ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #40762

Considerations for assessment, evaluation, and continuous improvement of a pre-college STEM summer program for promising Black high school students

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.

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

Cynthia Hampton (she/her) is a postdoctoral research fellow with the Center for the Enhancement of Engineering Diversity (CEED) at Virginia Tech. She has done work as a transformational change postdoctoral research associate with the University of Colorado at Boulder. Her research and practice spans student intervention programs, faculty agency, evaluation, grant-writing, and facilitation of change initiatives.

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

Considerations for the assessment, evaluation, and continuous improvement of a pre-college STEM summer program for promising Black high school students

Abstract

Providing opportunities to pre-college students for exposure to STEM is a common practice that is considered an action toward broadening the participation of racially marginalized groups in engineering. Cited as a process-focused practice recommendation, exposure to high school-level engineering and replicating successful practices is a common agenda for advancing Black Americans in engineering [1], specifically as an implementation mechanism. One such program intentional for this purpose is the *DISTINCTION* Summer Program at a large research university in the southeast. The purpose of this paper is to describe *DISTINCTION*, the preliminary process of considering its assessment and evaluation, and describe alterations and necessities of the program over time based on. As a program initiated during the summer of 2021, the co-director has led programmatic transformations and changes needed during its shift to an in-person offering starting in the summer of 2022.

Now in its third year overall and second year in-person, these evaluative considerations are necessary in recognizing need, inputs to the program, outputs of the program, and strengths, weaknesses, and opportunities for further growth and impact. The authors consider the following broad evaluative questions:

1. What is the program theory of the *DISTINCTION* program?
2. How can a preliminary data collection matrix be created?
3. What process or program improvements occurred in the summer 2023 offering of Distinction?

It is important to emphasize that the evaluation considerations contained in this paper are a starting place for continued evaluation and learning. This paper is an initial set of considerations for a two-week summer residential engineering program for rising junior and senior high school students who identify as African American or Black.

Introduction

According to the National Academies, there is a need for "culturally and linguistically effective" programs at early stages" [2, p. 26] for implementing a "whole student approach" [2, p. 26] and to offset various barriers to Black students in science, engineering, and medicine. This aspect of the implementation drove the creation of *DISTINCTION*, a two-week program for rising eleventh and twelfth-grade students, open to all but culturally responsive and highlighting Black experiences in engineering. A previous program to address the participation of women in engineering, also at the high school level, was representative of the majority cultural groups and socioeconomic statuses already prevalent in engineering. After creating *DISTINCTION*, the authors believed it best to reverse engineer the evaluative underpinnings and outcomes that were

clear to the program's administrators but not fully documented. As with other program administrators in the broadening participation space, it was clear that urgency to address needs superseded the documentation or alignment of evaluative processes, instead responding to direct needs through practitioner-based needs assessment that relies on survey and qualitative data to make changes year to year without capturing rich context and insight from practitioners on influences to their decisions.

The evaluation of programs serves as a mechanism to investigate the effectiveness of interventions [3]. STEM intervention programs have historically faced a need for evaluation to communicate effectiveness and respond to ongoing needs related to funding, sustainability, and perceptions of legitimacy [3]. The need for evaluation, but not the support to manage evaluation, can often be a hindering factor for programs with limited staffing or established assessment techniques. For newer initiatives, there may be a need to address population needs that include impactful activities without extensive needs-based assessment or sustained techniques for continuous learning and improvement mechanisms. However, often, it is the case that feedback is recognized and responded to in a manner to adjust and make alterations as needed from one year to the next. Recruitment, enrollment, retention, and graduation data play a vital role in the administration of programs created to increase the participation of underrepresented students in engineering. For organizations that can be categorized as providing a suite of STEM intervention programs [4], adequate evaluation and communication of data is critical in obtaining additional funding and representing legitimacy through impact.

Pre-existing work exists on the assessment cycle of broadening participation in engineering (BPE) programming, centered explicitly on intervention-based programming at the pre-college level. This paper responds to a key theme brought forward by Holloman et al. (2021), that rather than "highlighting positive evaluative claims," to document and highlight the process of "assessing the areas for change" and initiate assessment of the impact of said changes [3]. This thematic finding by the authors resulted from a systematic literature review on the assessment cycle of broadening participation in engineering and computer science. The authors additionally discuss the prevalence of various types of data, the types of findings communicated, focus on pre-college programming at predominantly white institutions (PWI), and focus on program-level assessment.

Program Theory and Overview

DISTINCTION offers an opportunity to explore engineering at a high-research university while learning about college life. Rising junior and senior high school students are split into four groups of 12-15 member cohorts, each with a distinct name, specific resident assistants, and schedule of activities. Evidence-based practices built into programming for *DISTINCTION* encourage engagement and exposure to engineering at the undergraduate level and a residential and rural college experience at a predominantly and historically white institution. Students are

paired with roommates in a residence hall on campus to encourage socialization and make connections in a communal setting. Residence hall activities include group activities initiated by residents and program assistants. Outside the residence halls, students connect with faculty through discipline, research, and student support-centered talks, with opportunities to interact closely with engineering faculty and graduate students. Lastly, an industry-sponsored and mentored project begins at the beginning of the two weeks and culminates with a presentation with proof of concept and presentation in participant teams. Figure 1 shows the initial logic model representing the inputs, activities, outputs, and outcomes created for this paper. This logic model was created to organize key components and outcomes of *DISTINCTION* based on states goals for participants as well as insider knowledge from a co-author of the paper who is also a *DISTINCTION* co-director.

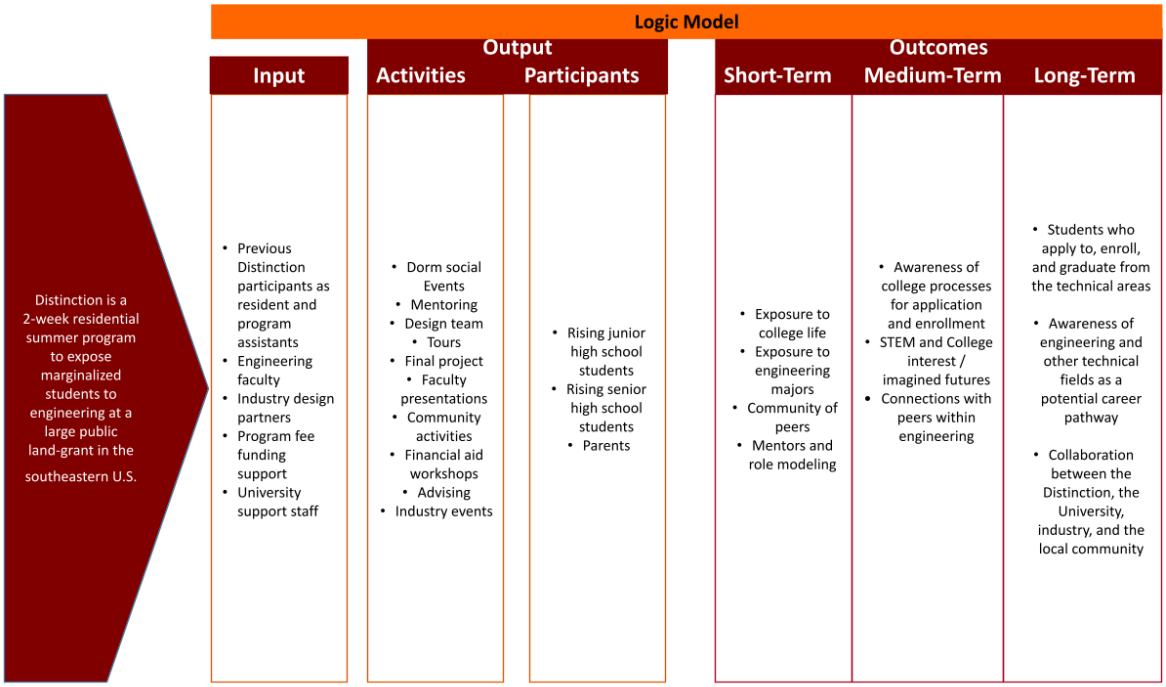

Figure 1. Initial Logic Model of the *DISTINCTION* Program

The program coordinators were intentional about the need for culturally responsive activities, training, and opportunities related to African American/Black culture and experience. Intentional events focused on music, sports, and cultural community engagement activities. They were used to highlight important topics such as integral wellness workshops with topics such as imposter syndrome, financial literacy, and mental health, exposing students to additional resources. Organizations such as the National Society of Black Engineers (NSBE), Society of Women Engineers (SWE), and Black Student Alliance (BSA) are in place to provide African American and Black students with social and professional opportunities.

DISTINCTION offers an opportunity to explore the many facets of engineering. However, a multicultural perspective places emphasis on Black identity and community building. Participants' lived experiences varied greatly across factors of high school type, academic history, geographic region, and college attendance of family. The students interacted in this space and could understand and relate to each other regardless of their academic differences. During the two weeks of the program, students participated in numerous activities with the goal of exposure to a faculty, student, and professional network. This paper is a stepping stone for further program evaluation that further serves the participants' voices.

A combination of program theories emerges in the planning and establishment of *DISTINCTION*, including organizational learning and systems theory, or a focus on continuous improvement as well as adjustments in coordinated ways that speak to the entirety of the program [5]. The structural components of the *DISTINCTION*, based on a pre-existing summer program for women, were critical to exploring necessary changes to the program based on feedback and the expertise of the co-author/administrator's expertise as a STEM high school educator. A guiding concept addressed for the pre-existing program was "Under what conditions does the [pre-existing program] work, and for whom?" and now, "Under what conditions does *DISTINCTION* work, and for whom?" [6][7]

Assessment Methods

The duration of *DISTINCTION*, two weeks, provided an opportunity to collect various forms of assessment from student participants. This feedback included a pre-survey collected before the students arrived at the program, a pre-focus group that occurred within the first 24 hours of participants being on campus, a week one activity survey conducted at the end of the first week; a week two activity survey conducted at the closing session; and a post focus group that occurred within the last 24-48 hours of the participants being on campus. The week one and week two activity surveys are meant to capture the interactive hands-on and informational activities students experience during the first and second weeks.

Additionally, pre and post-surveys use measures following the F-PIPES (Fit of Personal Interests and Perceptions of Engineering) [8] instrument, which measures perceptions of engineering. The STEM-CIS (STEM Career Interest Survey) [9] tool measures self-efficacy and interest in STEM classes and careers. The post-surveys include whether students found material in the individual sessions relevant to their goals, contained new knowledge, and presented in a manner conducive to learning. The survey of activities

spanned departments in engineering. The focus group protocol attempted to explore the students' journey in engineering and science and any thoughts related to their identification with engineering and their various cultural backgrounds. The focus groups aim to ascertain how participation in *DISTINCTION* shapes young Black/African American students' perceptions of engineering. An initial data matrix below shows the alignment of some of the sources of data as a starting place for the co-author's continued work. The surveys and focus groups were integrated sources of data in other pre-college programs that the program administrators manage and were utilized for the purposes of *DISTINCTION*. Because these data tools existed prior to the creation of *DISTINCTION*, the administrators needed to create a way to organize and view the practice of identifying indicators and evaluation questions rather than continuing to make primarily reactive programmatic decisions without considering what broader questions the data was used towards.

Evaluation Topic	**Evaluation Questions**	**Indicators**	**Data Sources**
Program Infrastructure and Processes	What implementation changes are needed?	Efficiency, cancellations, disciplinary actions, budget	Program Administrator/RA/PA/faculty experiences
Participant-Participant Interactions	How do participants describe their peer interactions in *DISTINCTION*?	Connections with peers, disputes	Surveys, focus groups, observations
Development of Community	How do participants describe their connections in *DISTINCTION*?	Role modeling, peer connections	Surveys, focus groups, observations, RA reports
Participant-Industry Interactions	How do participants describe their design project experiences?	Awareness/Interest in engineering careers	Surveys, focus groups, observations, industry feedback

Participant-Institution Interactions	How do participants describe their experience on campus/in [location]?	Awareness/Interest in engineering careers, applications	Surveys, focus groups, faculty feedback
Participant-Mentor Interactions (faculty/leaders)	How do participants describe their experiences with faculty and *DISTINCTION* staff?	Awareness/Interest in engineering careers, connections	Surveys, focus groups, faculty feedback
Activity and Resource Engagement	In what ways do participants describe scheduled activities?	Collaboration, Satisfaction	Distinction program pre/post survey Post focus group feedback Faculty participation lists

Table 1. Initial Data Collection Matrix of the *DISTINCTION* Program

Insight from 2022 Cohort, Needs for 2023 Cohort, and Change for 2023 Cohort

The insight, needs, and change addressed from 2022 to 2023 was a process that started with transcribing reflections from the co-author of this paper who is the co-director of *DISTINCTION*. Open responses from the 2022 cohort were also cross-checked to ensure that participants' communication of their experiences were integrated into this exercise. The insight for 2022 from the co-author and crosschecked, the needs derived from the insight to address in 2023, and the change enacted in 2023 is organized in this section.

Evaluation Topic: Infrastructure

Insight from 2022: Lenient on time and structure of free time.
Need identified for 2023: adjustments to routine to set boundaries
Change for 2023: Creating a routine for students to follow early was necessary. The age demographic of participants require a safe and consistent routine. This also assists in understanding when disciplinary actions are needed. When a disciplinary issue is identified, some privileges get revoked. However, when they are doing exceptionally well, students are given extra curfew time, or trust doing tasks on their own. Setting the expectation early is stressed to all staff involved so that they understand the expectations we have of the students.

Evaluation Topic: Program Processes

Insight from 2022: Most participants from [local metro area], handful from everywhere else.

Need identified for 2023: Need for greater representation from other areas in the state.
Change for 2023: Using network from local schools, the 2023 cohort was 1/3 [local metro area], 1/3 [coastal area], and 1/3 everywhere else. A more geographically diverse group of students allowed for an interesting student experience. Although sharing the identity of being African American, these students were able to experience a diverse work and living space. Essentially the same benefits from having a diverse work group with engineering groups. With students being from different backgrounds in a new place enables them to create their own sense of community that's not attached to their residence

Insight from 2022: A dearth of women participants
Need identified for 2023: Need for recruiting more women into the program
Change for 2023: More women this year, helped dynamic, women felt more comfortable to intermingle more and platonically. Stressing more advocating for having more women in the program improved the dynamic between the male and females in the dorm and during their engineering groups. This enabled more female empowerment by seeing more women of color interested in this field.

Evaluation Topic: Student Dynamics/Interactions

Insight from 2022: Possible issues with gender dynamics
Need identified for 2023: Strategically arranged groups
Change for 2023: Groups that were strategic, so there wouldn't be singular woman, majority of groups were fine. Even with one male, male dominating the group. Talking through that by guiding participants to recognize when it occurs - even in the first session and have this conversation repeatedly. do that conversation more than once that includes second chances and respect.

- Having conversations about gender dynamics in group and in the workplace is important so that students understand the implicit biases they may hold when working with new people. Having students understand this early will improve the efficiency of the engineering groups. It was vital to ensure that there was seldom a group that had predominantly males in a group to avoid male domination. However, we did find that some groups regardless of being female dominated, still struggled with male domination in the group.

Students were able to participate in mini design challenges which allowed them to be creative and innovative with the challenges presented. This was a great time for them to bond with their design groups as well.

Evaluation Topic: Student-Industry Interactions

Insight from 2022: Participant perceptions of company sponsor feedback on student design projects
Need identified for 2023: Additional communication needed with company sponsor to make clear the age demographic and possible receptions of feedback on projects
Change for 2023: Discuss with companies alternate ways to give feedback to this age demographic from experience of a k-12 educator. Incorporating time to teach the students how to receive criticism without crushing their determination or passions for the project. Important to have individual group meetings about the feedback so that the students can

talk out what they need improvement on. Also, it helped that the company was in person in 2023 rather than virtual (2022). It gave the students a great sense of pride that they had actual companies looking at their project designs.

Evaluation Topic: Student-Mentor Interactions

Insight from 2022: Connections between participants and their resident advisor staff in the residence halls created community in the program and create a cohesive student team
Need identified for 2023: Targeted recruitment of resident advisors
Change for 2023: Having staff that fit the cultural context of the program matters. These are the people who will foster the type of community and experience that the participants receive. This adds another layer for participants to see themselves as college students, as well as connect with alumni of *DISTINCTION* who serve as staff

Evaluation Topic: Student-Faculty/Leader Interactions

Insight from 2022: Virtual interactions were difficult to facilitate student engagement
Need identified for 2023: Improved engagement with faculty volunteers
Change for 2023: Ability to have faculty attend sessions in-person is ideal and assists in facilitating conversations. However, experience of online environment aided in convenience to faculty volunteers

Evaluation Topic: Activity and Resource Engagement

Insight from 2022: Exposure to local areas and experiences helped to debunk assumptions and increase sense of safety in participants. Ability of *DISTINCTION* to pick design challenge instead of industry sponsor assisted in matching likelihood for success and motivation of participants.
Need identified for 2023: Participants want to learn more about tools in the design studio they have access for their industry design projects
Change for 2023: Continued exposure to local activities and experiences, increased time to use and learn the tools in the design studio

Strengths, Weaknesses, Opportunities, and Threats

SWOT (strength, weakness, opportunity, threat) analysis can be used as an accompaniment to communicate areas of focus in program and evaluation data. The SWOT in the context of the *DISTINCTION* program will be used to focus on potential opportunities for the future. Weaknesses previously were identified in the past two years based mostly on satisfaction of participants. However, the program relies heavily on the intuitiveness and creativity of feedback from *DISTINCTION* students. However, a deeper dive will need to occur to account for an ever-changing landscape of adolescent development, made more complex by interruptions and impacts of COVID19 on middle and high school experiences and further exacerbated across socio-economic and racial lines. Financial pressures can create incredible barriers for successfully pursuing scientific careers, and often result in make-or-break decisions regarding students' futures. [10]

Closing Remarks and Future Work

We presented the beginnings of more structured evaluation through a program theory, preliminary data collection matrix, and process of reflection and capture for continued improvements. We consider continuous learning from the above modifications as "successful practices", rather than "best practices" [10]. The co-directors of this program acknowledge that year-to-year changes and responsiveness to ever-changing environments spurred by the recent Supreme Court decisions [11] will be necessary. Outreach to alumni and professionals in nearby areas will be necessary to provide representation to participant identifying students in the classroom environment who are ideal participants. Additionally, identifying outcomes that extend past the summer experience that may arise and be identified through relationships with K-12 educators as outcomes that have impacted interest and efficacy for attending college and engagement in STEM subject matter. Future work that is currently in progress is comparative analysis of the 2022 in-person cohort and the 2023 in person cohort. Although a challenging year for summer programming, the 2021 virtual cohort proved a unique opportunity to pilot *DISTINCTION* overall, but also to learn of methods that could reach students in future cohorts that might be limited due to programmatic funding constraints associated with the cost of residential summer programs.

References

[1] 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).

[2] Understanding and Offsetting Financial Barriers for Black Students in Science, Engineering, and Medicine. 2022. doi: https://doi.org/10.17226/26576.

[3] T. K. Holloman, W. C. Lee, J. S. London, C. D. Hawkins Ash, and B. A. Watford, "The assessment cycle: Insights from a systematic literature review on broadening participation in engineering and computer science," *Journal of Engineering Education*, vol. 110, no. 4, pp. 1027–1048, Sep. 2021, doi: https://doi.org/10.1002/jee.20425.

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

[5] Kezar, A. J., & Holcombe, E. M. (2019). Leveraging multiple theories of change to promote reform: an examination of the AAU STEM initiative. Educational Policy, 0895904819843594. https://doi.org/10.1177/0895904819843594.

[6] Pawson, R. and Tilley, N., 1997. Realistic evaluation. Sage.

[7] D. L. Reinholz and T. C. Andrews, "Change theory and theory of change: what's the difference anyway?," *International Journal of STEM Education*, vol. 7, no. 1, Jan. 2020, doi: https://doi.org/10.1186/s40594-020-0202-3.

[8] 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.

[9] M. W. Kier, M. R. Blanchard, J. W. Osborne, and J. L. Albert, "The Development of the STEM Career Interest Survey (STEM-CIS)," *Research in Science Education*, vol. 44, no. 3, pp. 461–481, Nov. 2013, doi: https://doi.org/10.1007/s11165-013-9389-3.

[10] National Academies of Sciences, Engineering, and Medicine. 2022. Understanding and Offsetting Financial Barriers for Black Students in Science, Engineering, and Medicine: Programs, Partnerships, and Pathways: Proceedings of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/26576.

[11] Supp, F. (2016). Admissions, Inc. v. President & Fellows of Harvard College, 980 F. 3 d. UCLA L. REV, 89, 91-92.