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Outreach at Scale: Developing a Logic Model to Explore the Organizational Components of the Summer Engineering Experience for Kids Program

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ABSTRACT

Striving to remain a global leader in innovation, the United States continues prioritizing broadening participation in engineering and other STEM fields. For this reason, STEM outreach programs are increasingly popular and vital. However, few programs offer such outreach experiences at a large, national scale and intentionally situate those experiences in locations that enable access for African American youth. In this paper, we present a logic model that showcases the resources and components that can expand the reach of an effective program, outlining the programmatic components involved in executing the National Society of Black Engineers' Summer Engineering Experience for Kids (SEEK) program, which has effectively scaled to cities across the United States. Using SEEK as an instrumental case, we highlight what goes into offering a large-scale community-based STEM outreach program, emphasizing aspects that are most important to preserve during expansion into underserved communities. Key findings illustrate that maximizing the potential of recruiting and engaging youth from underserved populations may hinge on the ability of established programs to scale up their initiatives while establishing appropriate assessment plans to measure effectiveness. Additionally, embracing the ideals of collective impact provides an opportunity for such programs to progress their initiatives by replicating program designs in more communities.

Key words: *broadening participation, informal learning, organizational assessment*

INTRODUCTION

The challenge of broadening participation in engineering and other STEM (science, technology, engineering, and mathematics) fields is illustrated by the low number of people from ethnic and racial minority groups in the STEM workforce. Despite an increase in the number of Black/African Americans and Hispanics/Latinos entering STEM disciplines and jobs since 1995, when compared to the U.S. population demographics, their representation remains relatively low (Palmer, Maramba and Dancy 2011, 493). More specifically, underserved minorities make up 29% of the U.S. population yet comprise only 9% of science and engineering fields (Committee on Underrepresented Groups and The Expansion of the Science and Engineering Workforce Pipeline 2011, 2).

Persistent underrepresentation can partially be attributed to historically imbalanced educational opportunities (Long III and Mejia 2016, 211-212). Although some policies and practices that contributed to these imbalances have been or are slowly being altered or removed, addressing education disparities remains a challenge. To mitigate these challenges, the engineering education community often leverages targeted approaches focused on underserved youth populations, or community-based outreach programs. The objective of such programs is to redress specific barriers to access for a specific population (Edwards et al. 2018, 2-3), addressing disparities in STEM engagement by providing experiences that ideally pique the interest of students from underserved populations and encourage prolonged engagement in these fields.

Offering successful STEM outreach programs at scale may offer a solution for broadening participation in engineering, but many challenges hinder program expansions. Sternberg et al. (2006) broadly summarize these challenges to include those associated with the overall suitability of the program for upscaling and those associated with transmitting the program to wider audiences (e.g., financial barriers, geographical barriers, and community-based barriers) (4). Those scaling up educational outreach programs also face challenges associated with standardization across programs. If these challenges are addressed, scaling up can be accomplished through replication of proven designs, enabling organizations to maintain their program practices and procedures (McDonald et al. 2006, 16).

One example of an outreach program that has scaled up successfully is the Summer Engineering Experience for Kids (SEEK) program directed by the National Society for Black Engineers (NSBE). Through this program, NSBE facilitates summer engineering experiences for students in underserved communities across the nation. By embracing many aspects of collective impact, NSBE illustrates the potential for leveraging interdisciplinary partnerships and aligning programmatic outcomes with tangible measures of success to expand the program's reach across many communities while maintaining an organizational design that permits effectiveness. As one of the largest engineering-focused programs in the United States focused on economically disadvantaged racial minorities, SEEK serves as an example in how to transmit a STEM outreach program to a wider audience.

OUR CASE: NSBE'S SUMMER ENGINEERING EXPERIENCES FOR KIDS

Building on over 10 years of outreach experience, NSBE's offering of SEEK provides a viable example of an organization conducting outreach in underserved communities. SEEK is designed to provide an engineering-focused, three-week summer experience for students between third grade and fifth grade, and sites are intentionally selected to encourage high rates of African American and Hispanic participation (Edwards et al. 2018, 2; Fletcher 2017, 16-18). During each week of SEEK, students are exposed to activities designed to grow their skills in math, science, critical thinking, and teamwork. Students are also exposed to activities meant to increase their knowledge and expand their perceptions of engineering as a field and future career. Although there are numerous ways by which NSBE works to achieve these objectives, its main strategies include hiring mentors that are racially similar to student participants, encouraging parental involvement, and holding camps in communities near their target populations (Fletcher et al. 2017, 2).

Focusing on SEEK as an instrumental case, the purpose of this paper is to outline the programmatic components that go into executing a large-scale community-based outreach program for underserved communities, highlighting program aspects that are most important to preserve during expansion. To address this purpose, we present an overview of the SEEK program grounded in the collective impact framework and logic model methodology as well as present evaluation data to demonstrate the program's effectiveness. We subsequently share insights gained from the construction of the SEEK logic model, and then discuss the implications of our findings and conclusions.

LITERATURE REVIEW

Over the past 20 years, there has been an abundance of programs aimed at broadening participation in STEM via out-of-school opportunities (Cardella et al. 2014, 24). By integrating the culture of the communities that they serve into STEM content, these programs provide STEM-focused learning opportunities aimed at promoting diversification (Edwards et al., 5-7). The findings of previous studies suggest that such programs, particularly those targeting pre-college students, can significantly increase participants' literacy and self- efficacy in related work (Fantz, Siller and Demiranda 2011, 308; Rohrbaugh and Corces 2011, 1136). As Rohrbaugh and Corces (2011) assert, exposing individuals from underserved populations to STEM fields prior to their matriculation into higher education can significantly impact the recruitment of individuals from racially underserved communities into STEM fields.

Community-Based Outreach Programs

Although outreach is conceptualized in varying ways, rarely do these conceptualizations lead to an explicit definition of the term. As articulated by Dewson, Davis, and Casebourne (2006), outreach refers to services provided to targeted local communities outside of mainstream, normative institutional settings. These services tend to be provided closer to home, are voluntary for participants, and offer different services than mainstream institutions (Dewson, Davis and Casebourne 2006, 11-13). According to Jeffers, Safferman, and Safferman (2004), K-12 engineering outreach programs are typically created to achieve at least one of five goals, including: 1) increasing engineering enrollment; 2) diversifying engineering; 3) educating our future; 4) teaching teachers; or 5) developing undergraduate students.

As defined in the literature, outreach closely aligns—and can at times intersect—with the initiatives of community-based programs. Harris and Kiyama (2015) conceptualized community-based programs within an educational and youth development context, defining such programs as not-for-profit programs that provide a wide array of services, functioning in both in- or out-of-school settings. Harris and Kiyama extend this conceptualization by defining these services to include activities such as tutoring, counseling, and advocacy for program participants.

The most glaring difference between these conceptualizations of outreach and community-based programs is the emphasis for outreach to occur *outside* of normative institutional settings, whereas community-based programs are presented as entities that can operate *within* and *around* these established institutions. Accountability is one aspect linking both community-based and outreach programs. Organizers from outreach and community-based programs are tasked with monitoring and measuring the areas of growth and successes of these initiatives (McLaughlin and Jordan 1999, 10–11).

In the context of STEM, outreach and community-based programs come in various designs, as demonstrated by an extensive literature review by Jeffers, Safferman, and Safferman (2004), who identified the following six approaches: (1) develop classroom and/or web-based material, (2) conduct outreach activities on the campuses of local colleges and universities, (3) conduct outreach activities in local grade schools, (4) sponsor and conduct STEM competitions, (5) sponsor teaching fellows, and (6) offer STEM related professional development to K-12 teachers. In addition to variation in design, STEM outreach programs also vary in target age, curriculum, and length. Given such variety amongst programs, questions remain about which aspects most directly encourage successful achievement of program goals.

CONCEPTUAL FRAMEWORK

Collective impact counters the commonly individualistic nature of non-profit organizations, as such organizations often operate within the domain of isolated impact (Kania and Kramer 2013, 1). Isolated impact is based on organizations working independently to obtain resources, develop and demonstrate the effectiveness of interventions, and independently extend the effect of their interventions more widely (Sagrestano, Clay and Finerman 2018, 91). By embracing the ideology of isolated impact, organizations can unintentionally compete with one another while exponentially increasing the resources needed to operate (Kania and Kramer 2011, 38).

Attempting to avoid the disadvantages of isolated impact, many organizations in public health and education have begun adopting the philosophy of collective impact for effective and lasting social change (Kania and Kramer 2013, 1; Sagrestano, Clay and Finerman 2018, 90). Collective impact removes the emphasis of working through a single organization, placing the focus on structured cross-sectional partnerships (Kania and Kramer 2013, 1). Cross-sectional partnerships have proven to be an especially impactful approach for organizations aiming to scale-up their initiatives to achieve large-scale systematic change (Turner et al., 2012). However, embracing collective impact is not solely based on established partnerships and increased collaboration. Collective impact also centers on systemic approaches focused on the dynamics between contributing organizations and the collective progression toward shared objectives (Kania and Kramer 2011, 4). According to the collective impact philosophy, achieving this degree of collaboration and change requires five conditions, introduced by Turner et al. (2012) as follows:

1. **Backbone Support:** A backbone organization that is separate from the community-based initiative coordinates participating organizations and agencies.
2. **Common Agenda:** All members of the organization share a consistent vision and understanding of the problem and agree on the appropriate means to address it.

3. **Mutually Reinforced Activities:** The roles and activities of participants should be differentiated while still aligning with an agreed upon plan of action.
4. **Continuous Communication:** Sustained and consistent communication is maintained across all members of the organization.
5. **Standard Measurement:** Approaches for data collection and measurement are consistent across all participants.

Herein, we argue that offering SEEK requires a combination of mutually reinforced activities across a structured partnership including schools, companies, and other partners. Though the positioning of SEEK as the only "mutually reinforcing activity" runs counter to the traditional collective impact efforts that engage multiple programs and initiatives to solve a complex social problem, this lens offered a starting point to understand how this existing effort has scaled up as well as the potential for expanding activities in other areas such as NSBE's Pre-College Initiatives and NSBE Jr. chapters, which would involve similar partners.

Although there are many challenges associated with collective impact, unrealistic expectations of solutions are one of the greatest (Kania and Kramer 2013, 1). Through collective impact, stakeholders aim to mitigate such challenges by using already-present resources to maintain continuous learning and simultaneously adopting changes across different organizations, which promotes a sustainable organizational culture across sites (Kania and Kramer 2013, 5). Herein, we demonstrate these points through a detailed description of SEEK and its programmatic design, examining the extent to which these five conditions are present in scaling up SEEK.

METHODS: LOGIC MODEL DEVELOPMENT

To outline SEEK's programmatic design, we turn to logic models. Logic models are evaluation tools that help outline organizational designs and map expected programmatic outcomes to the resources and activities that encourage those outcomes (Peyton and Scicchitano 2017, 156–157). Logic models are designed to visualize how programs work (or should work) through a systematic assessment of the comprising components. These tools are particularly important for community-based and outreach programs because they help administrators and other stakeholders evaluate overall program impact and identify which aspects of programs may contribute to their successes and failures (Savaya and Waysman 2005, 94–99).

The specific elements of logic models are often defined and detailed through a series of assessments methods (e.g., pre/post-test, interviews) (Savaya and Waysman 2005, 99). Logic models are traditionally composed of four main components: (1) inputs/resources, or the human, financial, organizational, and community resources that are invested in a program to support program activities, outputs, and outcomes; (2) activities, or the processes, events, and actions strategically planned to support the implementation of a program; (3) outputs, or the products generated from program activities; and (4) outcomes, or the expected impact of the products generated from the program (Savaya and Waysman 2005, 99).

Data Collection and Analysis

We developed the SEEK logic model through qualitative analysis of semi-structured interviews with SEEK mentors (n=25) and NSBE leadership (n=8) that focused on examining aspects of SEEK's organizational structure and culture. Through two phases of coding (inductive and deductive), each transcript was analyzed to identify the resources, activities, and outcomes needed for SEEK's operations. In the first phase of coding we applied an initial coding analysis, which served as a means to identify descriptive segments of data while highlighting regularities in participants' perceptions of a phenomenon (Anfara, Brown and Mangione 2002, 32). The second phase of coding was a deductive approach to focused coding, allowing for the sorting of large amounts of data based upon the most prevalent initial codes (Charmaz and Belgave 2012, 357). During this phase of analysis, the codes identified in phase one were organized into categories based on inputs/resources, activities, or SEEK's short-term, mid-term, or long-term outcomes.

RESULTS: SEEK'S LOGIC MODEL

The resulting logic model (see Figure 1) illustrates the key components of SEEK, including the outcomes necessary for evaluating SEEK's impact and the programmatic components necessary to duplicate for upscaling. It focuses on outcomes at three levels (short-term, mid-term, and long-term) and outlines the full array of associated resources and activities. This format enabled our research team and NSBE leadership to consider the impact of program activities over different time intervals. More specifically, this layout allowed for a clearer examination of how well SEEK's goals align with outcomes resulting from SEEK's activities. Nonetheless, it is important to note that because SEEK is geographically dispersed, there are nuanced aspects at each site that may not be captured in this overarching logic model.

Organizing Outcomes

As noted, SEEK's outcomes are organized based on their short-term, mid-term, and long-term goals. For SEEK, the long-term objective is to have implications on the participation of underrepresented racial groups in the field of engineering. To achieve this goal, NSBE and SEEK administrators outline objectives ranging from exposing youth from underserved populations to engineering to improving these youth's performance in math and science. In line with the framework of collective impact (Kania and Kramer 2013, 1), these outcomes are reflective of a common agenda held across SEEK stakeholders. More importantly, these outcomes illustrate the need for stakeholders to hold a common agenda so that objectives may be identified and achieved.

Short-Term Goals. Informed by the overall objective of the SEEK program, short-term student goals are focused on engaging students in engineering experiences, teaching students the principles of engineering, boosting student motivation and interest in STEM disciplines, and improving students' skill sets with STEM-related items. These objectives can be measured through targeted assessments.

Mid-Term Goals. Through its mid-term objectives, SEEK continues to focus on the academic development of its participants. More specifically, having students engage in the program aims to reinforce STEM skills. The hope is that the skills gained from the program will translate to their experiences and performances in school, helping them understand why certain skills taught in school (e.g., math) are relevant for exciting and transformative engineering careers. The program hopes that students who engage in SEEK will develop new motivation for certain classes when they return to school following summer vacation. Such outcomes tend to occur following the implementation of the SEEK programs and are challenging to measure because they fall outside of the program's scope.

Long-Term Goals. NSBE hopes to have a lasting social and educational change on SEEK participants in the long-term. This goal of increasing the number of engineers from underserved communities suggests that NSBE expects their programming to have a profound impact on the career trajectories of students. Without the appropriate measures in place (i.e., longitudinal data), however, assessing this particular goal is a persistent challenge. Building a longitudinal data system would require tracking SEEK students as they progress through middle and high school into college and into their professional fields. NSBE may be uniquely positioned to offer such a structure for data collection because it hosts a variety of different activities beyond SEEK (e.g., NSBE, Jr.) to keep students engaged throughout their secondary schooling.

SEEK's Resources

> *There has to be financial resources. Whether it's from a school system, a corporate partner or both. There have to be volunteers who are willing to invest their time. When you talk about the weekly culminating event, when you talk about the parents shepherding and advocating within their communities for the program for its sustainability, for instance... We've got to have the money, and we've got to have the human capital.*
>
> *– SEEK Mentor*

As illustrated in the above statement, SEEK operations are not solely contingent upon financial resources, but rather the balance of financial and human resources on various levels. In this section of the paper, we outline these resources (Figure 2) and describe how they contribute to the successful implementation of SEEK.

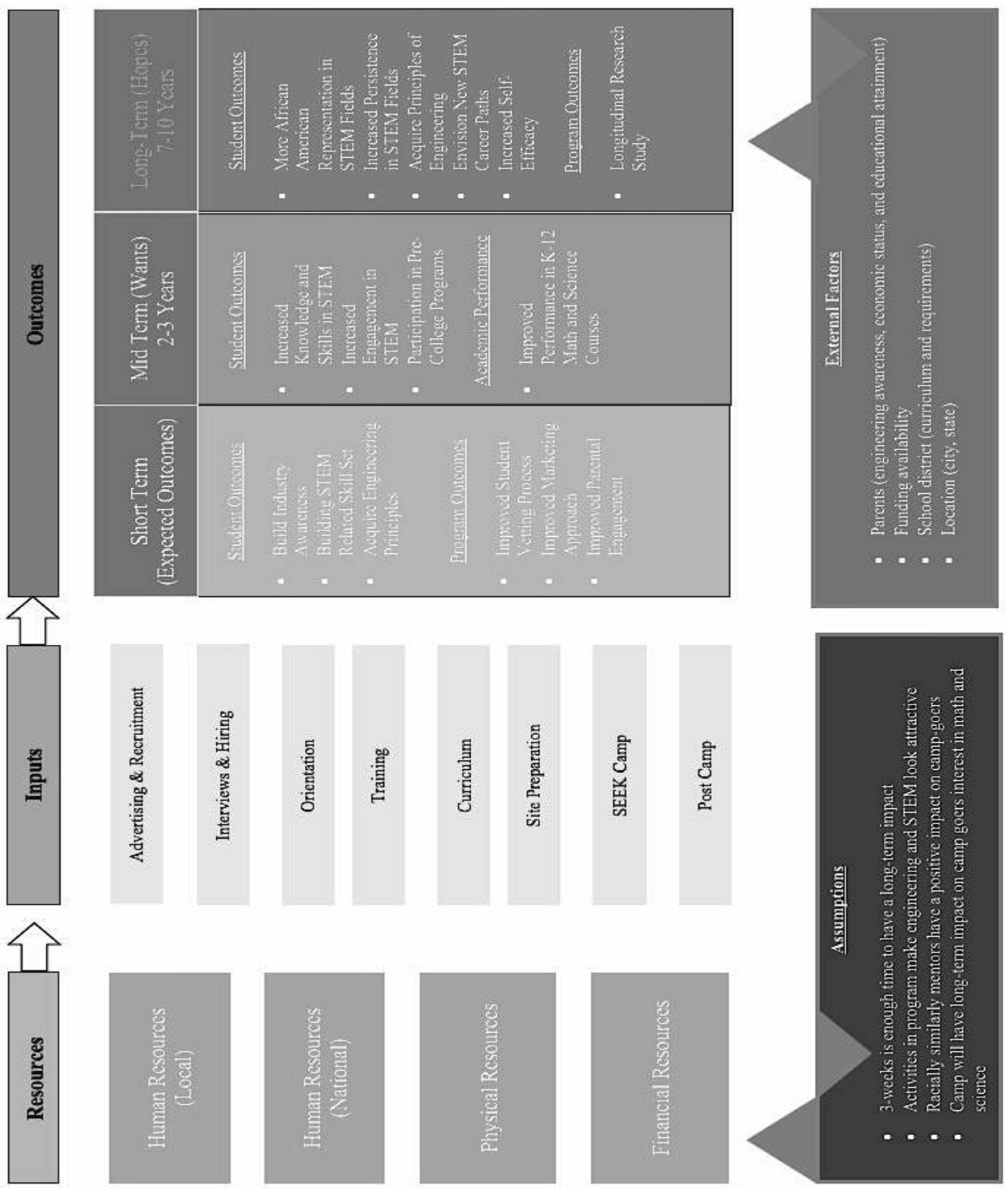

Figure 1. SEEK's Logic Model.

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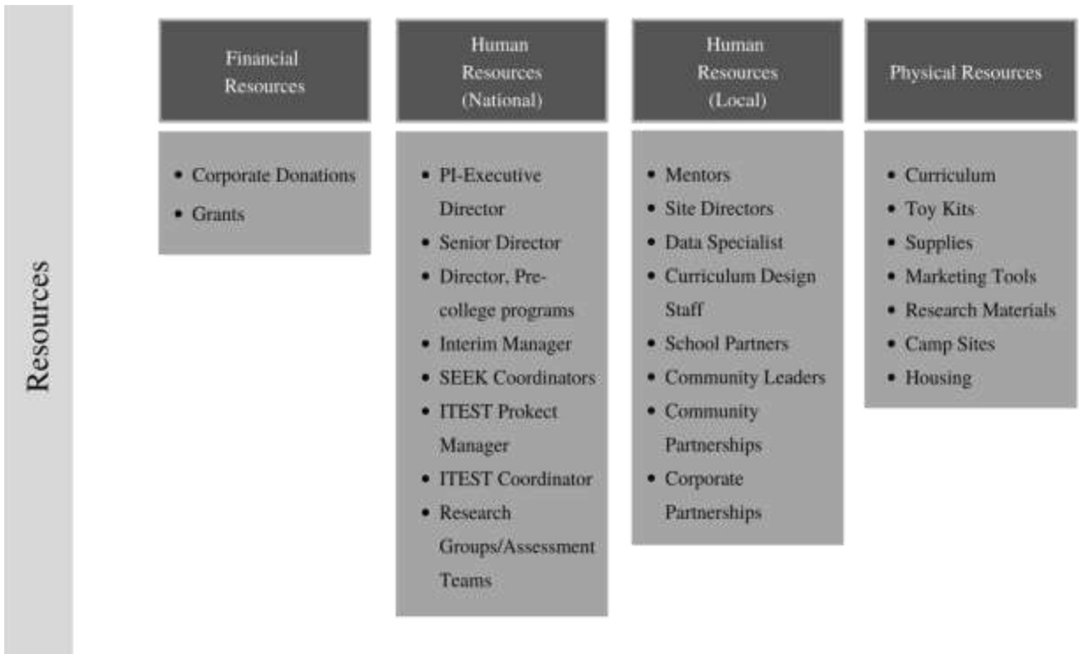


Figure 2. Detailing SEEK's Inputs.

Financial Resources Similar to other community-based programs, SEEK's financial resources are the overarching element through which all other components are able to operate. SEEK's resources are primarily generated from corporate donations and grants. Corporate donations are funds generated from local and national corporate partners who aim to support NSBE's mission by funding programs such as SEEK in communities in which they have major operations. Grants are funds generated by NSBE applying for financial support from an organization or governmental entity for a specific purpose.

By relying on such financial resources, in particular the local corporate partners, NSBE has further emphasized the community-focused aspect of the NSBE and SEEK objectives to promote STEM engagement in underserved communities. Building partnerships with corporations and grant providers allows the SEEK program to operate within underserved communities to bring STEM engagement to youth who otherwise would not have access to such opportunities.

Human Capital Those involved in the implementation of SEEK identified several other components that are necessary for regular and efficient operations. The resources that go into each SEEK site are numerous and extensive, ranging from each employee contributing to the camps to the teaching materials used at the camps. Additionally, the level of importance placed on specific resources differed based upon the position a participant held. For example, mentors and other SEEK site leadership focused on resources required for day-to-day operations at their particular location, whereas the NSBE headquarters team members were responsible for ensuring every site had all materials and supplies needed, which called for focusing at a higher-level, cross-site perspective. Because of SEEK's presence in 14 cities across the United States, the resources provided through human capital are examined on the local and national levels.

National-Level Human Resources. Human resources on the national level illustrate the collaboration necessary to plan, execute, assess, and, ultimately, offer SEEK at scale. Procurement of resources, program planning, and program implementation are all carried out by the NSBE headquarters team (i.e., executive director, senior director of programs, director of pre-college programs, the lead fundraiser, SEEK leadership team). Figure 3 outlines the roles and responsibilities of the NSBE team.

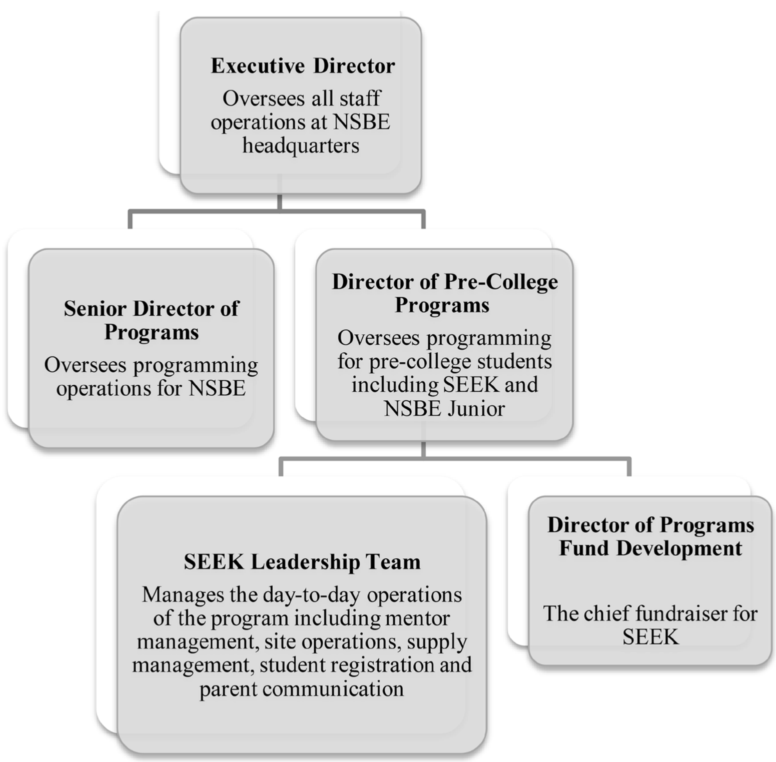


Figure 3. Outline of NSBE's Human Resources.

Although planning and executing the SEEK program is aimed at meeting the core objectives of the program, the design, execution, and coordination of research and assessment initiatives to assess the impact of the SEEK program requires additional human resources (e.g., ITEST (Innovative Technology Experiences for Students and Teachers) coordinator, ITEST project manager). The execution of research and assessments is currently led by research teams from two universities. Relying on researchers from institutions that are independent of NSBE and the SEEK program allows for an objective evaluation and a focus on implementation of research to practice (Young et al. 2017) but may not be sustainable without the presence of grant funding.

Site Level Human Resources. Whereas the NSBE administration developed the policies and procedures necessary to execute the SEEK program at multiple sites, policies and procedures are operationalized by local human resources. The roles and activities that SEEK Site Directors, classroom Lead Mentors, classroom Mentors, and Seasonal Site Coordinators either manage or execute are described in Figure 4. Collectively, these activities include: (1) managing and implementing

Figure 4. Outline SEEK's Local Level Human Resources.

curriculum at the site and classroom levels; (2) coordinating data collection at the site level; and (3) coordinating camp operations on the site level. Seasonal Site Coordinators act as liaisons between the NSBE headquarters and SEEK sites, Site Directors and Leaders maintain the day-to-day operations of the camp sites, and classroom mentors lead teaching, managing, and all other activities concerning a sub-group of students. Most importantly, mentors communicate the values of the SEEK programs to participants, making them vital players in instilling a lasting impression of STEM concepts and engineering values within their students (Lewis et al. 2018).

Physical Resources

Each SEEK site requires the buy-in of stakeholders within the community. Because SEEK is reliant on community-based sites to hold the programs, school administrators and other members of the community are necessary to assist with obtaining physical resources that may be out of reach to the NSBE headquarters team. In the following section we discuss in detail specific physical resources needed to implement SEEK programs across numerous sites.

Mentor Housing. As part of the support SEEK offers to local human resources, housing is provided for many of the mentors who need it to serve in their role. Mentors are typically college-age students from all over the country. Similar to selecting program site locations, the amenities of housing must align with the needs of SEEK. A primary necessity is the location of mentor housing. Although SEEK offers transportation between mentor housing and SEEK camp sites, it is desired that housing locations be proximal to the SEEK camp sites to reduce costs and time required for mentors to arrive on site. Historically, SEEK has partnered with nearby universities such as Chicago State University, Tulane University, California State - Dominquez Hills, Wayne State University, Drexel, and Jackson State University for housing.

Marketing. Marketing materials are an essential component to introduce families to SEEK and to recruit new participants and potential funders. SEEK practices a multi-campaign approach, engaging parents, students, funding partners, and general NSBE stakeholders through different media. This strategy begins with providing local schools and community organizations with hard and electronic copies of marketing materials. The next steps are numerous advertisements through social media channels, which increases access to information for students and parents. Even in using a multi-layered approach to marketing, SEEK still relies heavily on word of mouth to gain exposure in communities as illustrated in the following statement:

> *I think that was something we realized as we expand to new cities from our target areas that we've been with for years. We've learned that we have to market in new ways. I think most of our marketing just includes creating flyers and sending them out in the school districts,*

sending them to local YMCA's, Boys and Girls Clubs, but also our marketing team at WHQ. They also send press releases out in every city and try to contact media in the city as well. But a lot of SEEK is honestly where we get most of our people is word of mouth, but we still also try to play to the places of other media outlets as well and expose our program that way too.

~NSBE Staff Member

The above statement reinforces the community-centered approach SEEK adopts to implement the program.

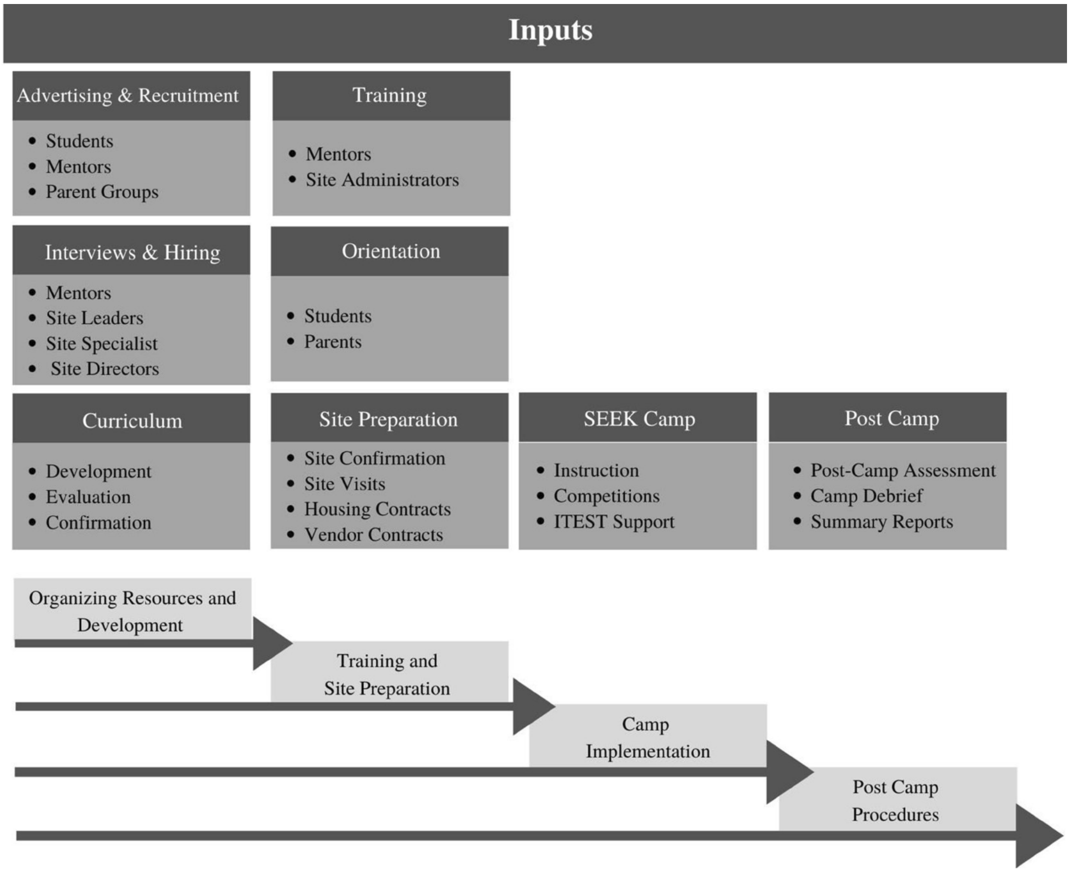
Curriculum & Classroom Materials. SEEK's curriculum and class materials are interconnected. Each week, SEEK sites engage in one of the 12 curricula offered—sites are broken into classes by grade level, and all classes at a site complete the same curricular module each week. By the completion of camp, each class will have completed a total of three curricular modules. With each module, SEEK participants build a "Toy," or a physical representation of the engineering curriculum. For example, during the week students cover the Drone curriculum, they are tasked with constructing a drone and participating in an end-of-week competition to test how well they are able to integrate the concepts taught during the week within the model they are tasked with developing. Coordinating the SEEK curriculum across sites is another way in which NSBE infuses its ideals through their curriculum as well as content.

SEEK's Activities

Once the requisite resources are secured, there are numerous activities in which NSBE engages to prepare for SEEK's program cycles. Because these activities are so numerous, we have organized our descriptions into four categories based upon the time of implementation and aspects of camp execution to which these activities pertained (see Figure 5).

Organizing Resources and Development. As SEEK programs are planned and organized for implementation, activities are focused on securing multiple site locations, recruiting and hiring site leadership and mentors, recruiting students, and developing curriculum and accompanying evaluations to measure short-term outcomes of the program. The focus of assessments is on short-term outcomes because assessing SEEK's mid-term and long-term objectives would require a longitudinal study which has yet to be developed. There are four main activities that occur during initial activities stage:

1. **Advertisement and Recruitment:** In this stage parents, students, and SEEK staff are recruited for participation in SEEK programming. The program utilizes similar tactics to advertise to all three groups. Additionally, word of mouth constitutes a large portion of brand awareness for SEEK in recruiting participants.



Note: *Activities in table are organized based on the time in which they occur. Events are organized at the bottom of the diagram with accompanying arrows.*

Figure 5. Detailing SEEK's outreach Activities.

2. **Interviews and Hiring.** Another important aspect of SEEK's pre-program process is hiring human resources. Hiring mentors, site leaders, and site directors involves screening for individuals who best fit SEEK's needs. Most importantly for SEEK staff is that they understand and adapt to the culture of the organization. SEEK's objective is to encourage prolonged engagement in the field of engineering, and it is important that local SEEK staff not only understand this objective, but also exude it through their roles within the program.
3. **Curriculum Development and Confirmation.** To ensure that providing an engineering experience is a primary focus in SEEK classrooms, curriculum modules are developed and selected before each cycle. Table 1 outlines a sample curriculum schedule across sites. During their time at the program, SEEK participants will have the opportunity to engage in three different

Table 1. SEEK Curriculum Schedule.

Program Site	Camp Cycles	Curriculum Schedule 2018		
New Orleans	Cycle 1	Wind Turbine	Fuel Cell	Trebuchet
Atlanta	Cycle 1	Wind Turbine	Drone	Fuel Cell
Birmingham	Cycle 1	Glider	Fuel Cell	Gravity Cruiser
Sacramento	Cycle 2	Trebuchet	Drone	RCM
Houston 1	Cycle 2	Trebuchet	Drone	Fuel Cell
Oakland	Cycle 3	RCM	Fuel Cell	Gravity Cruiser
San Diego	Cycle 4	Trebuchet	Cyber Security	Snap Rover
DC - Co-ed	Cycle 4	Fuel Cell	Firmenich	Drone
St. Paul/Minneapolis	Cycle 5	Glider	RCM	Tynker
Houston 2	Cycle 5	Glider	RCM	Trebuchet
DC - All Girls	Cycle 5	Trebuchet	Fuel Cell	RCM
Los Angeles	Cycle 5	Gravity Cruiser	RCM	Trebuchet
Chicago	Cycle 6	Fuel Cell	Wind Turbine	Snap Rover
Detroit	Cycle 6	Trebuchet	Wind Turbine	Fuel Cell
Pittsburgh	Cycle 6	Trebuchet	RCM	Cyber Security
Saginaw	Cycle 7	RCM	Fuel Cell	Wind Turbine

curricula. Multiple considerations set this schedule, including: ensuring a three-year rotation across sites so that returning students do not see the same curriculum in subsequent years of participation, availability of resources for each curriculum, and meeting unique local funder requests.

4. **Securing Program Site Locations.** Securing SEEK program locations in each city where camps are proposed is a vital step in finalizing program availability. To achieve this task, NSBE identifies potential cities based on an index developed by the organization that calculates communities in need based on family household incomes, African American population, STEM city rank, adult college completion rates, free and reduced lunch qualifiers (Edwards et al. 2018, 5). In addition, NSBE must develop partnerships with local schools that are both willing to house the summer program and available during the proposed program timeline. Once school locations are finalized, the SEEK program schedule can also be finalized.

Training and Site Preparation. SEEK uses people-centered inputs to encourage community building and the transmission of organizational policies and procedures. By purposefully utilizing this time to transmit values and expectations, SEEK maintains a standard of practice that may be helpful as they extend their services. Ways in which NSBE strives for standardization include the following:

1. **Training:** Each year before the initiation of site's program, all local staff engage in two training sessions. During this time, a Site Leadership training specifically for Site Directors also takes

place over a 2 to 3-day period (Fletcher et al. 2017). Each member of the staff is updated on the current policies and procedures related to their responsibilities within the SEEK program. Additionally, SEEK staff are briefed on any changes to the assessment plan.

2. **Site Preparation.** Following the selection of program sites, the SEEK headquarters team ensures that each site has the materials and amenities necessary to hold their programs.
3. **Orientation.** Orientations are held for both students and parents. During parent orientation, parents are walked through the program process to increase their awareness of their students' experiences. Parents are also invited to join the SEEK parent group and asked to complete parent surveys to gauge their perceptions of engineering and the SEEK program before and after their students have completed their experiences.

Program Implementation

Individual SEEK programs are held in cycles beginning in June and ending in early August. Cycles at each site last for four weeks, with the mentors and site leaders meeting first for a training week followed by the three-week camp with students. During the program, a new curriculum is taught each week. At the end of each week, students engage in competitions where they design and implement a product that reflects the skills that they learned during the week's lesson. Each site offers engineering and other STEM related experiences for 3rd, 4th, and 5th graders with the capacity to hold anywhere from 125 to 300 students.

Post Program Procedures

Following the completion of all SEEK camp cycles, post program procedures are initiated. This is a period in which NSBE and the other stakeholders (i.e., SEEK staff and research teams) work to finalize data collection and reflect on the performance of the camps. There are two main components of this stage: (1) program debrief and reports; and (2) research and assessment. Each of these stages aids in deciding the areas in need of improvement for the next camp cycle as well as the areas of success for the previous camp cycle.

Program Debrief and Reports. NSBE administrators and SEEK staff reflect on their experiences during the summer programs. This information is another avenue that encourages collaboration between the different partners involved with SEEK and highlights items that need to be addressed or maintained moving into the next summer's programs.

Research and Assessments. The SEEK program has followed a research-to-practice model enacted by NSBE and the research teams in recent years. Data are collected to understand parents' perceptions, feedback from mentors and site leader, and assessments of student performance and perceptions, and results of those data points help inform subsequent procedures and practices.

Additionally, assessments can help identify pain points or recommendations for improvements for the next SEEK cycle.

In the following section we provide a more detailed overview of student assessments and results to illustrate two key points: (1) Although SEEK offers a unique experience to underrepresented youth nationwide, the program still needs tangible measures of success; and (2) Employing assessments and reviewing the subsequent results of these assessments allows stakeholders to identify areas of need.

SEEK'S STUDENT ASSESSMENT

The full assessment process included assessing the experiences of students, parents, mentors, and site leaders. Through these different data sources, stakeholders are able to examine and communicate around aspects of the SEEK program that are successful and aspects of the program in need of improvement. This assessment plan aligns with the principals of collective impact as it encourages collective communication around common objectives.

Although the suite of assessments collectively provide a more complete view of the SEEK program, we focus on the results of the student assessments in this section because it most directly speaks to the short-term outcomes outlined in the logic model. The student assessments measured constructs (i.e., conceptual knowledge, engineering identity, and perceptions of engineering) that align with key components of SEEK's short-term goals (i.e., building industry awareness, building STEM related skill set, and acquiring engineering principles).

Assessment Plan

Across all sites (n=14, pre-and post-assessments were collected and analyzed from all SEEK students with parent consent to participate in the research study (n=654) to assess changes in the following: (1) conceptual knowledge, (2) engineering identity, (3) interpersonal and intrapersonal skills (see Figure 6). The research team worked with SEEK administrators as well as other project partners to ensure that the assessment timeline aligned with the program schedule for all locations.

Conceptual Knowledge. The conceptual knowledge portion of the assessment was composed of math (n=10) and science (n=10) questions. Questions were drawn from the National Assessment of Educational Progress (NAEP) and were a combination of easy, medium, and hard questions at the 4th grade level. Questions pertaining to engineering concepts (n=10) from assessments available at TeachEngineering.org were selected based on their alignment with the learning objectives from SEEK's curricular module (e.g., energy, Newton's Laws, electricity).

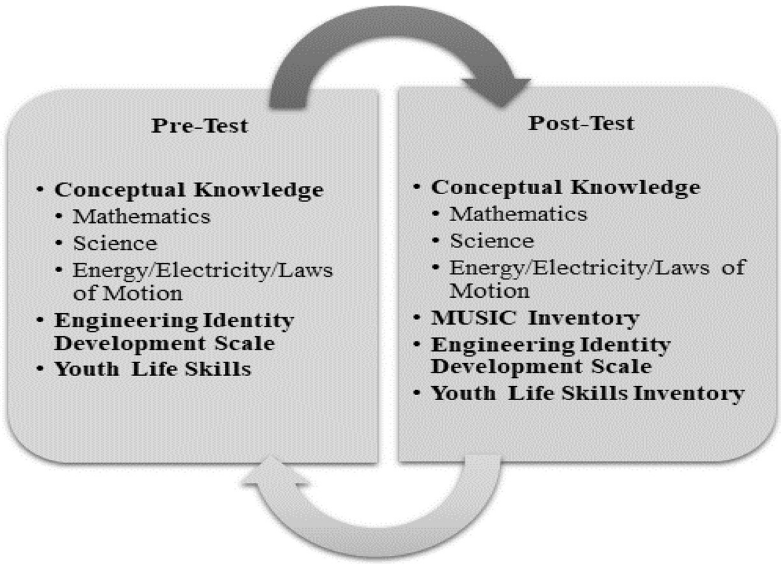


Figure 6. Constructs Measured on Pre/Post Assessments.

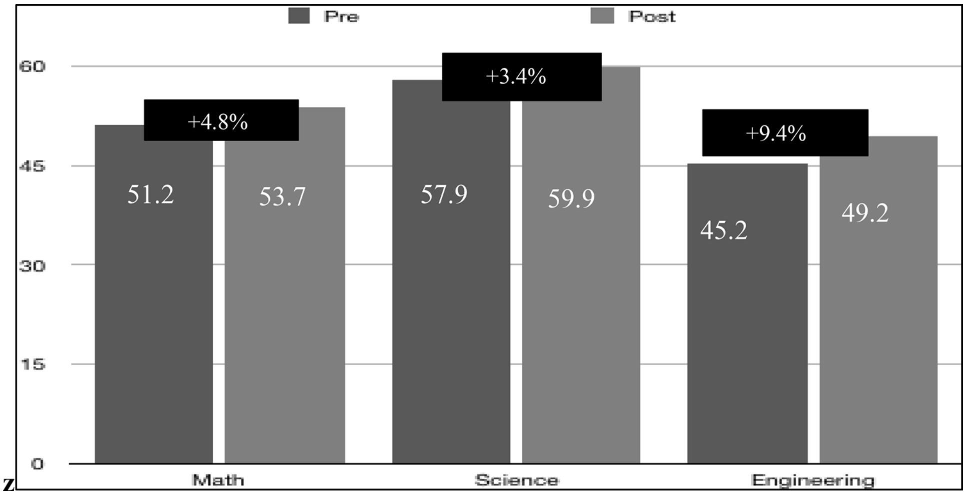
Youth Life Skills. To measure interpersonal and intrapersonal skills, we leveraged Robinson and Zajicek's (2005, 453) Youth Life Skills Inventory. This measure was adapted from the Leadership Skills Inventory (Townsend and Carter 1983, 21) to be applicable for measuring skills of students who are in grades 3–5. From this instrument, we included three scales: (1) Working with Groups, (2) Communication and (3) Leadership.

Engineering Identity. Questions were selected from the instrument by Capobianco et al. (2012, 705) to assess how SEEK students develop their sense of identity within engineering. Validity and reliability of the instrument were established for two constructs measuring academic and engineering identity.

Academic Motivation. Jones's (2009) MUSIC Model of Academic Motivation is a survey instrument that assesses the extent to which students perceive: 1) themselves to be empowered, 2) the content is useful, 3) they can be successful, 4) they are interested, and 5) that the instructor and students care about them. The version of the instrument used within this context was designed specifically for elementary-aged students.

Assessment Results

Results across all 16 SEEK camps in aggregate showed a significant increase along conceptual knowledge variables from pre- to post-tests (see Figure 7). More specifically, there was 4.8% increase for math, a 3.4% increase for science, and a 9.4% increase for engineering (see Figure 7). Thus, the results suggest that along these conceptual knowledge measures, the camp is successful



Note: *Value on a scale of 100 percent, with percent change anchored on the initial pre-test value.*

Figure 7. Conceptual Knowledge.

at achieving one of its objectives—to enhance students' STEM-related competencies. However, we also observed fairly large differences in performance along these measures across and within sites, largely driven by differences in pre-test scores. This finding suggests that although the program attempts to maintain consistency in curricular experiences across locations, SEEK stakeholders need to be aware of discrepancies in students' prior knowledge across and within sites.

Youth Life Skills. On the items related to professional skills (i.e., communication, leadership, and teamwork), the magnitude of each professional skills construct remained high for pre- and post-tests. However, there were slight decreases for communication and teamwork skills and slight increases for leadership skills. Because much of the time during the camp asks students to work in teams, the slight decrease in self-perceptions along teamwork and communication measures is not surprising, as engaging in collaborative settings can be quite challenging. The SEEK programming team is using this finding to inspire more focused training for mentors around team-based learning facilitation. Moreover, the research team is investigating gender dynamics on these teams to determine whether that influences students' experiences and self-perceptions.

Engineering Identity. On the pre-test, students scored highly on constructs pertaining to their engineering identity. Their mean scores for all items on the scale were over 2.5 on a 3-point scale. On items pertaining to students' self-beliefs regarding who they are as students, there was no significant change over the course of the SEEK program. However, students' beliefs about what engineers do and who they want to become as it relates to the field of engineering had a significant increase over the course of the program. Although longitudinal data is needed to determine if these beliefs translate to actual engagement in engineering fields, the results are promising as they suggest engagement in the SEEK program may encourage student self-efficacy as it relates to engineering careers. This finding directly connects to the objective of the SEEK program and provides evidence that the activity appears to align in the intended direction of this short-term outcome measure.

DISCUSSION & LESSONS LEARNED

From developing the SEEK logic model presented herein and assessing measurable outcomes, we highlighted the required elements to offer such a program at scale as well as ways in which NSBE can move closer to its own long-term objectives for SEEK. Many of the elements necessary for NSBE to achieve their long-term objectives are contingent upon adopting and maintaining elements of the collective impact framework. As made evident by the case presented in this paper, collective impact is an iterative process that requires the buy-in of the backbone organization, in this case NSBE, followed by the buy-in of other organizations that contribute to reaching overarching objectives. As the number of stakeholders involved in such projects grows, so too does the need for backbone organizations to lead and facilitate communication between their partners. This is because negotiating the collective mindset and assessing the long-term impact of choices made within these partnerships can be directly related to the success of such partnerships as well as the objectives they aim to accomplish.

Negotiating the Collective Mindset

> *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.*
>
> *~NSBE World Headquarters Member*

The framework of collective impact asserts that a common agenda must be shared between stakeholders to achieve large scale change (Turner et al. 2012). Stakeholders should also agree on how objectives should be achieved and measured. SEEK stakeholders generally share the same vision for the program's outcomes. However, reaching consensus on how those objectives should be achieved requires continuous communication and negotiation. For example, implementing SEEK assessments requires collaboration between SEEK administrators and the research team. Implementing assessments requires agreement on the content, format, and timing of implementation while maintaining reliability and validity of the instruments and rigor of the research process. SEEK mitigates these challenges by further engaging stakeholders through continuous communication, which is another key element of collective impact (Kania and Kramer 2013, 1). Furthermore, this practice reiterates that meetings within and across organizations provide opportunities for program partners to communicate their objectives and negotiate ways in which differing objectives can converge to achieve the overarching goal of the SEEK program (Kania and Kramer 2013, 2).

Nonetheless, fully embracing the ideals of collective impact requires more than building partnerships. As stated in the literature, effectively achieving change through outreach requires that such programs look back and understand the various organizational components that contribute to their successes (Gullatt and Jan 2003, 10-11) as well as measurable objectives (McLaughlin and Jordan 1999, 2-3). Thus, we assert that the value of understanding (1) the desired outcomes and resources available to achieve those outcomes, (2) embracing a collective impact approach, and (3) developing effective measures of impact should not be ignored by those aiming to develop impactful outreach initiatives in engineering and other STEM fields.

Our logic model shows that the SEEK program integrates the ideals of collective impact to manage and integrate the numerous components that go into implementing and offering the program at a large scale. This framework is embraced while relying on the financial contributors to assist with securing resources, human capital to maintain and transmit the culture of SEEK to its participants, and research teams to assess how well objectives are being met. Although most outreach programs have adopted a majority of these components, the assessment of programmatic design and outcomes are often lacking (Gullatt and Jan 2003, 10). For this reason, we paid particular interest to SEEK's assessment process to better illustrate the connections between partnerships, objectives, and outcomes. We also emphasize that there is no single silver bullet to make a program of this scope and size work—it requires a complex set of components, resources, and people to achieve its objectives (Edwards et al., 2018).

Assessing Long-term Impact

As the number of engineering outreach programs continues to grow, effectively assessing the impact of such programs still present difficulties (Poole, Degrazia and Sullivan 2001, 43–44), and SEEK has not been immune to this challenge. This is most likely due to the challenges associated with implementing standard measurement procedures such as: logistical complexities of data collection, building partnerships with capable researchers, and maintaining research continuity across multiple site locations (Edwards et al., 2018).

Even though NSBE has built partnerships with research teams, they too face challenges related to standard measurement. For example, although NSBE's organizational plan for SEEK outlines resources and inputs to obtain their core objectives, the organization remains limited in their ability to fully measure success. This is especially true for long-term outcomes as the core objective of SEEK is to grow long-term interest in the engineering field for youth within underserved communities. Without measures set in place (e.g., longitudinal studies) to track students' pursuits of degrees and careers in the field of engineering, it is difficult to fully assess the true impact of the camp. Tracking students' academic and career trajectories following their involvement in SEEK may be key in establishing measures for assessing SEEK's long-term impact.

CONCLUSION

STEM-oriented youth outreach programs have become a prominent strategy for broadening participation in engineering disciplines (Cardella et al. 2014, 24). As a result, there are a variety of out-of-school opportunities aimed at providing engineering and STEM experiences to youth from underserved communities. Maximizing the full potential of recruiting and engaging youth from underserved populations may hinge on the ability of established programs to scale up their initiatives. As we have asserted in this work, embracing the ideals of collective impact provides an opportunity for such programs to progress their initiatives by replicating program designs in more communities.

SEEK's research and assessment approach to understand this scaled up program reflects previous research findings (Eklcl, Plyley, Alagoz, Gordon, Santana, 2018) suggesting that maximizing the impact of community-based outreach programs is centered in establishing appropriate assessment plans. With the central focus of SEEK being increased engagement of underserved communities in engineering and STEM fields, student assessments are good indicators of how well the programming influences student learning and attitudes as they relate to engineering and STEM. The improved math, science, and engineering conceptual knowledge scores among SEEK students present compelling evidence of SEEK's impact over a short-term period as thus the potential of programs like SEEK to encourage the engagement of underserved communities in engineering and other STEM fields. Moving data collection beyond the contained SEEK experience to broader academic and career progress is the next frontier of research for this community-based outreach program.

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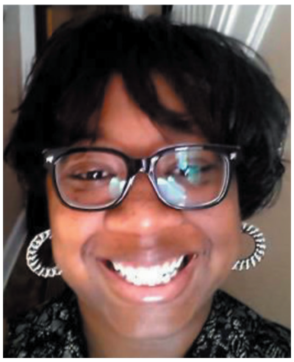

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