Attraction and Retention of Inner-city Under-represented Minority Students for Careers in STEM: Parent Perspectives

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The objective of this work is to identify the likely barriers to STEM success for students and parents within a specific inner city culture, provide a deeper understanding of these barriers and to suggest a solution that strategically removes or neutralizes these barriers. Surveys were issued to parents in the local community in order to gather opinions on the relevance of conventional questions and solutions suggested by the literature for this national problem. We hypothesized that, (i) not all research based initiatives reported to increase the STEM success of under-represented minorities are applicable to the inner city community, (ii) there are structural challenges unique to inner city that should be given greater value by the literature and (iii) other solutions can be formulated that directly address these unique challenges. The survey results indicate that inner city low income parents are just as interested in the success of their child in STEM areas as their wealthier counterparts, however they are aware of less STEM opportunities and are less able to take advantage of STEM pathways due to structural barriers that naturally emanate from living in a low income community. Inner city parents also reported systemic structural barriers that also inhibited their ability to support their children in STEM pursuits. The current solutions suggested by the literature are re-evaluated and adapted to incorporate insights based on the survey results in order to provide recommendations to overcome these barriers.

Introduction

In the last two decades, numerous strategies have been presented regarding the recruitment and retention of under-represented minorities to STEM careers. The literature, while acknowledging that actions from businesses, community and family should contribute to the solution, generally offers solutions that can be implemented by the secondary and higher education schools. Solutions such as mentoring, pre-college summer bridge programs, undergraduate research experiences, and high school internships have been reported as generally successful. Yet the percentages of under-represented minorities who receive Bachelor's degrees in STEM subjects as well as those who pursue careers in STEM areas continue to significantly lag their general population percentages.

Many programs developed by universities and colleges have been implemented successfully at the collegiate level. Since university resources such as human capital, computing and lab equipment, infrastructure and administrative structures are located on university campuses, it is much easier to implement, manage and assess programs at the collegiate level. Several research studies however have also suggested that the best predictor of academic success at the college level is the rigor of academic instruction at the K-12 level [1, 2, 3, 4, 5]. Unfortunately, under-represented minorities in STEM, particularly those from low income households, are more likely to be in programs with insufficient academic rigor [2, 5, 6, 7].

Universities and colleges, partially in response to these studies, have also introduced programs at the pre-college level, designed to enhance STEM success among under-represented minorities and low income students. Hill [8] described a program applied to Detroit area schools in 1976 which included: summer skill intensification classes for grades 9 through 12, Saturday enrichment classes and pre-engineering classes at the high schools. Hill's follow up survey in 1990 showed that 74% of the responding participants were enrolled in college in a STEM field and 81% of the program responding participants graduated from college in a STEM area. Note that only approximately 18% of the students who were sent surveys responded. The University of Akron introduced a six-week summer residential program coupled with an academic year tutorial component and summer transition activities in 1994. In 2005, Lam et al [9] conducted a ten year assessment of this program using statistical analysis. These authors showed that that the program improved the participant's grade point average by a magnitude between 0.14 and 0.30, and also concluded that participating students exhibited less anxiety about math and science, increased self-esteem and greater confidence. Other models that have been reported to be successful involve some or all of the previously described methods as well as general curriculum improvement, the inclusion of family in Saturday math and science activities, industry speakers and field trips. More recently, Lynch et al [10] proposed a conceptual framework for Inclusive STEM High Schools (ISHS's). The ISHS model is inclusive and selective, it implements a STEM focused curriculum with instructional strategies informed by research. The ISHS model also emphasizes project based learning, integrated innovative technology, blended formal/informal learning beyond the school day, real world STEM interaction, support for disadvantaged students, and early college level coursework. There does appear to be consensus agreement among current scholars that the ISHS concept, if implemented, would significantly improve

the STEM preparation for disadvantaged under-represented students, however long term outcomes have not yet been well documented in the research literature [11].

The majority of the aforementioned solutions adopt a "one size fits all" strategy, inevitably limiting the success of their strategies to those players that match some very general criteria. The term "under-represented minorities" is typically defined as those racial and ethnic populations that are under-represented in a specific field of study or profession relative to their numbers in the general population. In this work, the fields of study used to define an under-represented minority include Science, Technology, Engineering and Mathematics (STEM). Under-represented minorities do not necessarily have similar characteristics such as culture (family, ethnic, social), motivations, perspectives etc. For example, a Hispanic student who grows up in the inner city, is on free or reduced lunch, and lives in a government subsidized home often has little in common with a Hispanic student who is raised in a financially stable household in the suburbs. Additionally, an under-represented minority with immigrant parents may be raised in a cultural environment that fosters quite different perspectives compared to their counterparts with parents raised in the United States.

In this work, a survey is given to middle and high school parents of children within inner city schools in Savannah, Georgia, USA as well as schools external to the inner city but within city limits. The survey was designed to identify cultural and structural challenges that under-represented minorities living within the inner cities of Savannah face regarding STEM educational opportunities, as well as professional STEM career attraction and retention. Though there are many general similarities, inner cities across the US may have some unique aspects to the culture that are location specific. Additionally, minority groups from different cities may have different cultural tendencies, which would result in different responses to the same stimuli. The expected long term outcome is the development of streamlined initiatives that optimally address under-representation in STEM programs specific to one inner city community.

Savannah Chatham County School system

The Savannah Chatham County public school system (SCCPSS) services the population of Chatham County, GA, with 56 schools as of 2015. Chatham county was reported to have a population of 283, 379 in 2015. The county has a total area of 632 square miles, with 426 square miles of land and 206 square miles of water. For the 2009-2013 period, a median household income of $45,794 was recorded, with %19.1 of the population living below the poverty line. [12]. As of October, 2015, the district enrolled 38,323 students, 65.4% of these students qualify for free or reduced lunch [13]. The SCCPSS student ethnicity percentages are shown in Figure 1.
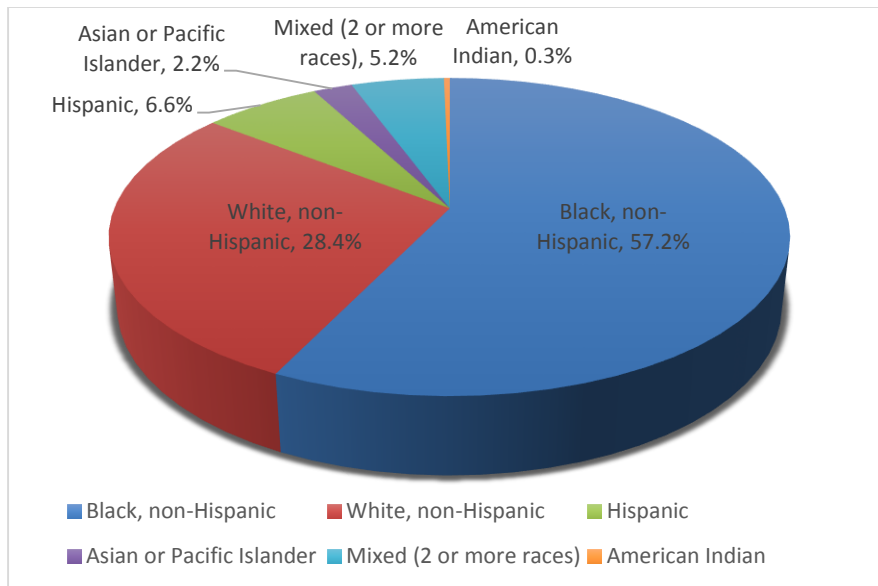
Figure 1. SCCPSS K-12 Student Ethnicity Percentages [14]

Methodology

The factors that may contribute to lack of participation of under-represented minorities in STEM programs at the college level have been well documented. These include: (1) school district funding disparities (2) tracking in remedial courses (3) underrepresentation in Advanced Placement courses (4) unqualified teachers (5) low teacher expectation (6) stereotype threat (7) oppositional culture and (8) premature departure from high school [11]. The weight of each contributing factor is unique to each community. Additionally, other issues more specific to a particular school system, community or local culture may also have an influence.

Hall et al [15] conducted a survey which indicated that beyond their own interest, high school students regard their parents as having the greatest influence on their thinking regarding future career options. Our survey was therefore developed to understand the parent's perspective, and interpret any additional factors unique to the community that contribute to parental attitudes, habits and expectations. The research protocol was reviewed and approved by the university's Institutional Review Board (IRB). The American Psychological Association (APA) ethical guidelines for research with human participants were strictly adhered to. Participation was voluntary for all participants. The opportunity to enter a drawing to win a restaurant gift card was provided as an incentive to complete the survey, and there were no penalties for non-participation.

The survey was initially tested on a pilot group of five parents who were able to provide immediate oral or written feedback. Questions that appeared subject to misinterpretation were modified or discarded. The content was also reviewed by peers from other departments (Psychology, Mathematics) who have conducted surveys and successfully published peer reviewed research based on their surveys. The

readability of each question was tested using an average score determined from three models: Flesch-Kincaid Grade Level, SMOG Index and the Automated Readability Index. All survey questions had a readability ranging between grades 6 and 8.5.

The survey was issued to parents of children from 8 high schools, 6 middle and 4 K-8 schools. Responses were divided into two categories, inner city and external schools. In this work, the term "inner city" as defined by the American Heritage Dictionary for the English Language, fifth edition, will be used: i.e. "the usually older, central part of a city, especially when characterized by crowded neighborhoods in which low-income groups predominate." The term "external" is used to describe public schools within the county that would not be classified as inner city. A total of 94 parents responded to the survey, 38 from the inner city and 56 external to the inner city.

The survey was divided into three sections that attempted to evaluate (1) Parent STEM awareness and child participation (2), Parent understanding of the value of diversity in STEM and (3), Parent evaluation of current solutions. Additionally there was an open question that sought parental perception regarding barriers unique to the inner city community.

Among the inner city respondents, 7% held a Master's degree or equivalent, 28% held a four-year college degree, 23% held a vocational certificate, 26% held a high school diploma, while 16% did not complete High School. 41% of inner city respondents were either married and living together or living with a domestic partner, 53% were either single or divorced and head of household, 6% were married and living apart. The median family income per family member was $10,000-$15000 per year. Among the outer city respondents, 27% held Doctoral, Medical or Law degrees, 31% held Master's degrees, 32% Bachelors, 10% held a high school diploma, all completed High School. 47% of external respondents were either married and living together or living with a domestic partner, 42% were either single or divorced and head of household, 11% were married and living apart. The median income per family member was $20,000-$30,000 per year.

Results

Awareness and participation results are shown in Table 1. While 45% of external parents were aware of STEM summer or weekend camps within the next 2 years for which their child (or children) were eligible, only 29% of inner city parents were aware of equivalent opportunities. The children of 47.2% of the external parents surveyed already had previous involvement with STEM summer camps, internships or after school programs, only 17.6% of inner city children had previously participated in these types of STEM programs. The trend continued regarding knowledge of STEM scholarships and internships, 27% of external parents were aware of STEM scholarship or summer internship opportunities compared to no inner city parents.

Table 1 Survey Results for Parental Awareness and Participation:

Awareness and Participation:	Options	Results	
		Inner City (n=38)	External (n=56)
Has your child ever participated in any of the following? STEM summer camps, STEM internships, STEM weekend or evening programs.	Yes No	17.6% 82.4%	47.2% 52.8%
Are you aware of any STEM summer or weekend camps in the next 2 years that your child (or children) will be eligible for?	Yes No	29% 71%	45% 55%
Are you currently aware of any STEM summer internships or college scholarships that your child or children would be eligible for?	Yes No	0% 100%	27% 73%

Survey results of questions designed to ascertain parental perception of the value of STEM success for children from under-represented groups are presented in Table 2. While 70.6% of inner city parents felt that STEM success for under-represented minorities was "very important" for economic growth, only 48% of external parents felt the same way. While 88.3 % of inner city parents surveyed believed that STEM success for under-represented minorities was generally "very important", 74.3% of external parents shared this belief. The percentages of both groups who "somewhat" agreed that they had adequate resources, knowledge and time to nurture their child's or children's interest in STEM was relatively close between groups (34.2%, 35.3%). A significant difference was seen regarding how each group interprets a reasonable cost for a one week summer STEM camp, with 37.1% of external parents considering $250-$599 as reasonable versus only 5.8% of inner city parents who shared that perspective. Among inner city parents, %47 considered $125 or less to be a reasonable STEM camp cost.

Table 2 Survey Results for Parental Understanding of Value

Understanding of Value:	Options	Results	
		Inner City (n=38)	External (n=56)
The goal of this project is to increase STEM success for under-represented minorities. How important is this for economic growth?	-Very Important -Important -Somewhat important -Not important	70.6% 23.5% 5.9% 0%	48.2% 35.7% 16.1% 0%
In your opinion, how important is it to increase STEM success for under-represented minorities?	-Very Important -Important -Somewhat important -Not important	88.3% 5.9% 5.9% 0%	74.3% 10.8% 14.9% 0%
Do you believe you have adequate resources, knowledge and time to nurture your child's or children's interest in STEM?	-Absolutely -Not at all -Somewhat	17.6% 47.1% 35.3%	43.1% 22.7% 34.2%
Assume there was a reputable elite one week summer STEM camp that had a proven track record of success. What do you think would be a reasonable cost for this one week camp?	$600-$1000 $425-$599 $250-$424 $126-$250 $125 or less	0% 0% 5.8% 47.1% 47.1%	0% 15.0% 22.1% 37.5% 25.4%

Survey results with parent evaluation of current and suggested STEM initiatives are shown in Table 3. Both groups were asked if their children had little or no interest in STEM. Among the parents who answered yes, both groups reported that the top reason their children had no or slight interest in STEM was that the children found other non-STEM activities just more fun (ex. sports, video games, social media etc.). The majority of external parents reported that the schools somewhat make them aware of national STEM opportunities while the majority of inner city parents reported that the schools do not communicate the availability of national STEM opportunities to them. Among suggested solutions, both groups ranked "more STEM hands on activities in the schools" as the most effective activity that will improve STEM success among under-represented minorities. "Mentoring from either a college or industry STEM professional" was deemed the second most effective activity by both groups. Dominant among the suggestions from parents to improve inner city under-represented student STEM success were: "the availability of transportation," "the availability of a modern community center with STEM activities," and "the availability of a STEM public high school."

Table 3 Survey Results for Parent Evaluation of Current Initiatives

Evaluation	Options	Results	
		Inner City (n=38)	External (n=56)
Why do you think your child has no or slight interest in STEM? You may select more than one answer.	-School lacks resources	10%	5%
	-Peer pressure	20%	30%
	-The manner of instruction	30%	25%
	-Limited exposure to engaging - STEM related activities	40%	42%
	-Other ways to spend time are just more fun (ex. sports, video games, social media)	50%	65%
	-Just a natural preference for other subjects (English, Art, History)	10%	22%
Do you agree that the school makes you aware of national STEM opportunities for your child?	-Absolutely	17.7%	19.2%
	-Not at all	52.9%	38.7%
	-Somewhat	29.4%	42.1%
Solutions that may successfully improve STEM participation by under-represented minorities are listed below. In your OPINION, how effective are these measures? Please rank them 1 through 6, where 1 is most effective and 6 is least effective.	-A STEM industry mentor who meets with you and your child occasionally (ex. once per month)	3.0	2.8
	-A STEM college mentor who meets with you and your child occasionally (ex. once per month)	2.9	3.1
	-More interaction between STEM businesses and your community, ex. sponsorship of competitions	3.4	3.8
	-More STEM hands on activities in the schools	2.4	2.9
	-More creative homework assignments involving construction, assembly, science, engineering	3.4	4.1
		3.1	3.4

	-More STEM competitions outside of schools		

Discussion

External parents demonstrated more awareness of STEM opportunities and their children naturally participated in more STEM activities compared to inner city under-represented minorities. It's important to note that 85% of respondents reported their ethnicity as black or African American. Therefore the majority of external parents were also under-represented minorities. Based on the answers to the "school communication of STEM opportunities" question, the lack of awareness of inner city parents regarding STEM opportunities for their children may be due to ineffective communication from the inner city schools. The majority of inner city parents did not believe they had adequate resources, knowledge and time to nurture the child's or children's interest in STEM. This is likely due to lower incomes and jobs that afford less flexible working hours. This is consistent with recent literature [16], which identifies structural influences at the family, neighborhood, school, and broader cultural levels as important factors which affect student STEM performance. Similarly, external parents perceived a reasonable cost of a STEM summer camp for their children that was $125-$450 more than what inner city parents considered a reasonable cost for the same camp. While there are several free STEM summer camps nationally, typical camp costs range from $275-$1000. This is far greater than what the majority of inner city parents reported as a reasonable cost. The majority of advertised STEM summer programs for which inner city under-represented children are eligible to attend require a plane trip or extended car drive. The inner city parents in Savannah, GA also reported substantial difficulty in transporting their children. For external two parent families that are able to survive on the income of a single parent, transport of their child may be difficult but still possible. For two parent inner city families, both parents typically work, providing daily transport for their child to STEM summer camps is likely not an option. Other barriers reported by inner city parents included the absence of a community center that supports STEM learning or a STEM high school that serves the inner city community. A STEM middle school as well as a High School with a MAGNET engineering program are currently the only schools in the county designed to target STEM areas. The latter services less than a hundred students. The establishment of a designated STEM high school within the inner city community would provide an appropriate transition for graduates of the STEM middle school within the inner city.

Conclusion and Recommendations

Based on the survey results, the implication is that inner city parents are less aware of STEM opportunities available for their child compared to external parents. Inner city parents also are less likely to believe that they have adequate time and resources to support their child in STEM activities. However a larger percentage (88.3%) of inner city parents believe the value of STEM success for under-represented minorities is very important compared to the percentage of external parents (74.3%) with a similar belief. The percentage of under-represented minority students in the inner city schools surveyed exceeded the corresponding percentage in external schools surveyed by approximately 6%. Therefore the larger

percentage may in part be attributed to a greater number of under-represented minority parents living in the inner city. An understanding of the value of STEM success is therefore clearly present among inner city parents. This is consistent with other recent studies which indicate that, contrary to popular stereotypes, the education of low income under-represented minority children is of primary importance to their parents [17]. The above percentage differences also imply that parents who belong to the majority class may not value the importance of under-represented minorities in STEM as much as under-represented minority parents do.

The survey identified specific structural barriers (transportation, inflexible work hours, income) which inhibit the inner city parents' ability to support their child in STEM pursuits. Parents also identified more creative and practical pedagogical techniques as part of a larger solution to improve SETM performance. These structural problems are not particularly unique to inner city Savannah compared to other inner cities throughout the USA. However it is unique that they were the top reported barriers. Other barriers reported in the literature such as stereotype threat, low teacher expectation, oppositional culture, unqualified teachers, diversity of parental involvement programs and under-representation in Advanced Placement courses are likely still present, however the parental feedback suggests where solution resources should initially target.

Current programs are addressing several of the other traditional influences. For example, Georgia was awarded the *Race to the Top* RT3 grant in 2010. Several bold STEM initiatives have emanated from this grant, addressing the areas traditionally recognized as strong factors that negatively affect inner city student STEM performance, such as unqualified teachers and poor teacher expectation. New STEM curricula with courses such as Robotics and Engineering, developed by the Georgia Institute of Technology's Center for Education Integrating Science, Mathematics, and Computing (CEISMC), have also been introduced in several Georgia High schools, however these new curricula are limited to schools in only a few Georgia counties [18]. The State Board of Education recently awarded the Savannah-Chatham County Public Schools a *21st Century* Community Learning Centers Grant. This program provides extra hours of structured learning support after school, targeting students who attend high-poverty and low-performing schools. This program addresses the previously identified universal factors (ex. Stereotype threat, premature departure from high school) [19]. The *21st century* program also addresses some structural challenges in that transportation is provided for some children.

However both programs are grant funded and sustainability after the grant periods end is a concern. Neither program addresses other important structural challenges nor do they incorporate mentorship, a proven strategy for increasing STEM success. Various small programs that address mentorship exist, however these programs are generally not consistent and many of the mentors have little to no STEM expertise.

For the inner city surveyed, the following solution strategy is recommended: (i) a review of and re-design of the STEM curricula to introduce more STEM hands on activities in the classrooms, and the addition of new STEM coursework in emerging fields such as renewable energy or mechatronics. CEISMIC's programs should be expanded so that curricula implementation and teacher advanced STEM training are feasible options that can be supported in all Georgia counties, (ii) the development of an inclusive mentoring plan

that partners with local colleges, community organizations and STEM industry to recruit and retain mentors. As a one to one mentor relationship is likely not feasible, group mentoring is suggested. In this scenario, one student gets a chance to interact with more than one mentor, (iii) stronger use of social media and developing a well maintained central internet site to communicate new opportunities for STEM (summer camps, internships, competitions) and (iv) the development of a more nimble responsive inner city transport system that allows low income individuals opportunities to efficiently transport their children to STEM activities.

Future Work

Currently the survey results provide an understanding of what factors are critical for advancing the STEM pursuits of under-represented minorities, however knowledge of the relative importance (weight) of each contributing factor would enable more efficient solutions to be formulated. The authors recommend a follow up study to determine these weights. Additionally, longitudinal studies should be performed for the current STEM initiatives supported by *Race to the Top* and 21st *Century* grants.

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