each.

BETA Program

BETA provides hands-on learning experiences in STEM fields with a focus on engineering, specifically aimed at interest development for college and foundational skills development for

participants. To evaluate the impact of BETA, we employed pre- and post-test Likert-type items. Scalable items were developed from the F-PIPES (Fit of Personal Interests and Perceptions of Engineering) [13], [14] instrument, which measures perceptions of engineering as well as the STEM-CIS (STEM Career Interest Survey) [15] tool measures self-efficacy and interest in STEM classes and careers. The surveys included a pre-survey before arriving on campus, a survey at the end of week 1 and week 2 to capture feedback on specific activities, and a post-survey at the end of BETA. All surveys were available via QR code for mobile devices. The post-surveys include whether students found material in the individual program sessions relevant to their goals, contained new knowledge, and presented in a learning-conducive way. The survey of activities spanned departments in engineering [16].

Additionally, we conducted pre- and post-camp focus groups. These focus groups involved meeting with a groups of 12-15 students in a room setting to discuss their experiences, expectations, and any changes in their perceptions of engineering. Focus groups were audio recorded, and students sat in circles of chairs or at a conference style table. One-hour time blocks were built into each of the programs' schedules so that participants could see the location and times of the focus groups and who was conducting the focus groups. An explanation of the focus group and the purpose was communicated to students at the beginning of each session. Example focus group questions for each program can be found in Appendix A.

GAMMA Program

GAMMA is a two-week summer camp that targets high school girls and introduces them to engineering and technology through a variety of hands-on activities, lab visits, and interactions with role models in the field. Similar to BETA, we used pre- and post-test Likert-type items from the F-PIPES and STEM-CIS surveys, along with pre- and post-camp focus groups. Like BETA, surveys included a pre-survey before arriving on campus, a survey at the end of week 1 and week 2 to capture feedback on specific activities, and a post-survey at the end of GAMMA. All surveys were available via QR code for mobile devices. The focus groups for GAMMA were designed to capture the unique experiences of female students in a predominantly male field and to assess how the camp influenced their interest in pursuing a career in engineering.

MU Program

MU is designed to support high school girls to develop interest in engineering fields, specifically related to microelectronics manufacturing and cleanroom fabrication (e.g., electrical, computer, material science, and chemical engineering fields). Activities are lab-based as well as social and include engagement with corporate and industry partners. At the request of the MU directors and because this program was being offered for the first time, only pre- and post-camp focus groups occurred.

UPSILON Program

UPSILON program (summer bridge) is aimed at incoming first-year engineering students. This five-week program provides a head start on college life by offering academic support, mentoring, and exposure to engineering coursework before the start of the fall semester. Given the extended

duration and the target audience, we employed a more rigorous assessment method for UPSILON. This included the use of the MUSIC Model of Academic Motivation [17], Expectancy-Value Theory [18], and School Belonging [19] framework to assess students' motivation, expectations, and sense of belonging. The assessments were comprehensive, involving a combination of Likert-type items and open-ended questions to measure the students' transition into college life and their preparedness for engineering coursework. For the evaluation of UPSILON, we used a longitudinal design, administering Likert-type and open-ended items at the beginning, during the first week, third week, and at the end of the program. This approach is intended to capture the evolution of students' motivation, sense of belonging, and engineering identity development, as well as changes in their short-term and long-term goals. The schedule of surveys for UPSILON specifically is included in Appendix B at the end of this work in progress paper.

Considerations Throughout the Evaluation Process

The considerations represented in this work in progress were the first time in multiple years that the scale, types, and coordination of assessment has been revisited in a more intentional way – especially post-shutdowns of 2020-2022. In revisiting the evaluation of the summer camps several key considerations were central to ensuring the effectiveness and accuracy of the assessments. We present the below categories that were essential in exploring: *What changes and considerations are needed for documentation, data, and collection to capture participant experiences in four programs during the summer of 2024 outreach program cycle?*

Collaboration with Program Directors

From the outset, we held regular meetings with the program directors to understand their specific needs and goals for each camp. These discussions were crucial in shaping the assessment tools, as they provided direct insights into what the directors wanted to learn about their programs. This collaborative approach ensured that the evaluation aligned with the program objectives and allowed us to create and refine assessment tools relevant and targeted. As an example, the UPSILON program (summer bridge) director communicated a need for a new assessment strategy, including tools. The primary reason for needing to pilot an assessment strategy was due to no consistent formal instruments being used, changes in program directors, and transitions that occurred at the height of 2020 due to campus/residential shutdown followed by a slow reintroduction to residential intervention programming. The schedule of surveys coordinated for UPSILON is provided in the appendix. In comparison, the MU program (microelectronics) technical leads wanted a focus group assessment process to gain understanding of the experiences of participants before instituting any form of survey methodology. The conversations with program directors occurred during the late fall and spring semesters prior to the 2024 summer program cycle.

Dedicated Periods for Surveys

A significant consideration was establishing a dedicated period for students to complete the surveys. Based on experience from previous years, we knew that survey response rates tended to drop when no specific time was allocated for this purpose. To address this, we worked closely

with the program directors to schedule dedicated time slots during the camp sessions for survey completion. This strategy was vital in maintaining high response rates and ensuring that the data collected was representative. In the case of new surveys in UPSILON (summer bridge), the 5-week duration of the program meant that the spacing of the surveys was also important and could align with key experiential components such as academic testing and midpoints of the program that were observed in previous years to be pain points.

Balancing Reliability, Validity, and Parsimony

In designing the surveys, we aimed to balance reliability and validity with the need for parsimony. While it was essential to include enough items to ensure the reliability and validity of the instruments, we also wanted to keep the surveys concise to avoid survey fatigue and encourage higher response rates. This balance was crucial in obtaining accurate and meaningful data while maintaining participant engagement. Completing the surveys can only be encouraged, so this delicate balance is something that was closely considered. Where possibly, if participants provided pertinent programmatic feedback on pre-surveys, there was an attempt to share aggregate feedback to key personnel, such as program directors and coaches/mentors for accomplishable adjustments or needed clarifications in real time. In some way, we hoped this would also show the assessments as providing utility in the viewpoint of the participants.

Flexibility in the Assessment Process

The evaluation process required a degree of flexibility, particularly in refining the assessment tools based on initial findings. Insights gained from the pre-tests and pre-focus groups led to adjustments in the post-tests. For example, if a particular question did not yield useful information during the pre-test, we revised or removed it in the post-test to improve the quality of the data collected. This iterative approach allowed us to continuously refine our tools to better meet the needs of the evaluation. This practice was particularly helpful for the new assessment process piloted for UPSILON and to accommodate the scheduling and constraints of the director and staff to accommodate changes in the program schedule.

Considerations for Focus Groups

When planning and conducting the focus groups, several key considerations were addressed to ensure a supportive and productive environment. We reviewed relevant literature on focus group methodologies and consulted with facilitators who had experience working with similar audiences [20], [21]. The protocol used for the focus groups is available upon request.

Given the age of the participants and the sensitive nature of discussing gender and racial issues, certain ethical considerations were paramount. It was important to create an environment where students felt comfortable and willing to share their thoughts. To facilitate this, we began each session with an ice breaker activity where students were asked to show a GIF or emoji that represented their current emotion. This activity helped to lower barriers and encouraged openness among participants. Participants also interacted or commented on each other's choices which assisted in comfortability, especially during the pre-focus groups that were conducted on day 2 of the programs meaning that participants had limited peer-to-peer interaction up to that

point. To further reduce anxiety, we provided students with processing guides and pencils. These guides included focus group questions, allowing participants to jot down notes or simply doodle if they felt nervous. This small adjustment proved effective in helping students feel more at ease during the discussions.

The focus groups were conducted by two facilitators not involved in designing or facilitating the camps. This separation was explicitly communicated to the participants to ensure that they felt comfortable expressing their honest opinions. After the initial introductions, the facilitators clearly outlined the discussion rules, emphasizing the importance of mutual respect and the value of every opinion. Participants were encouraged to comment on each other's points, and it was made clear that there were no right or wrong answers to any of the questions. Additionally, if a participant was being talked over, or not able to insert their thoughts into a discussion, attention was paid to follow up and call upon those individuals so that listening and acknowledgment was modeled for focus group participants. Attention was also paid as to whether a participant was taking up most of the discussion space, and if so, observation to identify others trying to comment was done to call on those individuals.

Hiring a Graduate Assistant for Program Evaluation

Administrative internships can offer assessment opportunities for graduate students and professionals in education, evaluation, and higher education with the results of evaluation processes and data contributing to improvement of programming [22]. For the intern, the experience can provide real-time application and experience, especially if the experience can enhance cultural competency needed in the evaluation and programmatic space. As a recommendation of Rincon and George-Jackson [7], results of these internship-type outputs of evaluation and assessment processes can contribute to legitimacy and potential funding avenues by providing evidence of impact.

For the first time, an intern was hired to help evaluate the summer camps. The intern, a Ph.D. student in Educational Psychology with research interests in academic motivation, engagement, and their effects on identity development, brought a valuable perspective to the process. Working closely with the program directors and a research fellow, the intern played a crucial role in communicating the specific needs of each program.

The assistant's expertise in educational psychology was instrumental in finding and applying validated instruments for the assessment of UPSILON (summer bridge). Being from outside the organization, they provided a fresh perspective that contributed to the evaluation process's effectiveness. Their involvement ensured that the assessment tools were both rigorous and relevant, aligning with the program's goals and the broader objectives of understanding student motivation and engagement.

Data Cleaning and Management

For the data management process, we used different platforms based on the needs of each program. For the first three camps (BETA, GAMMA, MU), we utilized Google Forms, while for the UPSILON program, we opted for QuestionPro. After collecting the data, the files were

meticulously cleaned in Excel to remove incomplete and repeated responses. This data cleaning step was crucial in ensuring the integrity and accuracy of the final data set, providing a solid foundation for subsequent analysis.

After the data cleaning, the quantitative data will be analyzed to identify trends and measure the effectiveness of the interventions. The qualitative data, which includes open-ended survey responses and focus group transcripts, will be coded to identify key themes. These results will then be reported to the program directors to inform the refinement of the programs for Summer 2025.

Preliminary Findings

The findings from the evaluation of four summer outreach programs can be categorized into two main areas: insights into students' perceptions of the program and engineering, and lessons learned for refining both the evaluation methods and the structure of future camps to improve their effectiveness.

To understand students' perceptions of the camp and their attitudes toward engineering, we began by cleaning the data—removing duplicate responses, excluding students who completed the survey significantly faster than others (indicating they may not have read the questions), and discarding incomplete responses. After data cleaning, we averaged the scores for key constructs from the Likert-type survey items. Preliminary findings suggest that participants maintained high levels of motivation and engagement, as reflected in their consistent scores across the MUSIC Model constructs [17], Expectancy-Value Theory [18], and belonging [19]. Specifically, for the UPSILON program, preliminary findings revealed an increase in students' engineering identity (the extent to which students see being good at engineering as part of their self-concept) and confidence in their ability to succeed in future engineering coursework, along with a strengthened sense of belonging within the engineering community. The visualization of the collected quantitative data from the UPSILON program, across four data points for participants' program perceptions and their motivational beliefs, can be found in Appendices C and D. Qualitative feedback from the open-ended survey items emphasized the value of hands-on learning and the social aspects of the camp, while also identifying opportunities for improvement, such as increasing activity variety.

The findings for the program evaluation emphasized the critical importance of collaboration with program directors to ensure that assessment strategies were aligned with specific program goals. Tailored planning was essential, as the unique nature and audience of each program required specialized evaluation methods. A one-size-fits-all approach was not feasible; understanding the distinct needs of each program was essential. Moreover, overly idealistic assessment goals were impractical, necessitating realistic timelines and logistical considerations for administering assessments. Factors such as the time available for students to complete surveys, the optimal settings for administering them, and the appropriate frequency of assessments were carefully calibrated. While deliberate scheduling helped maintain response rates, they were still around 75%. Selecting well-established, reliable, and valid assessment tools was vital to preserving the evaluation's integrity and enabled us to interpret responses more systematically. Flexibility in

refining the tools, particularly for focus groups, was crucial for adapting the evaluation process based on early findings.

Conclusion

The perception of the educational programs plays a significant role in shaping students' motivation, academic engagement, their goals, and ultimately their development of a science identity [23], [24]. When students develop a strong interest in the subject matter, perceive themselves as capable of success, and experience caring relationships, feelings of belonging, and a sense of being valued, they are more likely to see themselves as future engineers. These elements are critical in fostering a science identity where students not only engage with STEM fields but also envision themselves pursuing careers in these areas.

Through the summer camps, we aim to provide these essential experiences to the participants. Our goal is to create an environment where students can develop a deep interest in engineering, feel confident in their abilities, and form meaningful connections that support their sense of belonging. By evaluating whether these perceptions influence their identity development, future goals, and behaviors, we can better understand the impact of these programs.

For future administrators and practitioners wishing to implement similar interventions, here are the major takeaways from our work:

- Maintain regular communication with program directors to align goals and assessment strategies.

- Allocate dedicated time slots for surveys to ensure high response rates, considering participant availability.

- Use validated, reliable tools, balancing thoroughness with parsimony to prevent survey fatigue.

- Incorporate both quantitative and qualitative assessments to capture the diverse experiences of participants and enhance validity.

- Be prepared to revise assessment tools based on early feedback; adjust focus groups and surveys as needed.

- Create a supportive environment with icebreakers and external facilitators to encourage honest feedback.

- Consider hiring graduate assistants or interns to bring fresh perspectives and ensure rigorous assessment practices.

The lessons learned from the summer of 2024 have provided valuable insights into how we can refine both the programs and our evaluation methods. These insights will be applied to the summer of 2025, ensuring that the camps continue to evolve and effectively support the identity development and future aspirations of underrepresented students in engineering.

References

[1] Myers, C. B., & Pavel, D. M. (2011). Underrepresented students in STEM: The transition from undergraduate to graduate programs. Journal of Diversity in Higher Education, 4(2), 90.

[2] National Science Foundation, National Center for Science and Engineering Statistics. (2023). Diversity and STEM: Women, minorities, and persons with disabilities 2023 (NSF 23-315). Retrieved from https://ncses.nsf.gov/pubs/nsf23315/report/stem-occupations#characteristics-of-the-stem-workforce.

[3] National Science Board. (2023). Science and Engineering Indicators 2023: The State of U.S. Science and Engineering. National Science Foundation. Retrieved from https://ncses.nsf.gov/indicators.

[4] Robinson, K. A., Perez, T., Nuttall, A. K., Roseth, C. J., & Linnenbrink-Garcia, L. (2018). From science student to scientist: Predictors and outcomes of heterogeneous science identity trajectories in college. Developmental psychology, 54(10), 1977.

[5] Eddy, S. L., & Brownell, S. E. (2016). Beneath the numbers: A review of gender disparities in undergraduate education across science, technology, engineering, and math disciplines. Physics Education Research Conference Proceedings, 13(3), 79–89. https://doi.org/10.1103/PhysRevPhysEducRes.13.020108.

[6] Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. Race, Ethnicity and Education, 8(1), 69–91. http://dx.doi.org/10.1177/07399863910131002.

[7] Rincon, B. E., & George-Jackson, C. E. (2016). STEM intervention programs: funding practices and challenges. Studies in Higher Education, 41(3), 429-444.

[8] Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. Educational Researcher, 32(1), 5-8.

[9] Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? Educational Researcher, 41(1), 16-25.

[10] Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. Educational Researcher, 18(1), 32-42.

[11] Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. Journal of the Learning Sciences, 13(1), 1-14.

[12] London, J. S., Lee, W. C., Watford, B. A., Ash, C. H., Holloman, T., Pee, C. M., & Hampton, C. (2022). Climbing uphill: Toward a common agenda for the advancement of Black Americans in engineering. Journal of Women and Minorities in Science and Engineering, 28(3).

[13] Moore, Tamara J.; Guzey, Selcen; and Harwell, Michael, "Development of an Instrument to Assess Attitudes Toward Science, Technology, Engineering, and Mathematics (STEM)" (2014). School of Engineering Education Faculty Publications. Paper 79. http://dx.doi.org/10.1111/ssm.12077.

[14] Hynes, M. M., Maxey, K. R., & Su, R. (2021, July). Development of the Fit of Personal Interests and Perceptions of Engineering Survey (F-PIPES) Instrument (Fundamental). In 2021 ASEE Virtual Annual Conference Content Access.

[15] Kier, M. W., Blanchard, M. R., Osborne, J. W., & Albert, J. L. (2014). The development of the STEM career interest survey (STEM-CIS). Research in Science Education, 44, 461-481.

[16] McDaniel, J. M., Hampton, C., & Lester, K. (2024, February). Considerations for assessment, evaluation, and continuous improvement of a pre-college STEM summer program for promising Black high school students. In 2024 Collaborative Network for Engineering & Computing Diversity (CoNECD).

[17] Jones, B. D. (2009). Motivating students to engage in learning: The MUSIC model of academic motivation. International Journal of Teaching and Learning in Higher Education, 21(2), 272-285.

[18] Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values and academic behaviors. In J. T. Spence (Ed.), Achievement and achievement motives (pp. 75-146).

[19] Goodenow, C. (1993a). The psychological sense of school membership among adolescents: Scale development and educational correlates. Psychology in the Schools, 30(1), 79–90.

[20] Parker, A., and J. Tritter. 2006. “Focus Group Method and Methodology: Current Practice and Recent Debate.” International Journal of Research & Method in Education 29 (1): 23–37. https://doi.org/10.1080/01406720500537304.

[21] Krueger, R. A., & Casey, M. A. (2008). Focus groups: A practical guide for applied research (4th ed.). Thousand Oaks, CA: Sage.

[22] George-Jackson, C. E., and B. Rincon. 2012. “Increasing Sustainability of STEM Intervention Programs Through Evaluation.” In Advancing the STEM Agenda: Quality Improvement Supports STEM, edited by J. Furst-Bowe, F. Padro and C. Veenstra. Milwaukee, WI: ASQ Quality Press.

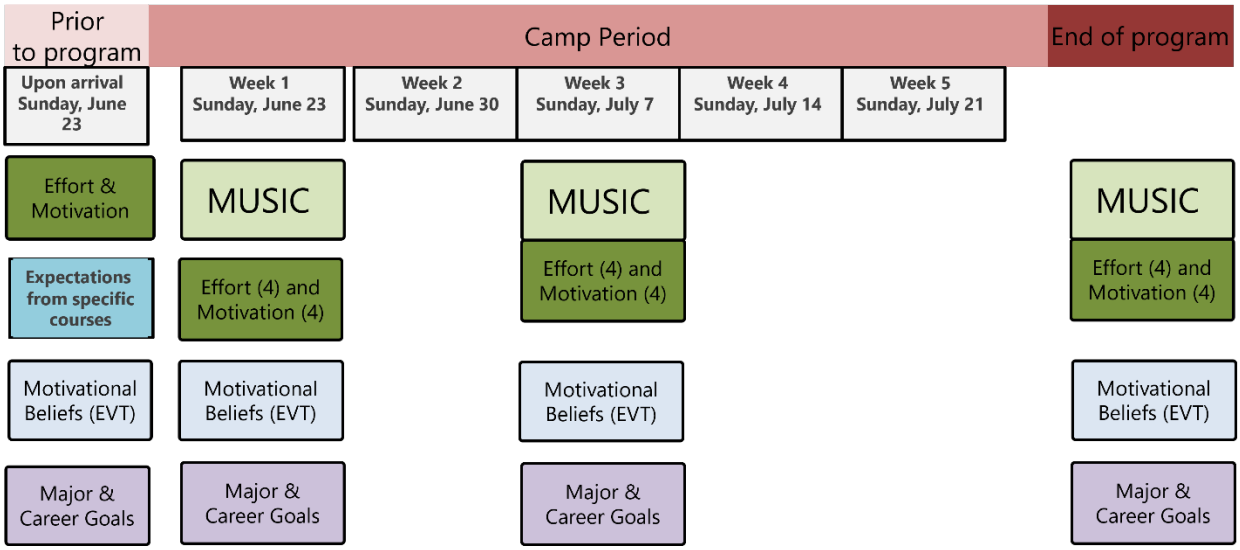
[23] Brett D. Jones, Jason W. Osborne, Marie C. Paretti, and Holly M. Matusovich. 2014. Relationships among students' perceptions of a first-year engineering design course and their engineering identification, motivational beliefs, course effort, and academic outcomes. International Journal of Engineering Education 30, 6 (2014), 1340-1356.

[24] Brett D. Jones, Chosang Tendhar, and Marie C. Paretti. 2016. The effects of students' course perceptions on their domain identification, motivational beliefs, and goals. Journal of Career Development 43, 5 (2016), 383–397. http://dx.doi.org/10.1177/0894845315603821.

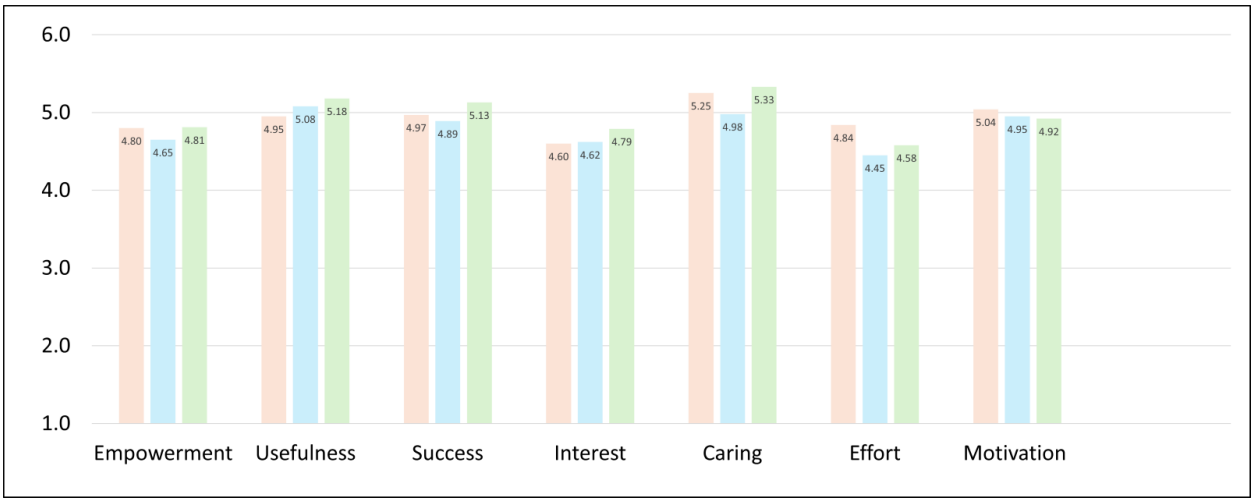
Appendix A – Example Focus Group Questions for Each Program

Program	Example Question
BETA	Which parts of BETA are you most excited about?
	In what ways do you think your culture will have an impact on your experience in engineering?
GAMMA	What types of engineering careers do you see yourselves in?
	Why do you think we have such a shortage of women in engineering?
MU	Are there any parts of MU that you are nervous about?
	Do you think being a woman will have an impact on your experience in engineering?

Appendix B – UPSILON Survey Schedule with MUSIC and Motivational Beliefs Items

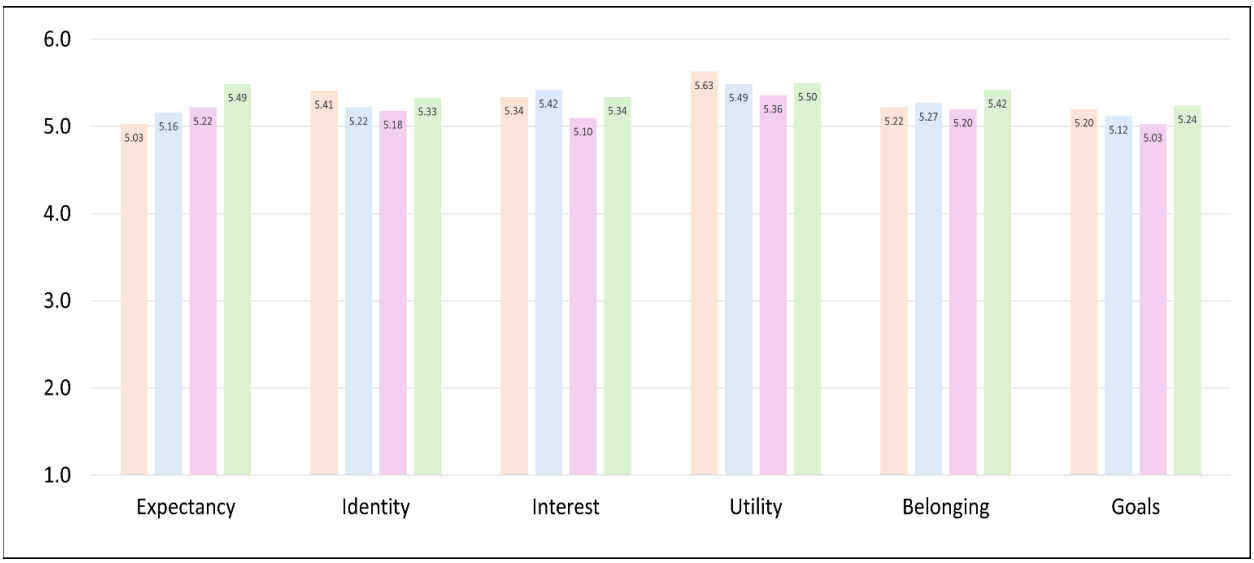


Appendix C – Average Values of MUSIC Model Constructs, Effort, and Motivation Across Three Time Points



(Each color represents a different time point)

Appendix D – Average Values of Engineering Expectancy, Values, Belonging, and Goals Across Four Time Points



(Each color represents a different time point)