Investment in Informal Outreach Programs: A Systematized Literature Review of Informal Pre-College STEM Programs in African-American Communities

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Abstract

This paper is a systematized literature review examining pre-college informal STEM (science, technology, engineering, and mathematics) education in African American communities and evaluates which outreach method might be best for corporations. To this end, the study focuses on responding to two research questions: 1) Which informal STEM education programs are used in African American communities? 2) Out of these outreach programs, which might be beneficial for corporations to focus on to fully maximize time, money, and other resources? This study's search results are directed by education, economic, humanities, and social science databases and restricted to peer-reviewed articles. This systematized review is based on 23 peer-reviewed articles published between 1986 and 2015. From the 23 peer-reviewed articles, two topical categories emerged: pre-college minority STEM outreach efforts and pre-college and industry partnerships. These categories capture universal themes of the articles including purpose, result, approach, and nature of work in which various subjects and concepts materialized. By exploring these themes, identification of pre-college informal STEM outreach programs and common outreach methods exercised by industry were identified, and their value to the student and industry stakeholders are examined.

Keywords: out of school, informal STEM, African American, industry, community

Introduction

Several national reports by the federal government have called for growth in student enrollment in STEM fields to increase national competitiveness [1]. In addition to government spending in STEM programs, industry leaders have created comparable investments to produce equivalent benefits which intend to produce advantageous results in STEM education programs, many of which are focused on African American and other disenfranchised populations [1]. These programs extend from financial grants and awards to schools, educationalists, and local communities, to less formal activities including industry involvement through volunteering and mentoring. Despite these well-meaning investments, present metrics seem to display only slow movement to validate positive demographic changes in STEM fields and little to no slowing in the decline of STEM associated career interests for all students including African American and other underrepresented minority students [2].

Presently, African Americans make up only 3.9% of bachelor degrees in engineering [3]. While a considerable amount has been written about the evaluation of formal STEM programs focusing on African Americans, little research has been completed regarding the success of the many industry-sponsored and lead informal (out of school time) programs engaging African Americans to encourage interest in STEM-related careers. Smith [4] strengthens this argument by showing the direct link between inadequate and appealing STEM education opportunities and the lack of

African American students in STEM careers. Further, Seiler [5] reports that having a cultural engagement in program development is "a way to reverse the power structure of school, which has been oppressive to urban African American students" (p.2). Finally, Tsui [6] provides research outlining effective ways to increase diversity in STEM fields, presenting empirical and research evidence proposing ten strategies which include mentoring, tutoring, and financial support, yet Tsui [6] and others call for the need of further research and discussion.

The basis of this work is to expand the perspective on the justification for and the amount of literature available on this critical and under-explored subject of informal industry lead STEM programs. Specifically, using the evidence-based PICO (population, interest, comparisons, outcomes) framework to form and assist literature review research strategies [7], this work responds to the following research questions:

1. What informal STEM education programs are used in African American communities?
2. From these outreach programs, which might be beneficial for corporations to focus on to fully maximize time, money, and other resources?

Additionally, because academic publications are circulated only within communities of educators, industry leaders may not be either aware or knowledgeable of current viewpoints that could assist in their outreach investment choices. Direct benefits of this work include an opportunity to connect the domains of education and industry, by sharing a systematic collection of researched insights with critical "external" audiences and stakeholder groups, including industry. Provided with this information, directors of informal, industry supported, African American outreach programs can more strategically and accurately refine operational approaches to meet the need for STEM education funding while advancing impactful STEM programs that might more efficiently increase diversity in the workforce.

Methods

This systematized literature review uses the PICO framework [7] to articulate the critical elements of the research questions, namely the population to be explored, targeted area of interest., means of research comparison, and potential beneficial outcomes. This context generates a proper scope that intellectualizes the research inquiries (table 1).

Table 1. Literature review design

Applications in systematized literature review	**Description**
Population	K-12 students in African American communities
Interest	Evaluating which pre-college informal STEM method is best for outreach for industry
Comparison	Compare various informal STEM outreach methods to evaluate which

	method maximizes time, money, and other resources for industry
Outcomes	Informal STEM outreach opportunities that benefit both the African American K-12 and industry

Search and Criteria

This systematized review explores literature dating from 1986-2015, a time range that showed extensive growth in research between industry and school partnerships. The search conducted September 17, 2016, was limited to combinations of the keywords (table 2) found in the entire peer-reviewed articles selected. The search utilized nine databases (table 2), with article inclusion criteria (table 2). This is based on empirical evidence and exclusions made under two conditions: 1) articles did not include STEM (science, technology, engineering, or mathematics) topics, or 2) articles were related to advanced education (ex. College and beyond).

Table 2. Literature review search criteria

Search Databases	**Exact search strings (keywords) used in database query**	**Inclusion Criteria**
Begell Digital Portal: this database contains an extensive range of information in engineering.	"industry and pre-college STEM education"	Represented a peer-reviewed article published in a reputable journal
EBSCOhost: ERIC—this database includes noteworthy articles in education.	"outreach and STEM"	Researched focused on pre-college (K-12) period
EBSCOhost: Education Full Text—this database includes essential articles in education.	"out of school and STEM"	Focused on STEM, engineering, science, technology, or mathematics
J-STOR Arts & Sciences: this database contains scholarly journals focused on social, sciences, humanities, mathematics, and economics.	"African American and STEM"	Concentrated on informal (outside the classroom) education settings

Project Muse: this database has a distinctive collection of humanities and social science journals.	"business and school partnership"	Industry related articles included terms like professional, corporation, management, business, firm, commercial, corporate
ProQuest Dissertation and Theses: this database provides a collection of reviewed dissertations and theses.	"minority and STEM education"	
ProQuest Research Library: this database provides an assorted set of peer-reviewed journals.	"underrepresented and STEM"	
Web of Science: Core Collection: this database focuses on literature for sciences, social sciences, art, and humanities.		
Wiley Online Library Journals: this database is a collection of multidisciplinary areas including social sciences and humanities.		

Selection Process

Using the selection criteria noted in table two and Qiqqa research management software for academic researchers and business professionals [8], 125 articles were harvested, with 24 out of 125 articles removed as duplicates. To reduce the result further (n= 14), only title and a brief abstract review were used. Finally, the inclusion criteria mentioned was applied which narrowed the search to 53 articles. Based on the information reviewed using results, 30 additional articles were removed leaving 23 carefully narrowed articles. Each article was skimmed to confirm a final article set was correctly selected.

Data Analysis

The 23 articles that satisfied the inclusion criteria were reviewed in three phases: initial review, comprehensive examination, and recording of results. The objective of the initial phase was to discover universal characteristics in each article and then summarize. Next, the full text of the 23 articles was expansively reviewed and articles were then characterized based on the viability of responding to the research questions. Last, each article was reviewed for significant content, and categorized (figure 1):

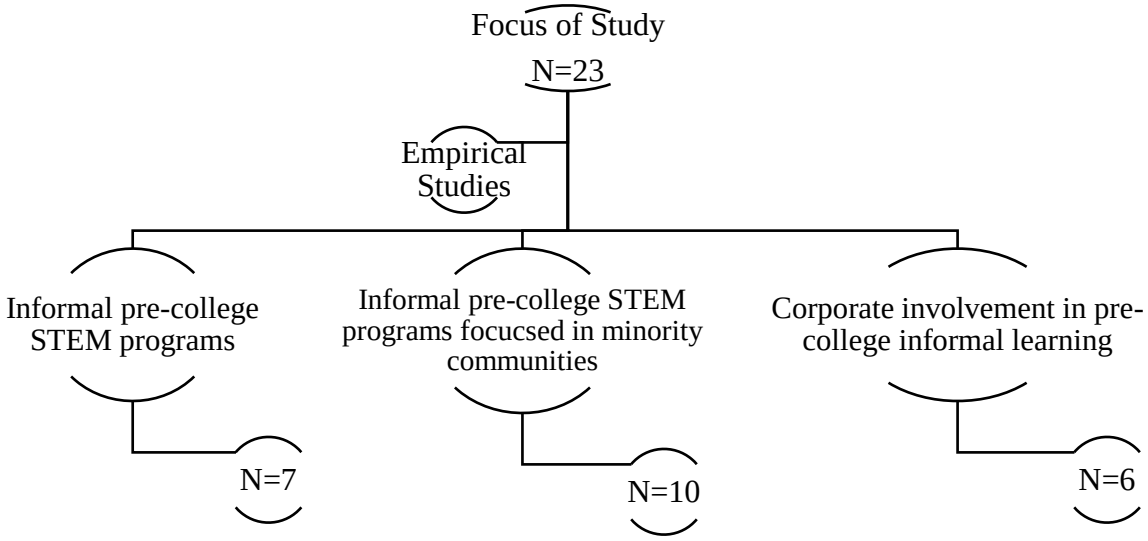

Figure 1: Classification of systematic literature review with output (n) values.

Results

In response to research question one "What informal STEM education programs are used in African American communities?", most articles focused on only one or a couple of informal STEM education programs, while others referenced many informal STEM education programs. Four themes emerged from the research: 1) an increased need of access to after-school and summer STEM workshops, 2) need/access for pre-college students to have a professional role model for mentoring, career counseling, or discipline awareness, 3) need for tutoring and learning center programs, and 4) students need for STEM field exposure to gain research awareness and experience. Detailed examination of the literature in each theme offers rich insights beneficial to both industry and educators.

Research question 1/Theme 1: Increase need for STEM workshop access

Many of the studies focused on the limited number of informal STEM opportunities in African American communities due to lack of resources [9] – [11]. Informal STEM programming outside of school can increase interest in STEM for students by closing the gap between what students learn in the classroom which creates a more collective student learning experience [12]. Students who attend high-quality STEM informal programs outside of school have improved attitudes towards STEM fields and careers, and an increased interest in STEM careers [13]. For students interested in STEM, after school and summer STEM workshops can help strengthen their curiosity in these disciplines [14].

Research question 1/Theme 2: Access to professional role models

Articles in this theme presented and discussed the importance of having a professional role model involved in the lives of African American students [4], [6], [11], [15]. Based on [16], the absence of professional role models is a critical issue that prevents the employment of young African Americans into these (STEM) fields. Even in students with satisfactory scores in

STEM-related subjects, confidence and interest can decline due to lack of encouragement and professional examples [15]. Even though there is an increased need for African Americans to obtain a mentor, there is a shortage of minority mentors STEM fields, especially science and engineering [6]. However, the use of strong language to describe the emergency need for STEM growth like the "STEM crisis," has caused increased focus by organizations including industry and governmental agencies to improve access to STEM programs for all precollege programs, especially African American programs. US2020 is a direct partnership with non-governmental organizations (NGO) and industry, focused on STEM products and programs [17]. This strategy seeks to match one million STEM mentors with students from K-16, especially girls, underrepresented minorities, and low-income children, to spark interest in STEM careers [17].

Research question 1/Theme 3: Tutoring and learning center programs are essential

The disenfranchisement of African Americans in education begins early in the pre-college system and continues into higher education [18]. To raise the number of African Americans in STEM fields, there is a need for a more significant intervention at the pre-college level [15]. Because of insufficient guiding and tutoring possibilities in African American communities, students who were once interested in STEM eventually switch to other disciplines noting lack of support [6]. It is known that learning center environments provide both academic and personal growth by vigorously engaging, understanding, and assessing information learned in these environments [12].

Research question 1/Theme 4: Increased exposure of students to STEM fields

Students engaged in hands-on research experience outside the classroom with industry can increase the number of students who pursue STEM careers in the future [6]. The importance of showing a positive intrinsic value of a profession, identifying a job that is enjoyable, and choosing a job that gives responsibility to self and community are imperative to pre-college students [14]. Internships and co-ops are usually thought of activities once a student is in higher education. However, programs like Inroads provide internships and co-ops to "develop and place talented underserved youth in business and industry, and prepare them for corporate and community leadership [19]".

In response to research question two, "Out of these outreach programs, which might be beneficial for corporations to focus on fully maximize time, money, and other resources?", the literature is substantial in its view that industry involvement in pre-college partnerships helps to ensure students are well trained for jobs and provides a reliable supply of people educated to work in an ever-changing society [20]-[23]. Two themes around workforce development emerged from the literature: 1) internships and cooperative education programs (co-ops) are employment accelerators; and 2) employee volunteers help increase STEM field awareness for pre-college students.

Research question 2/Theme 1: Internships and cooperative education programs (co-ops) as employment/success accelerators

Industry can support the purpose of pre-college institutions to prepare students for college and industry through various means of employment [22]. Student internships are defined as an excellent way for students to gain industry experience for industry to screen and recruit potential hires [24]. Cooperative education, also called co-ops are defined as "a partnership among students, educational institutions, and employers, with specified responsibilities for each party" [25]. Supplying these types of experiences to high school students can provide an opportunity for African Americans and other disenfranchised students to gain direct industry experience. These opportunities are typically provided outside the academic calendar year, and future employment is an incentive for students to participate, as it offers both personal (social network and skill development) and financial gains (salary). Other skills that are gained from internships and co-ops can include targeted vocational training and work experience [26].

Research question 2/Theme 2: Employee volunteering as STEM awareness for pre-college students.

Research shows that personal contact with discipline related professionals, like STEM, is a significant factor for students when determining a career [27]. Industry volunteers can use skills learned on the job to help educate students. For example, the Georgia Power Corporation used Six Sigma tools and methods to help students develop skills by teaching process improvement methods that could be used in STEM fields [17], [28]. Employee volunteer programs like this example can expand the learning experience by introducing industry knowledge directly to students [23]. This is an essential step in attracting students to the profession, as research has shown that awareness and alignment of personal values and occupational, professional values, contribute to motivation and academic success in engineering [29].

Study Limitations

While this literature review advances the body of knowledge on this topic in meaningful ways, every study has its limitations. In the case of this study, only a single individual was used to choose, review, and decide which articles to include and exclude. While the approach was well documented and methodical, including another reviewer in the process may have altered the list of inclusion criteria which may have expanded the initial article population in meaningful ways. Additionally, there were very few articles focused solely on informal STEM in African American communities. Some articles were focused on other minority groups such as women or only African American male students. The absence of a larger population of articles to review further punctuates the need for expanded research on this topic.

Discussion

The first research question in this study examines which pre-college informal STEM programs are used in African American communities. Overall, while a variety of informal STEM programs exist, only a few are specifically focused on African American communities. African Americans and other disenfranchised groups may have been excluded from these essential informal learning contexts due to lack of funding and resources, yet a review of the literature demonstrates that implementation of such programs for these groups could encourage empowerment and success in STEM areas. Further, pre-college STEM programs can inspire

students in meaningful ways through the presence of STEM professional examples and mentoring that help students become familiar with STEM career opportunities. Additional benefits include professional and technical skill development, as well as other less exacting student development such as agency and personal autonomy that arises from salaried employment.

Internships and co-ops extended to high school aged students can offer the most significant incentive for students to explore and consider STEM education and areas of work. To that end, the second research question in this study focuses on which informal pre-college STEM outreach program can add the most value to industry. Evidence from this literature review suggests that industry can see a direct value from internships and co-ops by incentivizing students with employment before college. However, no articles in this review attempted to quantify the direct financial benefit/value of these programs. Further, these employment opportunities are usually reserved for graduating high school level students. Given the large number of open and unfilled STEM jobs in companies, and considering the ongoing labor shortage in STEM due to retiring Baby Boomers and a shortage of American talent [30], these findings should encourage industry to start informal STEM work programs in high school earlier. Such efforts would not only gain new mindshare, but would help students focus on their life-goals during middle and high school years, and prepare them both scholastically and professionally for success in their internships, co-ops, and beyond.

Other outreach methods uncovered (mentoring, tutoring, workshops) can (and should) be retained, but perhaps be pulled into and occur throughout the K-12 school years, to increase their visibility to students who have not yet formulated an "anti-STEM" mindset. If these programs are well branded, consistently offered, and appropriately marketed to parents and others in student circles of influence, these programs can serve as "feeder programs" for the more coveted (by students) and more beneficial (to industry) initiatives, such as internships, and other employment opportunities. Also, employee volunteering programs that offer visible professional role models as mentors can be introduced to students at any stage in the education process. These professional role models will not only demonstrate STEM career possibilities while promoting future opportunities in their firm's internship and co-op programs, but they will serve as examples of success that comes with higher education and skill development beyond K-12. In summary, these findings demonstrate that although many methods have been used as outreach in African American communities, mentoring to students has shown to be effective in laying the groundwork for inspiration in different career fields [6].

Conclusion

This systematized literature review intended to determine which informal pre-college STEM outreach programs offer the most significant benefit for industry while establishing a lasting relationship to students in African American communities. Using the evidence-based PICO framework to form and assist search strategies for research, twenty-three articles were analyzed.

Exploring what informal pre-college STEM outreach programs are used in African American communities, workshops, camps, mentoring, tutoring, field trips, internships, and co-ops were among the most prevalent. Also, four themes identifying greater needs emerged, including

access to after-school and summer STEM workshops; access to professional role models; tutoring and learning center programs; and early STEM field exposure to gain research awareness and experience. Finally, when examining which outreach programs might be most beneficial for corporations to focus their resource investments on, the literature suggests that any efforts to aid students' skill development for STEM roles, will not only enrich student's lives but offers the benefit of training a more diverse and qualified workforce.

While this systematic literature review has yielded informative summary results for work completed to date, opportunities exist for ongoing studies to explore new informal industry-funded STEM programs in the African American community. Research in these areas will not only continue to shed light on benefits to industry, but should consider examining metric driven, quantitative or qualitative impact (or latent impact) of industry programs in these communities while concurrently examining metric driven, quantitative or qualitative impact (or perceived impact) on students and their communities at large. Utilizing exacting measures to evaluate program performance offers the opportunity to motivate significant, results-oriented change for the future of STEM workforce concerns among this critical population.

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