Journal of Pre-College Engineering Education Research (J-PEER)

Volume 11 | Issue 1 Article 8

2021

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Recommended Citation

Lee, W. C., Knight, D. B., & Cardella, M. E. (2021). Promoting Equity by Scaling Up Summer Engineering Experiences: A Retrospective Reflection on Tensions and Tradeoffs. *Journal of Pre-College Engineering Education Research (J-PEER), 11*(1), Article 8.
https://doi.org/10.7771/2157-9288.1288

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Keywords

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Document Type

Special Issue: Asset-Based Pre-College Engineering Education to Promote Equity

Available online at http://docs.lib.purdue.edu/jpeer

Journal of Pre-College Engineering Education Research 11:1 (2021) 138–154

Promoting Equity by Scaling Up Summer Engineering Experiences: A Retrospective Reflection on Tensions and Tradeoffs

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Abstract

A central challenge in engineering education is providing experiences that are appropriate for and accessible to underserved communities. However, to provide such experiences, we must better understand the process of offering a geographically distributed asset-based out-of-school program. This paper focuses on a collaborative research project that examined the broad implementation of the Summer Engineering Experiences for Kids (SEEK) program organized by the National Society of Black Engineers (NSBE). SEEK is a three-week summer program that engages participants in hands-on, team-based engineering design projects. NSBE's goal is to make SEEK culturally sustaining, community-connected, and scalable. The purpose of this paper is to provide a retrospective reflection on various aspects of our collaborative project and highlight a series of tradeoffs that must be carefully considered to offer and examine the effectiveness of an intervention designed both to affirm cultural background as well as to broaden access. Guided by Yosso's community cultural wealth (CCW) framework, we engaged in individual reflection and group discussions about the evolution of our three-year project. We considered the six types of capital outlined in CCW to examine various program design elements and tradeoffs. By illuminating the tradeoffs that are required, we hope this paper can help other program designers and researchers to intentionally, preemptively, and proactively consider such tradeoffs.

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Introduction

Providing experiences that are appropriate for and accessible to underserved communities is a central challenge facing stakeholders working to broaden participation in engineering (Holloman et al., 2018). In hopes of addressing this challenge, the National Society of Black Engineers (NSBE, n.d.) implements the Summer Engineering Experiences for Kids (SEEK) program, a three-week summer program that engages participants in hands-on, team-based engineering design projects. NSBE offers SEEK in carefully selected cities across the United States in an effort to bring this experience to Black children at scale. In this paper, we examine the difficulty of offering such a geographically distributed program to thousands of children annually and highlight institutional, structural, and administrative tensions between scaling up and remaining an asset-based out-of-school program.

We offer a retrospective reflection as educational researchers who collaborated with NSBE partners to understand and expand the impact of SEEK. Retrospective reflections have been used by other educational researchers to examine the perceived success of educational interventions after the fact (e.g., Kee, 2009; Sablina et al., 2018; Stefl-Mabry et al., 2012).

https://doi.org/10.7771/2157-9288.1288

Before we began our reflection process, we considered SEEK the perfect example of an asset-based out-of-school program because it aims to be culturally sustaining (Paris, 2012) and community-connected. However, we soon came to realize that some aspects of SEEK were misaligned with traditional notions of asset-based programming (i.e., programming that recognizes and values the different types of capital that children develop in their families and communities; Samuelson & Litzler, 2016), largely because of NSBE's aim for SEEK to also be scalable.

Asset-based and *needs-based* philosophies are often at odds, creating a paradox for out-of-school programming that must be managed if these programs are to be effective and widely available. The asset-based philosophy is commonly focused on local sustainability, prioritizing the use of existing strengths, resources, and potentials (Nel, 2018). The emphasis on scalability derives from the more traditional need- or problem-based approaches to community development, prioritizing the desire for efficient, large-scale change. The push for both needs- and asset-based approaches is represented in the Innovative Technology Experiences for Students and Teachers (ITEST) program solicitation (National Science Foundation [NSF], n.d.). In NSF 19-583, "Scaling, Expanding, and Iterating Innovations" is listed as a priority and solicitation-specific review criteria emphasize the need for projects to recognize both the challenges and strengths that learners bring to learning environments. Our collaborative project with NSBE was funded through this program.

We situate our reflection in Yosso's (2005) community cultural wealth (CCW) framework to examine the decisions made in offering a large-scale out-of-school program as well as the decisions made in conducting research on the said program. In doing so, we demonstrate a continuum of considerations regarding cultural capital as it relates to promoting equity in engineering via engineering-focused out-of-school programming designed specifically for Black children. Through our analysis, we surface three main tensions that organize our findings and discussion of implications for program leaders: (1) including dominant narratives and counter narratives, (2) balancing strategic recruitment and participation management, and (3) supporting a shared vision and divergent objectives.

Context for the Study

Organized each year by NSBE, SEEK is a three-week-long, out-of-school program geared toward upper-elementary-aged children. Intentionally aiming to reach underserved communities with high populations of Black children (and in certain cities, both Black and Latinx children), the program is hosted in more than a dozen cities to provide an engineering-focused experience that enables children to experience the engineering design process, build their math, science, and critical thinking skills, and engage in team-based environments (see Edwards et al. (2018) for more complete descriptions of the experience and recruitment strategies). Week-long curriculum modules each focus on a different engineering challenge that culminates in a competition day attended by children's families, friends, local engineers, and industry sponsors, where teams of children across grade levels demonstrate their learning and project work for the week. This suite of activities, combined with interactions with Black and Latinx college-aged mentors and teachers who staff the camps, works toward broadening children's perceptions of engineering as a field and career path. The program hopes to help children see themselves as future engineers as well as highlight and develop skills, such as teamwork, and competencies, such as math, that are associated with the engineering profession.

Our retrospective reflection is based on the decision-making that our team observed during the multi-year ITEST project funded by the NSF. The collaboration described in this paper started in 2016 and ended in 2020. The SEEK program, however, began in 2007. This timing is an important part of the context because SEEK was designed, developed, and implemented before much of the modern research on promoting equity in pre-college engineering learning experiences (e.g., Calabrese Barton & Tan, 2018; Celedón-Pattichis et al., 2013; Mejia & Wilson-Lopez, 2016; Nazar et al., 2019; Tan & Calabrese Barton, 2018; Tan et al., 2019; Tucker-Raymond et al., 2018; Wright et al., 2018). These recent studies highlight the promise of out-of-school spaces for promoting equitable learning experiences, the importance of taking assets-based approaches, and the value in centering relationships and mutuality. Though these studies have informed the ways we think about our research and equity and can inform future implementations of SEEK, changing existing programming (particularly those occurring across multiple sites across the country) requires different processes and considerations compared to the processes used when developing and designing an entirely new program.

Theoretical Foundation

Yosso's (2005) CCW model, building on the notion of metaphorical capital, helps us examine the decision-making of program stakeholders in our retrospective reflection. "Metaphorical capital (also called symbolic capital) refers to non-monetary, non-material resources within a community…which can be used to some benefit" (Hinton, 2015, p. 299). The metaphorical capital that exist within families and communities are often the focus of asset-based approaches to education and education research (e.g., Harper, 2010; Lane & Id-Deen, 2020; Martin & Newton, 2016; Mejia et al., 2018;

Samuelson & Litzler, 2016) and are frequently conceptualized as community cultural wealth (Yosso, 2005) or funds of knowledge (González et al., 2006; Rios-Aguilar et al., 2011).

Yosso's CCW disaggregates cultural capital into a combination of six forms of capital. According toYosso (2005):

1. *Aspirational capital* refers to the ability to maintain hopes and dreams for the future;
2. *Social capital* refers to networks of people and community resources;
3. *Linguistic capital* refers to skills attained through communication experiences in more than one language (e.g., Spanish) or style (e.g., art, music, or poetry);
4. *Familial capital* refers to cultural knowledge nurtured among familia (kin), including a broad understanding of kinship, that carry a sense of community history, memory, and cultural intuition;
5. *Navigational capital* refers to the skills of maneuvering through social institutions, acknowledging individual agency within institutional constraints; and
6. *Resistant capital* refers to knowledge and skills fostered through behavior that challenges inequality.

As Yosso (2005) notes, "These various forms of capital are not mutually exclusive or static, but rather are dynamic processes that build on one another as part of community cultural wealth" (p. 77). The central idea behind such an assets-based approach for designing an educational experience is that it is as valuable, if not more valuable, to focus on what children, families, and/or communities have than what they are lacking. This mindset allows educators to connect school curricula (or out-of-school programming) to children's lived experiences.

Prior work has tended to focus on leveraging the existing capital of the children participating in an experience (e.g., Colquitt, 2020; McKnight, 2016; Tolbert, 2017; Tolbert & Cardella, 2016). Although it is important for pre-college engineering programs to recognize and leverage the strengths and assets that children bring to engineering, we also recognize that there is a disconnect between the ways that children's assets and strengths are recognized in these programs and the current state of undergraduate engineering education and engineering professional practice, which often does not recognize or value these assets. Recent work by Denton et al. (2020) reminds us that it is also important to consider the other people who contribute significantly to youth's development and identification of capital so that we do not "plac[e] the burden of succeeding on the students themselves…to promote change, assets-based research should include [family members, faculty, advisors, administrators, and program managers], as they may be in a unique position to identify assets, change institutional structures and encourage student success" (p. 574).

We must also recognize that there is variation in the experiences and capital of the different groups of children served in asset-based programs. Because of this variation, it is important to recognize that the same mechanisms for leveraging capital can also have negative tradeoffs, such as excluding others (Portes, 1998), when one considers the entire process of offering an out-of-school program that is voluntary and broadly accessible. As Hinton (2015) notes, "Any capital-based theory would seemingly draw explanatory power by evoking the way an economic resource is gained and passed on, from generation to generation. This reveals a logical quandary: If a poor [or disadvantaged] community has a certain amount of cultural wealth or funds of knowledge, what amount does a wealthy community have?" (p. 305). Consequently, in addition to focusing on how to *leverage* existing capital, we used CCW to focus on instances where capital was either *nurtured* or *disregarded*. Doing so enabled us not only to identify instances in which existing assets were leveraged, but also instances in which the lack of some forms of existing capital worked against SEEK's mission.

Methodology

We parse out the methodology section into two subsections. We begin by describing the steps we followed in our retrospective reflection. Much of the evidence we drew upon in our reflection came from data previously collected as part of the larger research project. Thus, in the second subsection, we briefly describe how the relevant data noted in this paper were collected.

Retrospective Reflection

Retrospective reflection is a "form of reflection-on-action in which participants in a collaborative process systematically re-examine their process" (Krogstie, 2009, p. 418). The three co-authors on this paper are engineering education researchers from academic institutions, and we engaged in the ITEST project described herein as co-principal investigators with NSBE. Collectively, we were responsible for conducting educational research and evaluation of the program, disseminating research findings, working with NSBE team members to refine curricula, developing new materials for children and their parents, and enhancing mentor training processes.

We first engaged in individual reflection about the evolution of the project. We began this process by each responding to a series of questions associated with the different forms of capital outlined by Yosso. The purpose of this initial activity was to identify instances in which (a) each form of capital was *nurtured* as a part of SEEK, (b) existing capital was *leveraged* by SEEK, or (c) existing capital was *disregarded* or worked against the target population of SEEK. Each author had access to existing documents associated with the project (e.g., meeting notes, annual reports) and was given a week to record their ideas in a word processor.

Next, we engaged in group discussion. During this process, we came together to discuss similarities and differences across our ideas, drawing on multiple forms of data (e.g., quotes, quantitative data; subsequently described) that were collected throughout the larger project. This activity helped us collectively identify the tensions that were apparent across different aspects of the program. We did not anticipate surfacing such tensions; rather, our initial plan was to highlight how SEEK might be an exemplary asset-based program. The retrospective reflection process, however, led us in a different direction, which we share in this paper. We present examples of the different forms of capital, as we had initially planned, but organize these findings within the different tensions that became apparent as we engaged in reflective dialogue across our team.

Incorporation of Data from NSF ITEST Project as Evidence

To support our reflections, we draw on data collected throughout the partnership sparked by the NSF collaborative grant. This study focused on researching the effectiveness of SEEK and studying its organizational features to understand how to offer such programs at scale. The research aims included the following high-level objectives:

Objective 1: Evaluate SEEK's success at influencing science, technology, engineering, and mathematics (STEM)-related academic and career identity, conceptual knowledge, and interpersonal and intrapersonal skills.
Objective 2: Generate evidence and a greater understanding of organizational contextual factors that operate to enhance, moderate, or constrain SEEK's impact from site to site.

We organized data collection and analysis using an input–environment–outcome logic model (Figure 1), which connects children's background characteristics and experiences (inputs) to their experiences in SEEK to a set of learning outcomes aligned with the overarching aims of the program. Such an approach fundamentally considers children's prior knowledge, interests, and experiences, which is consistent with an assets-based approach.

To address the project's objectives and gain a holistic understanding of the experiences, we collected data from a variety of stakeholders (Cardella et al, 2019; Knight et al., 2018; Young et al., 2017). Children completed assessments on the first (i.e., pre-tests) and next-to-last day of the camp (i.e., post-tests) to capture information about their conceptual knowledge,

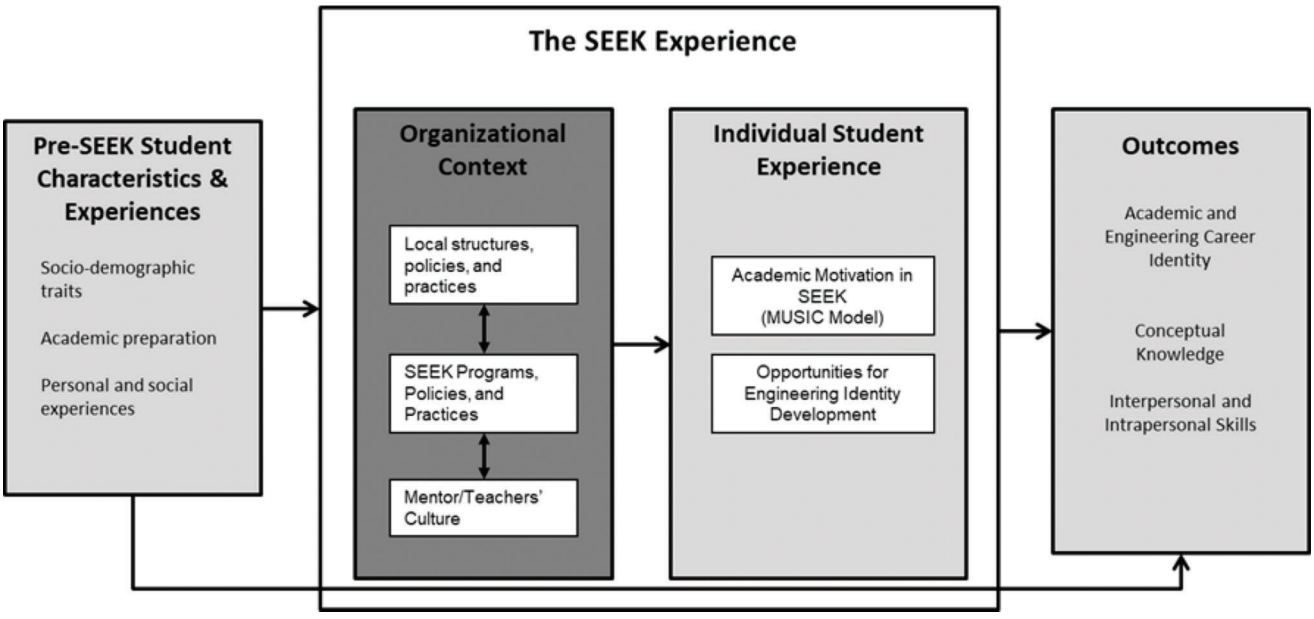

Figure 1. Organizing input–environment–outcome framework.

self-reported identity, interests, teamwork and communication skills, design skills, experiences in SEEK, and perceptions of engineering using Likert-style questions as well as the Draw an Engineer task (Lightner et al., 2021). In our retrospective reflection, we draw on some of those data both to demonstrate efficacy of the program's rhetoric and goals as well as to illustrate how a variety of considerations influence what data are actually collected.

We also collected information from parents via the camp application as well as survey information (pre- and post-) regarding children's backgrounds, prior experiences, access to other engineering experiences, and satisfaction with SEEK. To understand SEEK implementation across sites, as well as the perceived goals and impacts of the camp from the staff members' perspective, we interviewed and surveyed SEEK mentors (typically undergraduates and in-service teachers who facilitated the camp activities each day), site leaders, and NSBE headquarters (HQ) employees. Members of our team also visited several sites to observe classroom activities and competition days. This approach to data collection allowed us to understand SEEK holistically. For our retrospective reflection, we drew heavily on the interview data with staff members in various roles because they captured both rationales for decision-making as well as on-the-ground implementation. When quotations appear in the Findings and Discussion section, those are from these interview data as opposed to our own reflections.

Findings and Discussion

We identified three themes across our reflections. First, underlying philosophies created a tension related to whether an out-of-school program focuses on acculturation or transformative resistance (Including Dominant Narratives and Counter Narratives). Second, the dual emphasis on socioeconomic status and race created a tension related to differential access within the target populations (Balancing Strategic Recruitment and Participation Management). Third, the challenge of managing multiple stakeholders created a tension related to considering the mission of the host organization and the performance expectations of sponsors (Supporting a Shared Vision and Divergent Objectives). We elaborate on each of these themes in the following sections.

Tension I: Including Dominant Narratives and Counter Narratives

Our first theme focuses on the tension resulting from the underlying focus of an engineering summer program, and it comes down to a challenging question: Should pre-college engineering programs strive for acculturating participants into the engineering culture, or should they strive for transformative resistance? This tension exists because programs could work toward helping prepare children to navigate existing education systems (e.g., engineering norms, rhetoric) to become engineers in the formal sense. Alternately, programs also have the potential to redefine what it means to be an engineer using participants' existing skills, interests, and backgrounds, which aligns more with an asset-based framing. Hoffman et al. (2019) highlight a similar dichotomy in their study of higher education, where they describe institutional spaces as either being focused on facilitating student integration into the broader campus culture or being focused on encouraging the transformation of the hegemonic norms. During our retrospective reflection, we identified evidence of both in SEEK.

Dominant Narratives

As it relates to acculturation, NSBE reinforced several aspects of the dominant narratives surrounding science and engineering (e.g., Conefrey, 2001; Secules, 2019). In particular, SEEK (1) included a strong focus on math and science in the content delivered; (2) emphasized competition as the culmination of each week of the program; and (3) highlighted the importance of business professional attire through the appearance of the camp mentors (e.g., "dressing up nicely" and "looking the part"). Each of these approaches was focused on equipping children with capital that they might need in the future to navigate engineering as it currently exists.

We noted an emphasis on math as an approach for developing *linguistic capital* (i.e., math is the language of engineers) and *navigational capital* (i.e., math and science courses are necessary prerequisites for pursuing engineering in college). As one member of NSBE HQ noted, one of the central goals of SEEK was "planting the seed" that will lead children to place more value in education and increase their interest in STEM education. Such an emphasis resulted in statements from children such as, in the words of one mentor, "You know what, this actually may be something I can do," or, "Hey, you know what, let me take my Algebra I class a little bit more seriously because I was told that if I wanted to become an engineer, I need to be pretty good at math." The importance of developing math skills was also echoed by mentors who made suggestions such as creating more interactive activities that made learning math fun and exciting, relating math concepts to everyday use, and establishing an encouraging environment in which math is easy to understand.

Beyond stressing the importance of math, mentors also realized that they were a visual representation of engineering. As one mentor noted, "I think we help SEEK as mentors and site leaders to show that professionalism. It develops the kids'

minds like, 'Yo, this is what a professional is.' As an engineer, we have to look the part." This approach is another example of aiming to develop *navigational capital* by preparing children for the expectations regarding professionalism that they may encounter in the future.

Lastly, beyond developing new capital, there were also instances where NSBE saw an opportunity to connect children's existing capital to the existing engineering culture. For instance, the rationale for emphasizing competition was that many of the children enjoyed and were already skilled at competing with one another. As one mentor noted:

> I feel the underlying goal was to see education as fun because, how a couple of athletes would like to say it and bring it out, "You won't work as hard on your paper as you will on the field. You won't work as hard to do this Math problem as if I told you to go do 50 jump shots." So if SEEK can get the kids, now young, to feel like doing this math problem is doing 50 jump shots, they might do that math problem like they do the 50 jump shots… So really I feel like the goal is to try and change the mindset of the kids to try and see learning as fun. If kids see learning as an activity like sports where they can get up, do the numbers, make it more relatable to what you want to do. It can be a more [supportive] environment to have you succeed a lot better in life. Because if not, then you're just going to be thinking, "Well, I can't do this, I can go on the field and I'm very fast." You can be fast on paper, you can learn on a paper, you can make easier corrections on a paper than on a field.

As illustrated in this example, even in instances where mentors did not aim to disrupt the dominant narrative around engineering, they were able to identify opportunities for connecting the children's existing capital to the norms of the discipline.

The previous examples represent two different approaches for addressing the dominant culture as it relates to capital. Educators can (1) focus on developing new capital that aligns with the dominant narrative; and (2) help children see how their existing capital aligns with the dominant narrative. The logic for incorporating some elements of the dominant narrative is expressed in the National Academy of Engineering (NAE) report *Changing the Conversation*. The report notes, "A better understanding of engineering should encourage students to take higher level math and science courses in middle school, thus enabling them to pursue engineering education in the future" (NAE, 2008, p. 2). Although there is value in helping children see what engineering can be, there is also value in helping children recognize its current state to assist them with navigating the dominant culture and institutional systems.

Counter-narratives

As it relates to subversion or transformative resistance, NSBE also made intentional decisions to provide children with counter-narratives (or counter-stories) about engineering and Black people. "Counter-stories can shatter complacency, challenge the dominant discourse on race, and further the struggle for racial reform" (Solórzano & Yosso, 2002, p. 32). When asked to describe NSBE's goal in their own words, a mentor summarized it as, "They're trying to change the culture around engineering and STEM and higher education in Black communities to where that's no longer a situation in X amount of years." Three of the major counter-narratives developed through SEEK are: (1) engineering is artistic, (2) engineering is social, and (3) engineering is Black. Unlike strategies focused on the dominant narrative, these examples highlight the value of allowing children to connect individually with their community peers.

As an example of the first two counter-narratives, SEEK included an artistic portion in each module and also had children complete each activity with a team. Regarding conveying engineering as an artistic field, a mentor offered the following:

> The oral and artistic presentation really hits on a lot of things that are pretty important to engineers that aren't as well thought of because presentation skills [are] very important if you want to develop yourself as an engineer, not just as the hardcore skills but the soft skills are also very important.

Our quantitative data support the notion that SEEK helps participating children recognize the artistic and social nature of engineering, which also aligns more closely with their general personal interests (e.g., Hynes and Maxey, 2018). Prior research using Holland's career theory suggests the value of "fit" between an individual's personal interests and their eventual choice of a career or discipline (Kossek et al., 2017; Su et al., 2009). Accordingly, we collected data related to children's personal interests on the first day of the camp (i.e., pre-tests) as well as their perceptions of engineering on both the first day of camp (i.e., pre-tests) and next to last day of camp (i.e., post-tests) along several different dimensions. Interests are more stable over time, whereas perceptions of an activity can be more variable and influenced by an intervention. Two of the dimensions in particular, social and artistic, are noteworthy. Children's perceptions of engineering at the end of the camp were in greater alignment with children's interests on these constructs relative to their perceptions of engineering at the beginning of the camp (as shown in Figure 2). The theory suggests that where interests and perceptions align, children are

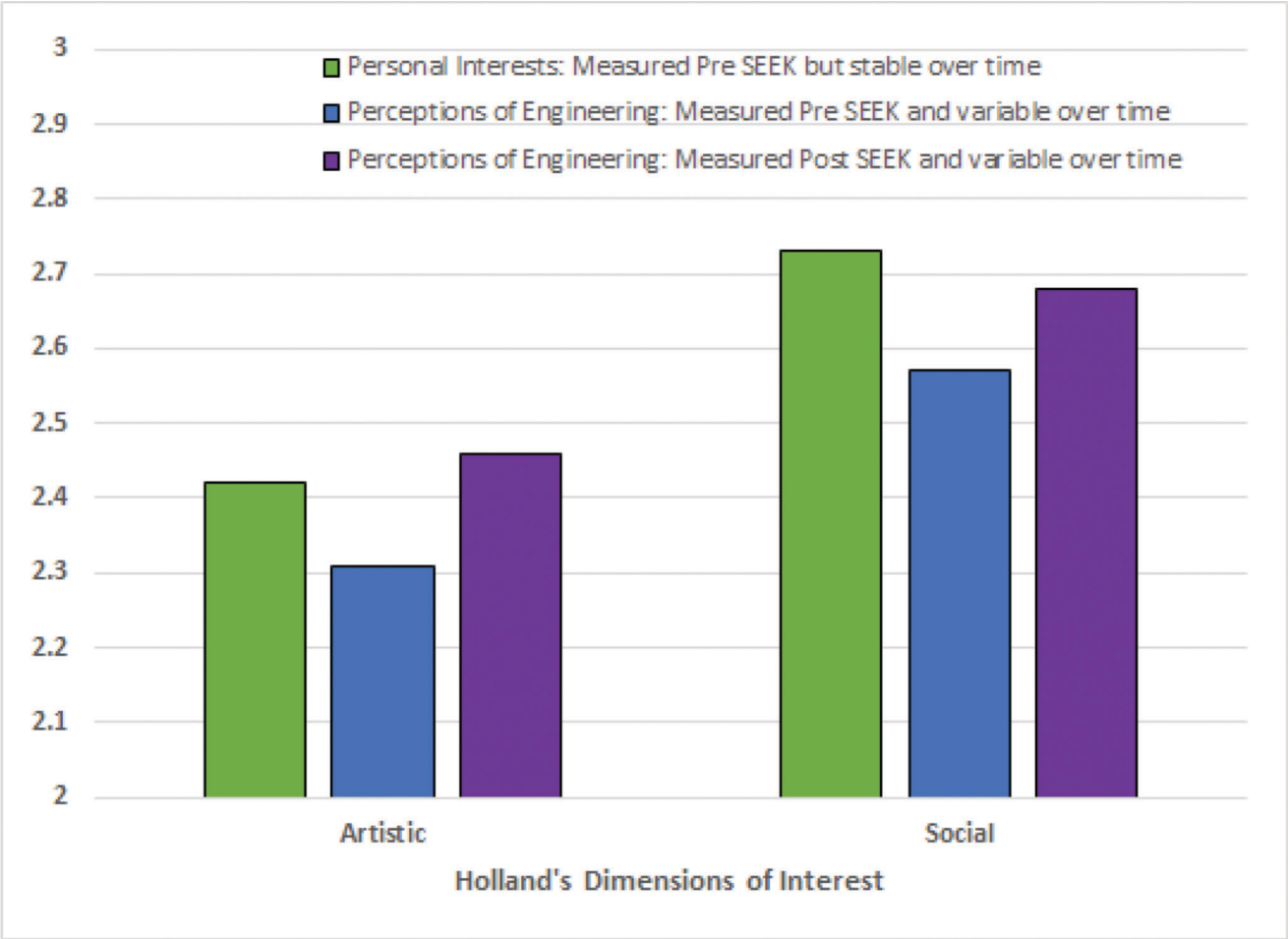

Figure 2. Matched 2019 sample (n = 1,254) showing children's perceptions of engineering before and after SEEK as well as their general personal interests (measured at the start of SEEK, but the construct is stable over time relative to perceptions of an activity). (Note: 1, not at all; 2, somewhat; 3, a great deal).

more likely to be motivated to engage in a subject area, and building that kind of motivation around engineering is one of the key objectives of SEEK; it works to build a counter-narrative of what engineering entails for these children.

As it relates to the third counter-narrative and the development of *aspirational capital*, NSBE emphasizes its mission "to increase the number of culturally responsible Black Engineers who excel academically, succeed professionally and positively impact the community" (NSBE, n.d.). In doing so, NSBE's hope is for SEEK participants to see themselves as future engineers. Our observations of SEEK classrooms noted that the NSBE mission statement was displayed in each classroom and periodically recited by members of the program to reinforce this messaging.

We also observed that each classroom included posters related to definitions of engineering, an introduction to different engineering disciplines, SEEK team roles, the SEEK design process, and the standard and metric measurement systems. The first three of these posters included images of Black engineers and/or Black children to continue emphasizing to children that people who are Black are, and can be, engineers. The SEEK mentors were also provided with smaller posters that featured successful Black men and women and their engineering backgrounds (Leeker et al., 2019; Lightner et al., 2021). Additionally, as part of the SEEK camp experience, children and their SEEK mentors co-constructed additional posters for their classrooms, which included lists of camp expectations as well as class chants. Such chants leveraged the children's existing *linguistic capital*. As a mentor notes, "They do cheers and chants and they come up with these dances and they're cheering like, 'I'm an engineer.'" According to one mentor, both the children and parents would become involved with the chants, further demonstrating how SEEK enhances this form of engineering identity.

Our evaluation data point to some success on this front. In analyzing children's drawings of engineers, for example, one of the most common ways we noticed race was when children explicitly stated that anyone, regardless of race or gender, can be an engineer. Similarly, our quantitative data show that SEEK is making some strides towards this goal. For the 2017–2019 SEEK programs, we observed statistically significant positive, albeit small, changes from the start to the end of the camp on an Engineering Identity self-report construct (e.g., Knight et al., 2018). Children's beliefs about engineers and

who they want to become relative to engineering increased over the course of the three-week camp. Both of these observations align with the counter-narrative that SEEK aimed to advance.

Tension II: Balancing Strategic Recruitment and Participation Management

Our second theme focuses on the tension produced from the intersection of race and socioeconomic status, and it comes down to a challenging question: How should pre-college engineering programs address differential access between subgroups within their target population? This tension is similar to enrollment management in higher education, and it exists because participation in out-of-school programs is voluntary, populations are non-monolithic, and children often do not have the agency or means to attend such programs (i.e., their guardians must help facilitate participation). When determining a target population, pre-college engineering programs could choose between reaching all children from a broader target population or prioritizing a narrower subset of children who are particularly underserved. This tension is not unique to SEEK, as evidenced by the existence of the Eligibility, Recruitment, Selection, Enrollment, and Attendance component of the Head Start program aimed at ensuring they "recruit the children and families most in need" (U.S. Department of Health & Human Services, n.d.). We found evidence of a similar goal in SEEK as it relates to recruitment and selection, but achieving such a goal can be challenging.

Strategic Recruitment

As it relates to race, NSBE maximized the reachability of SEEK by offering the program in cities where the target population likely resides. To do so, NSBE developed a SEEK Index that considers key population variables to maintain the primary objective of reaching Black children in low-income communities. Once a city is selected, NSBE HQ identifies specific sites to hold the camp. From a strictly pragmatic perspective, choosing a site first hinges on availability of a school, with the desire to select a school that is in a reachable location for participants; this combination makes it possible for the program to intentionally plan for the children's *social capital* and *navigational capital* to serve as assets. Beyond space availability, a key to success is selecting a site in which community partnerships can be developed with leadership willing to engage in partnerships with SEEK.

NSBE also considers advertising and marketing so that parents and their children can both discover SEEK and understand SEEK's mission. NSBE uses multiple approaches in its marketing strategy, ranging from radio advertisements to social media campaigns with a core strategy to inform and recruit parents/guardians—parents/guardians are key contributors (i.e., *familial capital*) in helping build the SEEK community. Such a targeted recruitment strategy propagates the goal of affirming Black identity and placing the camp in specific communities where Black and Latinx children can easily access the program.

In summary, NSBE intentionally selects locations to hold the program to reach the target population. Three different considerations enter into this decision process: (1) city identification, (2) site identification, and (3) advertisement and marketing (Edwards et al., 2018).

Participation Management

As it relates to differential access, NSBE also made intentional decisions to ensure certain children were not at a disadvantage with respect to being included in the program in instances when more children applied than could be accommodated. Doing so was important because, although NSBE's recruitment approach is targeted, the comprehensive marketing strategy reaches parents and children beyond the target population. As shown in Table 1, the recruitment strategy is successful at engaging Black children, with about 95% of participants identifying as Black or African American in some capacity. By this metric alone, one could posit that the recruitment and enrollment strategy is extremely successful.

Data related to socioeconomic status tell a more complicated story, however: over 40% of children who participated in SEEK 2019 had at least one of their guardians hold a master's degree or higher, and over 70% of children had at least one of their guardians hold at least a bachelor's degree. Relatedly, although nearly one-third of children's families had annual household income levels less than $50,000, about one-third of children's families had annual household income levels greater than $90,000 (note: SES composition varied significantly across sites). Thus, the program has done a fantastic job enrolling children from racially underrepresented groups but has not always met the objective of reaching children from low-income households.

Because participation is voluntary, internet-based marketing and application strategies give some children and parents an advantage in accessing the camp because of disparities in online access (Anderson & Kumar, 2017). As a result, decisions must be made regarding the timing of accepting children into the program. Without this intentionality, it is likely that the program will enroll a disproportionately high number of children from households where parents/guardians have more capital, particularly *navigational capital*, as it relates to education systems. As a NSBE staff member described, the leadership team recognized this potential access inequity and adjusted their strategies:

Table 1
Racial breakdown of 2019 SEEK participants (n = 1,544).

Race/ethnicity	Percentage
Black or African American	87.2%
Multiracial (with African American)	7.4%
Hispanic or Latino	2.8%
Other	2.5%

> In the past, the student acceptance policy was first come, first serve. If you had a computer and you were able to log on at 9:00 AM when the application opened, you were in. Then we realized that underserved parents who maybe did not have access to a computer or the internet, they weren't getting in and those are exactly the people we want to target.

This phenomenon aligns with previous research about opportunity hoarding in college. For example, Hamilton et al. (2018) used interviews with 41 families to examine how parental involvement contributes to social class variation in children's experiences at a single university. Their findings illustrate how more affluent parents serve as a "college concierge," using class resources to provide youth with academic, social, and career support and access to exclusive university infrastructure. A similar phenomenon can occur at the K-12 level, where more affluent parents (or those who engaged in more education degree programs) may be more familiar with navigating different formal and informal educational systems (e.g., Diamond & Gomez, 2004; Lareau, 2011).

Any program that requires children to sign up also necessitates some aspect of *aspirational capital* from either the child themselves or their parents. Consequently, it is harder to reach children whose caretakers do not have a certain level of aspirational capital towards engineering. Offering the program at no cost and placing it within specific communities lowers the threshold for participation, but that strategy still cannot guarantee that the program will be only composed of the intended population. As noted, NSBE HQ strategically revoked its "first come, first serve" policy for accepting children to try to make enrollment opportunities more equitable. However, because NSBE simultaneously had a desire to scale up the number of participants as well as reach certain enrollment targets to meet funders' expectations, SEEK coordinators felt pressure to enroll applicants early to ensure spaces are filled. This discrepancy highlights tension between reaching Black youth who are already interested in engineering (i.e., children who already have *aspirational capital* related to engineering) versus the goals of raising awareness and cultivating interest in youth who are not yet interested in engineering. Both of those goals can be and are met simultaneously in SEEK, but the tension highlights different strategic choices that program leaders must make.

Tension III: Supporting a Shared Vision and Divergent Objectives

Our third theme focuses on the tension produced by a focus on the multiple stakeholders involved in the design, development, and implementation of an out-of-school program, and it comes down to a challenging question: How might pre-college engineering programs effectively balance the interests and goals of multiple stakeholders? This tension directly connects to and is exacerbated by NSBE's desire to scale up SEEK; and it exists within the current program context because (1) NSBE is a student-led organization and (2) offering a multi-site pre-college engineering program requires significant resources that NSBE does not have internally.

Shared Vision

SEEK achieving its mission requires contributions from a variety of stakeholders. SEEK brings together a professional society, industry partners, community stakeholders, the formal K-12 environment in some cases (e.g., teachers, school leaders, and school buildings), college-aged mentors, and members of families. This combination of stakeholders allows SEEK to nurture and leverage *social and aspirational capital* in multiple ways. As one mentor noted, "So for SEEK to be free and have these amazing mentors and these amazing sponsors come for just this one program, that's really what sets it apart from [other programs] to me." Local industries are able to invest in the program to promote the future success of participants. Engineers from these local industries serve as examples of professionals who can help foster aspirations. A mentor described how this happens:

> There are a lot of camps that have engineering stuff behind it, but like the competition Friday, right? I feel like it's kind of unique having the sponsors come in. So the kids can see, "Oh! This is the sponsor from BP. This is an actual chemical engineer. This is what he does." Right? That's unique to SEEK alone.

Having that professional role model helps build children's *aspirational capital*; it replaces the generic description of an engineering professional with actual people.

Mentors are central for nurturing participants' aspirational capital, in particular the college-aged mentors who are primarily Black and Latinx and come from both local communities and from different locales. This opportunity seems to be one of the strengths of SEEK. A different mentor illustrated this unique aspect of SEEK:

> So let's say there's an engineering camp that looks like SEEK somewhere. They're probably going to get a mentor from that region, right? But SEEK is different in the sense that, oh they're going to grab somebody from Texas in there. Grab somebody from LSU, somebody from Brown University, Spelman College, all over. And that gives the kids a more like…they get to see people from all different walks of life. So that's different, that's unique.

Because the mentors are primarily students themselves, albeit college students, SEEK provides NSBE with the opportunity to nurture these forms of capital for both children participants as well as for college-aged mentors. As one mentor described:

> In sites where the sponsors are fully involved in the program it actually helps the program to run better. One thing I like about the Houston camp is that Shell is fully involved in that camp. Shell is not only looking at the development of the kids. They're also looking at the development of the mentors, so just little things like Shell taking you to their facility to see how they operate can actually spark a lot in mentors to aspire to want to be great or just have that opportunity. To spark that desire to want to work for such a company that is actually making an impact, because I feel if the mentors are impacted, these college level students, it's like you're setting an example… Say David was my mentor and he works for this company now, and so I feel it's a chain reaction. You equip the mentors, the mentors equip the kids, the kids see what the mentors have become, and then they aspire to that.

A different mentor described a similar experience that illustrates how the involvement of multiple stakeholders in SEEK builds both *social and aspirational capital*:

> In Denver, we were sponsored by CH2M Hill, and we had our training at their facilities. They were really hands-on, so we were not just meeting them; we were in their facility meeting them and seeing what they do and they were open to interviews… I did get an internship through CH2M Hill, and that's only because they were our sponsor and I had a really good relationship with the HR rep. She was on site 24/7 and she observed me teaching, and she put in a recommendation for me. That's why I say it's really important because sometimes if you have sponsors coming in, and they see you do your work, they might go that extra mile for you to get hired.

This example demonstrates how the involvement of multiple stakeholders from a personnel perspective created an opportunity for this mentor to expand their social capital.

Divergent Objectives

Offering an out-of-school program at scale requires a substantial amount of fiscal resources, making it particularly difficult for a nonprofit organization to manage the full program independently. As a result, beyond finding people to support the on-the-ground operations of SEEK and its mission, NSBE must also find organizations willing to bear some of the financial burdens. In the case of SEEK (2017–2019), funding came from two primary sources: (1) industry sponsors and (2) the NSF ITEST grant.

By relying on funding from external entities, NSBE does not have complete control over programmatic decision-making without running the risk of losing a potential source of revenue. Even if NSBE placed an asset-based framework for its program at its core, by not having full control over decisions, the organization must also weigh the considerations of other stakeholders—a phenomenon that is quite common and explained by *resource dependency theory* in the literature. As described by Pfeffer and Salancik's (1978) seminal work on the subject, one must understand the context and surrounding environment of an organization to understand its behavior, and interdependence between organizations is fundamental in this understanding. "In social systems and social interactions, interdependence exists whenever one actor does not entirely control all of the conditions necessary for the achievement of an action or for obtaining the outcome desired from the action" (Pfeffer & Salancik, 1978, p. 40). Described in more recent literature:

> Organizations rely on external forces due to their inability to create all the necessary resources needed internally. As a result, organizations face pressure to conform to environmental desires and develop structures readily identifiable as legitimate with value to the environment in order to increase the likelihood of obtaining resources. (Harris, 2013, p. 42)

In offering SEEK, NSBE is dependent on resources from industry, which influences decisions related to their goals, site selection, curriculum, activities, and assessment. As one NSBE HQ staff member noted:

> I think something that I've learned more in this role is the demands of our sponsors. A lot of our sponsors aren't just giving money and going to hope your program goes well. They want it to be in a specific location, they want specific [curricula] taught at their program.

As a mentor similarly noted, "Wow, this is real, these sponsors are real, they're going to make you listen." The mentor continued to illustrate his point by comparing mentoring experiences with sponsors across sites:

> Sponsorship is definitely different everywhere, each camp you go to…so that definitely plays a huge role in how you orchestrate your camp…it's like different things they need from us that we have to make sure we're giving out but making sure we're not stepping on other sponsors toes… Say for instance in Compton the main goal was to reach Latino children although we're the National Society of Black Engineers, so we had to make adjustments and you have to do it, you don't really have a choice so we had to do that. Here, it's not so much like that but if they want a picture or if they want time to speak you have to give it to them, you have to make it work.

Mentors and staff also pointed to specific activities within the camp that were influenced by sponsors; several suggested that strong relationships with sponsors made camps run more smoothly, and, as noted in the prior section, sponsor involvement enhanced mentors' experiences and competition Fridays for children. One mentor pointed to the new dress code as having a link to sponsors: "I think that actually impacted the SEEK program positively by adding that dress code because I've even noticed sponsors come in and say, 'Oh everyone is dressed so nicely on competition Fridays everyone is wearing a suit,' and just little things like that can change optics."

For three years, NSBE also received funding from the NSF to support the scaling up of SEEK, which enacted another source of resource dependence. This funding source also pushed NSBE to invoke certain changes. For example, as part of the award negotiation process, NSBE was asked to respond to concerns about not offering the program free of charge when a goal of SEEK is increasing access to engineering experiences. Similarly, the grant brought researchers from two universities into the SEEK planning and evaluation processes, adding new voices into curriculum planning, strategy around scaling, and mentor training, a new external pressure that NSBE had to balance in its implementation of SEEK.

With multiple external funding sources and players, each with a specific set of interests and needs, assessment and evaluation has often illustrated the complexity of resource dependency. As a NSBE staff member noted:

> We need to evaluate the program. That's one of the requirements really by all of our sponsors that, "Hey, we need to know how things went. We need something to take back to the folks that cut the check." So making sure we have a good evaluator and we get all the research or data that we need to share that with our sponsors.

Because of these demands, the research team collected some data to evaluate possible impacts that they would typically see as beyond the scope for this kind of three-week summer experience, such as conceptual understanding in math. Similarly, the NSF ITEST program solicitation (NSF, n.d.) highlighted certain constructs that may have been out of alignment with sponsors' interests. The resultant approach to assessment sought to balance all of these competing demands from stakeholders.

In summary, NSBE relies on external fiscal resources to offer SEEK in cities throughout the nation. As one mentor succinctly described in response to a question about what is needed to scale up SEEK, "You've got to find the sponsors. You've got to get that cash. Without capital, capital is so important in everything. Cash rules. Cash is king." As resource dependency theory predicts, because industry sponsors and federal funding agencies hold those key resources, the interdependence forces the organization to adapt to external demands and expectations, which contributes to the tensions that arise with respect to the involvement of multiple stakeholders.

Implications

Insights from our retrospective reflection reveal the extent to which operationalizing an asset-based approach to pre-college engineering programming at scale is extremely complex and challenging. We highlight some of the specific tensions between scaling up and remaining an asset-based out-of-school program that aims to promote equity in engineering. We discuss the extent to which the asset-based and needs-based philosophies appear to be at odds, noting instances in which

practitioners (and partnering researchers) must overcome a paradox if their offerings and study of out-of-school programs are to be simultaneously effective (asset-based) and widely available (scalable).

Our implications for those confronted with these complexities are grounded in a central recommendation: We must abandon either/or thinking and replace it with both/and thinking. We encourage educators to view the asset-based approach and desire to scale as "interdependent pairs," a practice referred to as polarity management (Johnson, 1996, as cited in Van Wyngaard et al., 2011). In the context of broadening participation in engineering, we must affirm children's cultural background and broaden access simultaneously. As noted by Johnson (2014), "Leveraging the potential from the interdependent pairs requires the engagement of key stakeholders in two processes. The first is the creation of *Action Steps* [emphasis added] to maximize the upside of each pole. The second is to identify *Early Warnings* [emphasis added] that will let us know, as early as possible, when we are getting into the downsides of a pole so that we can self-correct to minimize our time in either downside" (p. 211). In the sections that follow, we apply this idea to the overarching tensions that we observed with SEEK as well as the specific tensions that we outline throughout the Findings and Discussion section.

Implications of the Overarching Tension: Asset-Based and Scalable Approaches

Maximizing the upsides of both asset-based and scalable approaches requires careful consideration regarding the program staff. More specifically, because of the particular focus of SEEK, the most optimal staff includes a combination of engineering knowledge, teaching experience, and a sense of familiarity and comfort with the culture and communities of the participating children. Though the specific knowledge, skills, and attributes may vary from program to program, carefully selecting program staff is essential for asset-based pre-college engineering education. Examining the composition of program staff and questioning whether there is an appropriate balance of experiences and expertise is one mechanism for identifying Early Warnings.

Programs must also focus on marginalized groups without broadly applying cultural stereotypes. Although it may be productive to recruit participants based on their cultural similarities—in SEEK's case, predominantly focused on race—one must be cautious about cultural essentialism, or treating individual children as representatives of a homogeneous group with innate interest and abilities. This concern is raised by Gutiérrez and Rogoff (2003): "We are concerned with how researchers and practitioners can conceive of regularities in approaches to learning among people of similar cultural background experiences without reifying those cultural patterns and practices as located in individuals" (p. 21). Even though SEEK participants are largely comprised of Black children, it cannot be assumed that all participants share similar prior experiences or interests, or that mentors with shared racial identities will be able to relate with them. As we discussed in Tension II, for example, participants' parents/guardians have a wide range of educational backgrounds. Examining demographic variation within a site—or showing differences between sites as our project did—and questioning whether and how these differences are attended to is one mechanism for identifying Early Warnings.

Beyond the careful consideration of program staff and participants, programs must also carefully consider which elements of a program should be standardized as they scale up. A pure asset-based approach requires simultaneously considering culture, community context, gender differences, and individuality, which can be quite challenging in practice for a geographically dispersed program offered at scale. The pressure to achieve standardization becomes a competing goal, as noted by a member of NSBE HQ:

> We want to make sure that we are standardized. We want the third grader experience in Sacramento to be more or less the same that a third grader has in Houston or at one of our other sites around the country. In being consistent, we've been very, very purposeful with our training and what's expected and how you run a site. We want to do that so we can ensure quality, that there are policies and procedures in place that everybody follows, and that we're operating at a high level of excellence. It's very important to us to have consistency across the sites, across the country.

Therefore, although following an individualized or place-based approach (Sobel, 2004) for informal learning opportunities aligns with an asset-based approach, tensions arise in practice when seeking to scale up such experiences across multiple communities. Two ways SEEK balances these poles are by: (1) partnering with local industries to bring in local examples that might resonate better with the children in a specific city; and (2) employing mentors to work with multiple sites, either within the same year or across years. Examining the extent to which the desire to maintain a quality experience across the board (i.e., standardization) impacts the ability for individual sites to tailor activities to specific participants or communities is one mechanism for identifying Early Warnings.

Implications of Tension I: Including Dominant Narratives and Counter-Narratives

To maximize the upsides of introducing children to both dominant narratives and counter-narratives, the latter of which aligns more with an asset-based approach to education, program staff must pay careful attention to their messaging around

what it means to be an engineer. SEEK does a laudable job in this area. As noted throughout the findings, SEEK aims to disrupt dominant narratives of what engineering entails and what engineers look like, providing children with a clear take-away message that Black people, women and men, are and can be successful engineers. SEEK additionally pays close attention to acknowledging dominant narratives because those will not go away, and children will continue encountering such dominant narratives as they progress through their educational and professional careers. Examining the implicit and explicit messages being conveyed in a program and questioning whether and how these messages reinforce or combat dominant narratives surrounding engineering, and to what end, is one mechanism for identifying Early Warnings. For example, whenever a conversation around curriculum moved too far away from the dominant narrative that math skills are important, SEEK program leaders would think about how math might be woven into camp programming in a new, fun way. Over the course of the project, we saw shifts away from using math worksheets as a means to achieve this goal toward using math games instead.

Tension I also highlights an important implication for researchers. When implementing a standardized research protocol across multiple out-of-school programs, it is likely that dominant narratives become captured as opposed to the counter-narratives. Because counter-narratives are linked to the particular characteristics of a given program, standardization likely does not optimize that side of the pole. Thus, our findings highlight the need for researchers to consider how their data collection strategies (e.g., instruments, research protocols) should be customizable and adjusted to particular program/research contexts, and the need for qualitative and mixed-methods research that can better capture counter-narratives. It may make comparing across out-of-school programs more challenging from a quantitative perspective, but aggregating objectives across such programs through research likely loses essential contextual elements of specific programs.

Implications of Tension II: Balancing Strategic Recruitment and Participation Management

To maximize the upsides of strategically recruiting children from a target population and managing the process of accepting children into an out-of-school program, program staff must pay close attention to the entire pre-camp process as it relates to access and adhering to a planning and decision timeline. As we showed through the Findings and Discussion section, SEEK sought to balance broad access with the realities of who opted in as well as the timeline for needing to make final decisions about participants so that decisions around staffing and resourcing could move forward. Critically examining the demographic characteristics of who ultimately applies to and participates in a program is one mechanism for identifying Early Warnings. For example, one of the clearest examples of polarity management that we saw in SEEK was the recognition that a first-come, first-serve process created inequities. In looking at the implications of that acceptance practice, SEEK demonstrated how an Early Warning intervention pushed the organization toward thinking about new ways to make decisions that broadened potential access. We see this scenario as an important consideration for other pre-college engineering education programs. In short, there needs to be a consideration of capital and assets before (i.e., during recruitment and selection) children even have the opportunity to engage in educational experiences because failing to do so can result in certain children never having the opportunity to become participants.

Implications of Tension III: Supporting a Shared Vision and Divergent Objectives

One of the key take-home messages from the Findings and Discussion section tied to Tension III is the recognition that it is important to understand what each stakeholder hopes to gain from a partnership. Each external group will have a set of demands that may or may not align with a program's underlying philosophies—and even if certain ideas may align with a program's core values, they may not be able to be carried out fully if they collide with a different partner's ideas. SEEK did an admirable job in balancing all of these pulls and recognizing that different sites had different sponsor demands. Sometimes SEEK staff met these demands by ensuring specific curricular modules were at a certain site, considering other ways to meet demands tied to student enrollment strategies, and ensuring industry sponsors had more frequent access to certain sites relative to others. These were all examples of Action Steps that were catered to specific situations such that SEEK's core values and activities maintained a balance with external demands. Other similar out-of-school programs could think about following such a multi-strategy approach tailored to an individual sponsor's needs but ultimately aiming to balance a set of poles. Nonetheless, we caution out-of-school programs from over-relying on external resources as it can potentially redirect program efforts from the original mission.

Examining the extent to which the objectives of different sponsors diverge from the vision of the program is one mechanism for identifying Early Warnings. If a sponsor's demands become too out of alignment with program goals, or the program is unable to shift the sponsor's perspective, the program may need to shift toward new partners. In the case of programs similar to SEEK (i.e., geographically distributed programs), one approach could include selecting cities where potential sponsors' views might better align with SEEK's program goals. Likewise, if a program's goals shift over time and

a sponsor's demands do not similarly shift, it may be time to find new partners. For example, if SEEK aimed to emphasize counter-narratives more in the future but a particular sponsor wanted the program to emphasize the dominant narrative of the importance of math, such misalignment may suggest the partnership is no longer symbiotic. As resource dependency theory suggests, whenever an organization has a reliance on an external entity, there will always be some compromise so that each partner benefits from the relationship. Ultimately, if that give-and-take becomes too much for the out-of-school program, it is time to find new sponsors. The most obvious way to avoid such a scenario is to become self-sufficient, which is practically impossible for out-of-school programming offered at scale when the target participants cannot be asked to provide the resources to engage in the experience and it would be unjust to ask the mentors to provide the SEEK experience for free.

Lastly, from a research and evaluation perspective, it is important to recognize and view both research activities and program evaluation activities as additional sets of external demands, particularly in instances where there is pressure to demonstrate a return-on-investment for sponsors (e.g., NSF, industry sponsors). Under such circumstances, there may be desires or pressures to collect more data than necessary to examine or evaluate a program. We encourage educational researchers and program evaluators to be creative and unobtrusive in crafting both research and evaluation plans for these kinds of programs. Whether engaging in research or evaluation, one should proactively work to avoid disrupting children's experiences as much as possible because causing assessment fatigue (or fatigue associated with any form of data collection) works in direct contrast to the objectives of most out-of-school programming.

SEEK as an Example of Successful Polarity Management

Although we present these ideas as a series of considerations, it is not our intention to make evaluative judgments that prescribe any particular way of thinking about each topic. When seeking to scale up out-of-school experiences, or any educational endeavor, a series of tensions will likely arise. Thus, program leaders and researchers should be prepared to make a series of decisions and compromises. Additionally, we do not want our analysis to lead readers to view SEEK negatively. In actuality, NSBE has done a remarkable job in balancing the aforementioned tensions as it has successfully scaled up this experience. In a survey of parents following the 2019 SEEK camps, more than 90% of respondents stated that it would be "extremely likely" for their child to attend SEEK in a subsequent year if the experience were available. A majority of parent respondents expressed they would like to join a NSBE Jr. chapter (i.e., NSBE pre-college programming designed to stimulate interest in STEM) and encourage their children to participate in other engineering programs because of their positive experiences with SEEK. Repeat participants are not limited to children and their families—mentors also routinely choose to work in SEEK for multiple years, and funders and host sites routinely invest in the program year after year. As a NSBE staff member noted:

> So corporate sponsors that continue to give funding to the programs…still continuing to give because they see for themselves once they go on-site and talk to parents and other stakeholders, again, like the school leaders. We have principals that fight to keep SEEK at their school because they're so committed to the program and they see the value in it. So overall I do think we're doing a great job at providing that access and exposure for our target population.

Such triangulation of positive evaluations through self-reports and year-over-year behavior of engaging in SEEK demonstrates how NSBE has successfully navigated these tensions as the experience has scaled up—indeed, we can learn a lot from how the organization has engaged in successful polarity management.

Conclusions

Our reflections highlight that a series of required tradeoffs must be carefully considered to offer and study an effective intervention designed to affirm a cultural background simultaneously with broadening access by offering the intervention at scale. Our contribution to the literature expands the discussion about asset-based engineering beyond that of local pedagogical action, in particular in thinking about issues of broad access and scaling up of opportunities. Offering an out-of-school program involves much more than local pedagogical action (e.g., classroom practices), which is often the primary focus of work that offers implications for how educational activities can leverage the skills and resources of low-income communities. In reviewing our findings and existing literature, we note that counter-narratives, cultural stereotypes, pedagogical action, and personnel are central in much of the existing work on asset-based approaches; however, the dominant narrative, participation management, and divergent objectives complicate that approach. By illuminating the tradeoffs that we had to make, we hope this paper can help other program designers and researchers to intentionally, preemptively, and proactively consider such tradeoffs.

Acknowledgments

The work presented in this paper was done in partnership with the NSBE, a student-governed organization. Staff and students from NSBE designed, implemented, and oversaw the SEEK program. The program was first developed under the leadership of Dr. Darryl Dickerson in 2007 while he was chairman of the board for NSBE and a biomedical engineering graduate student. During the four-year project described in this paper, and the preceding year when the grant proposal was developed, Brittany Boyd, Loylita Ennis, Dr. Trina Fletcher, Amanda Jones, Thomas Harris, and Greg Meerpool all played leadership roles with the SEEK program. Dr. Karl Reid, Executive Director of NSBE, served as the PI for the project and Elizabeth Blume served as Project Manager. The research also reflects the contributions of a larger team of faculty, postdocs, graduate students, and undergraduates: Morgan Hynes, Cheryl Beauchamp, Cherie Edwards, Glenda Young, Sreyoshi Bhaduri, Donovan Colquitt, Tikyna Dandridge, Cynthia Hampton, Natali Huggins, Jessica Rush Leeker, Racheida Lewis, Taylor Lightner, Kayla Maxey, Desen Ozkan, Johnny Woods, Janna Schorfheide, and Sarah Whisman. This material is based upon work supported by the NSF under Grant Numbers DRL-1615143, DRL-1614710 and DRL-1614739, and upon work conducted while Monica Cardella was serving at the NSF. Any opinions, findings, conclusions, and recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF.

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