Increasing STEM Engagement in Minority Middle School Boys through Making

Dr. Jumoke 'Kemi' Ladeji-Osias, Morgan State University

Dr. J. 'Kemi Ladeji-Osias is Associate Professor and Associate Chair for Graduate Studies in the Department of Electrical and Computer Engineering at Morgan State University in Baltimore. She teaches undergraduate and graduate courses in computer engineering. Dr. Ladeji-Osias earned a B.S. in electrical engineering from the University of Maryland, College Park and a Ph.D. in biomedical engineering from Rutgers University. She is the Principal Investigator for Doctoral Scholars in Engineering.

Dr. Ladeji-Osias' involvement in engineering curricular innovations includes outcomes-based articulation and online delivery of undergraduate engineering degrees. In addition to conducting research on color image fusion and real-time implementation of algorithms, she is the immediate past chair of the Middle Atlantic Section of the American Society for Engineering Education and a member of the Institute of Electrical and Electronics Engineers. She enjoys observing the intellectual and professional growth in students as they prepare for engineering careers.

Dr. Cindy S Ziker, SRI International

Cindy Ziker, Ph.D., M.P.H., is a Senior Researcher at SRI International's Center for Technology in Learning, where she leads research projects that focus on technology in education. She holds a doctorate degree in the psychology in of education from Arizona State University and a masters degree in public health from the University of Arizona.

Mr. Derrick Cornell Gilmore, Kentucky State University

Derrick C. Gilmore is the Director of Research, Grants and Sponsored Programs at Kentucky State University. In this role he provides oversight of administrative functions that include research compliance, research ethics, education and policy, administration, and technology transfer. His research interest include: sponsored research capacities/impacts at Minority Serving Institutions, behavioral health for African-Americans and disparities in drug law/arrest rates for minorities. He has served as a reviewer for numerous federal agencies. He also serves as the Principal Investigator/Project Director for Verizon Minority Male Maker Program, the Substance Abuse and Mental Health Services Administration (SMASHA) supported KSU Substance Abuse and HIV Prevention Initiative and the Morehouse School of Medicine HBCU Center for Excellence in Behavioral Health Capacity Expansion Grant. He earned M.S. from Albany State University.

Dr. Clay Gloster Jr, North Carolina A&T University (Tech)

Clay Gloster, Jr. is currently serving as the Associate Dean in the School of Technology at North Carolina A&T State University. He received the B.S. and M.S. degrees in Electrical Engineering from North Carolina A&T State University (Greensboro, NC) and the Ph.D. degree in Computer Engineering from North Carolina State University (Raleigh NC). He also has been employed with IBM, the Department of Defense, the Microelectronics Center of North Carolina, North Carolina State University, and Howard University.

His research interests are in the general area of reconfigurable computing. Current research focuses on the development of a suite of software tools that allow scientists to benefit from the potential order of magnitude speedup in execution time offered by reconfigurable computers over typical desktop computers. Dr. Gloster has also conducted research in the area of technology-based curriculum development, distance education, and VLSI design for testability.

Dr. Gloster has taught courses on digital system design, ASIC design, microprocessor system applications, FPGA-based system design, and VLSI design for testability (using VHDL/Verilog). He has served on the program committee and as session chair for several international conferences. He received best paper and presentation awards for a paper presented at the International Conference on Computer Design and has received numerous fellowships and distinguished awards. Dr. Gloster holds one US patent and led the effort to establish a new BS degree program in Computer Engineering at Howard University.

Dr. Kamal S. Ali, Jackson State University

Kamal Ali is a professor of Electrical and Computer Engineering and Chair of the Industrial Systems and Technology Department at Jackson State University (JSU), Jackson MS. Dr. Ali received his PhD in Solid State Physics from Reading University, UK. Prior to joining JSU, Dr. Ali taught at the University of Southern Mississippi (USM) for 20 years. During his tenure at USM, Dr. Ali served as a consultant for the United Nations, as a Professor of Electrical Engineering at the United Arab Emirates University (UAE) and as Director of the Computer Engineering Track at the College of Information Technology at UAE.

Dr. Ali's current research focuses on Unmanned Aerial Vehicles, Visualization and Big Data.

Philip Puthumana, Verizon Foundation

Phil Puthumana is the program manager for education technology at the Verizon Foundation, accountable for the development, implementation and measurement of the organization's STEM programming. Before joining the Foundation, Mr. Puthumana helped Verizon launch their Mobile Learning product portfolio as a member of the company's Public Sector Product Development team.

Prior to joining Verizon, Phil led business development for an Educational Video Game publisher, E-Line Media, co-founded an online math education company, MathThink, and has additionally worked with companies including Oracle and Ernst & Young.

Puthumana holds a BS degree in Accounting from the University at Albany and a dual-program MBA from Columbia University and the Haas School of Business at U.C. Berkeley. In addition, he is a Certified Public Accountant.

Increasing STEM Engagement in Minority Middle School Boys through Making

Abstract

African-American and Hispanic males are significantly underrepresented in science, technology, engineering, and mathematics (STEM) careers. While youth start narrowing their career choices in middle school, integrated STEM programs rarely specifically target minority males. Roadblocks that continue to challenge minority males in their pursuit of success in STEM fields include: disparity in access to high quality STEM educational resources, a lack of role models; and a shortage of highly trained, minority STEM educators. To address this need, four Historically Black Colleges/Universities (HBCUs) in different states, in partnership with The Verizon Foundation, established the Minority Male Maker Program in the spring of 2015. This program empowers underserved middle school students in urban and rural communities and their teachers by providing resources, instruction and professional development in 3D modeling, App development, and computer science. The long term goals of this project are to increase participant interest in STEM careers and college attendance. In the short term, we anticipate increased technology proficiency, STEM engagement and academic achievement. Additional outcomes include increased teacher and mentor understanding of STEM instruction delivery and mentorship. This presentation will provide evaluation results and lessons learned during the first year of this project, including the effects of strategies, such as mentorship and early exposure to university-based STEM resources. Recommendations for developing a prototypical process for developing programs that broaden participation of underrepresented students will also be discussed.

Introduction

In many institutions of higher education today, the enrollment of female students outnumbers that of male students. While black men make up about 6% of the US population, they are only 3% of the STEM workforce[1]. Coupled with the lower educational outcomes for minority males, there is an increased need to engage young men through STEM activities and mentorship[2]. If the US could achieve equal educational attainment between men of color and white men, it would result in a 1.8%[3] increase in the U.S. gross domestic product, a leading economic indicator. As part of the My Brother's Keeper Initiative, President Obama has increased attention to the plight of males of color in the educational and criminal justice systems[4] According to a recent report from the White House[3], the number of college degree holders among black and Hispanic males varies from 12% to 21%, versus 38% for white men. This is partly driven by the lower (but increasing) high school completion rates of men of color, particularly Hispanic (72%) and American Indian (67%); completion rates for white (95%) and black males (93.5%) is almost the same. A slightly smaller percentage of black and Hispanics pursue STEM fields versus their white counterparts (11.5% and 14.5% versus 16.4%), contributing to these statistics. The lack of pre-college preparation for STEM coursework through prerequisite courses, study skills, and knowledge of major have been identified as barriers to success of Black and Latino males in STEM[7]. These provide opportunities to identify large-scale approaches to addressing some barriers to STEM engagement and achievement for black men, starting in the middle grades.

Low-income youth, who are disproportionately minority students, are less likely to be ready for college, as measured by college entrance examinations. For example, 50% of high-school students from families with incomes of $36,000 or less do not meet any of the four ACT College Readiness Benchmarks for college readiness compared to 31% of all students who took the examination. For high school students with an interest in STEM, 29% met the readiness benchmark for mathematics while 25% met the benchmark for science, compared to 53% and 48%, respectively, for all students interested in STEM[5]. Available data indicates that academic preparation varies significantly by state and ethnicity. For example, in Kentucky, location of one of the MMM sites, 44.8% of all middle schools students attained proficiency in state-wide tests, while only 19% of African-American students attained proficiency[6]. When looking at high school readiness of African-American students, again in Kentucky, only 15% of 8th Graders meet the ACT EXPLORE benchmark for mathematics and 4.6% for science, a precursor to the college readiness benchmarks for high school students. Based on the National results of student performance by income, the ACT recommends expansion of college access and readiness programs for low-income students in the middle grades[5].

This paper describes a multi-university initiative designed for middle school-aged minority males. Details provided include the theory of action, program framework, context for implementation at four HBCUs, and the evaluation design and preliminary results.

Minority Male Maker Theory of Action

In order to guide this research, the following theory of action was developed:

> The cumulative effect/interaction of students' exposure to the essential MMM Program elements in a university setting and school setting will lead to increases in achievement, engagement in STEM activities, and attendance at school.

Our hypothesis for this program is: Minority middle school males, who are exposed to ethnically-matched mentors and STEM summer and academic year programming at four historically black colleges will report increased interest in STEM content and STEM careers, as well as increased interest in attending college. Our research question for investigating this hypothesis is: To what extent does participation in the MMM Program increase students' interest in STEM content, STEM careers, and college attendance? The theoretical perspectives that undergird the MMM program design include experiential learning theory[8], mentorship through ethnically matched mentors[9,10] and developing 21st Century skills[11,12] such as creativity and technology proficiency (Figure 1).

Experiential Learning Theory, posited by Kolb (1984), has five phases: 1) Experience – do the activity, 2) Share – reactions and observations in a social context, 3) Process – analyze and reflect upon what happened, 4) Generalize – discover what was leaned and connect to a life, and 5) Apply – what was learned to a similar or different situation[13]. We will apply this theory during 3D modeling and printing activities in which students work collaboratively to first design models using simulation computer software, then print and construct models. These simulations will parallel hands-on model-building activities and allow students to transfer what they learn while engaged in building physical models to other scenarios. According to Wingart[14], when students build physical models and adapt them over time, models serve to help explain phenomena, develop and revise students' thinking, and predict outcomes. These activities also reinforce concepts that are included in the Common Core Mathematics Standards[15], the Standards for K-12 Engineering[16], and the Next Generation Science Standards[17] (Table 1).

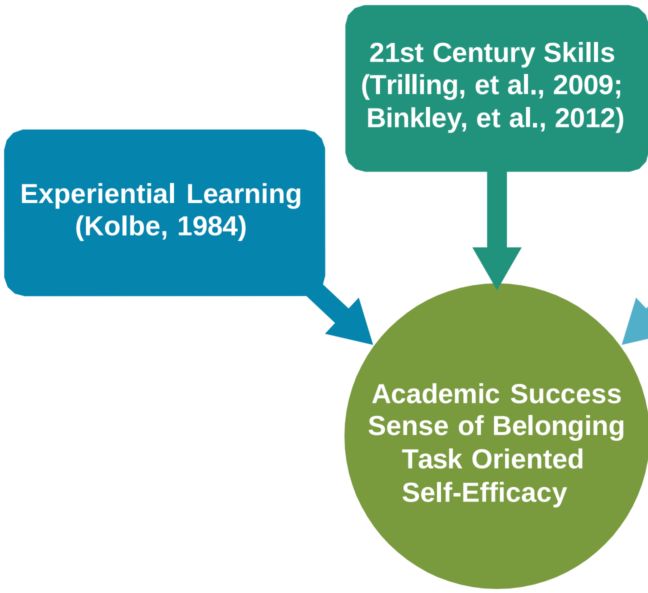

Figure 1: MMM Program Theory of Action

Table 1: Standards and Practices aligned with MMM Program Theoretical Underpinnings

Common Core Mathematical Practices	**Standards for K-12 Engineering Education**	**NGSS Science & Engineering Practices**
Make sense of problems and persevere in solving them.	MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	Asking questions and defining problems. Developing and using models.

Research on mentoring has been found to have positive behavioral and academic outcomes[9]. Some research has pointed to the importance of role models and mentors who come from similar ethnic backgrounds as the students[18] and who may have the potential to promote a sense of engineering identity, defined as the interface between academic performance, institutional connectedness, gender role and mentors in engineering[19]. Ethnically matched mentors and role models have been included in the MMM program in an effort to facilitate students' ability to envision themselves occupying these positions, instill a sense of academic self-efficacy[20] and enhance students' academic self-concept in mathematics and science[21]. The MMM program provides training and resources to mentors through a partnership with a national mentoring network, National Cares Mentoring Network, designed to empower underrepresented students in their pursuit of success in business and education goals.

The Framework for 21st Century Learning describes the skills that today's students need to thrive in a complex and connected world[11]. The Framework includes; life and career skills; learning and innovation skills (such as critical thinking, communication, collaboration and creativity); and information and technology skills. The Framework underscores the importance of applying technology effectively, by describing the links between information and communication technology (ICT) and core subjects such as English, mathematics and science. The MMM Program leverages this framework by incorporating student collaboration with coding instruction in app development using software that allows for downloading of apps to Android devices.

The framework and logic model for this program include elements that are similar to other outreach programs that target underrepresented minorities or a single gender. For example, the MOTIVATE framework utilizes technical and non-technical skill development, mentoring, parental support and informal education and was implemented in a program for middle and high school girls, primarily African-American, hosted at an HBCU,[22]. Project Exploration, a Chicago-based program to increase diversity in science, develops meaningful relationships with students, utilizes experts to teach content, and engages students in meaningful work to produce increased science capacity and encourage participants to envision science careers[23]. Girls Day Out has shown the successful impact of a one day workshop on reshaping girls and parents attitudes about engineering, increasing awareness of what is involved in engineering, and creating a pathway to an engineering career[24]. Hira and Hynes encourage creating engineering design challenges for the K-12 classroom that are tied to students' personal and situational interests, which drives the interests of underrepresented minorities in Making[25]. However, none of these programs provide minority males with instruction in STEM content, mentorship and university engineering resources that promote interest in college and STEM careers.

Program Context and Description

During the initial round of funding, four HBCUs were selected to implement the program after a competitive application process; additional minority institutions will be added in 2016. The four institutions discussed in this paper are Jackson State University (mid-sized public, urban, research university), Kentucky State University (small public, land grant university), Morgan State University (mid-sized public, urban, research university), and North Carolina Agricultural and Technical State University (mid-sized public, urban, land grant, research university). They are located in four states spanning the middle Atlantic region, Southeast and Midwestern regions of the United States. The MMM program at each university is housed in technology, engineering or science departments and the project teams include multidisciplinary faculty. Each institution is given autonomy to implement a summer and academic year program. However, all four have three common activities designed to support achieving the MMM short- and long-term goals; 1) instruction in 3-D modeling and 3-D printing, 2) instruction in software application (app) development and 3) mentoring from college students and minority men. In addition, each institution has added unique elements based on capabilities and philosophy. These activities exposed participants to activities designed to enhance their knowledge of personal development, entrepreneurship, and other STEM topics, and included workshops and field trips. For example, one university integrated robotics into the program activities and provided competitive opportunities. Participants are drawn from middle schools (grades 6 – 8) that enroll at least 40% of students from families falling at or below 185% of the poverty line ($44,863 in 2015, for a family of four), as measured by students receiving Free And Reduced Meals (FARMs)[26,27]. However, some of the participants are from schools in which over 90% of the students received FARMs in the 2015-2016 school year.

The MMM participants were introduced to designing 3-D models and developing software applications for Android devices using age appropriate computer aided design software. These topics introduce the students to engineering and computer science while equipping them with 21st Century skills such as critical thinking[28]. These program elements are described in detail below.

<u>3-D Modeling and Printing:</u> Additive manufacturing, more commonly known as 3D printing, has become common place in libraries and classrooms over the last couple of years. Available software has evolved to allow young children and adults, with limited engineering backgrounds to design models for printing. Programs targeted at middle school students emphasize hands-on modeling and participants are able to generate simple designs within 90 minutes using software such as TinkerCAD[29]. The MMM Programs provided participants with extended instruction that allowed them to design and print complex 3D objects. Since concepts of algebra and geometry are the foundation for solid modeling and application development, participants reviewed these and other mathematical concepts.

<u>Mobile App Development:</u> Coding was introduced using one of two age-appropriate visual programming languages, MIT App Inventor and MIT Scratch. When possible, participants downloaded their programs to Android devices to interact with their apps on mobile devices.

<u>Mentoring:</u> The participants interacted with college student mentors, local technology entrepreneurs and corporate leaders, minority inventors, and other speakers, to encourage self-efficacy. The National Cares Mentoring Network provided training to program staff on the mentoring needs of African-American boys.

<u>Middle School Teachers:</u> Each of the universities integrated middle school teachers into program activities. Teacher involvement ranged from being embedded with students who were learning the new skills, to having teachers develop lesson plans to use for instruction in their schools. Morgan State University hosted a week-long 3D modeling workshop where teachers developed four transdisciplinary lesson plans based on 3D modeling that could be integrated in middle school classes in at least two of the following areas: science, mathematics, engineering and technology. These lessons were piloted in several Baltimore City middle schools during the 2015 – 2016 academic year.

Table 2 illustrates a framework of the program design and logic model.

Table 2: MMM Conceptual Framework and Logic Model

Goals: (1) increase participant interest in STEM subjects, STEM careers and attending college; (2) improve students' academic performance and engagement in STEM activities; and (3) increase students' STEM task oriented self-efficacy and sense of belonging through exposure to mentors and role models.			
Associated Theories and Perspectives: Experiential Learning Theory[8], mentorship through ethnically matched mentors[9,10], and 21st Century Skills Framework[11].			
Activities	**Inputs**	**Outputs & Outcomes**	**Data/Evidence & Analyses Methods**
Instruction in 3D Modeling and Printing and Mobile App Development	University resources, 3D printers, software, and lab facilities	Increased proficiency in the use of technology	Documentation of artifacts and products, analyzed using rubrics
Mentorship	Exposure to role models, mentors and entrepreneurs	Increased student interest in STEM careers and attending college	% of students who report increased interest in STEM careers and attending college based on comparative analyses of pre-post student surveys
Guest speakers and Field Trips	Funding and guest speakers from The Verizon Foundation and other partners	Increased student engagement in STEM activities	% of students who report increased engagement in STEM based on comparative analyses of pre-post student surveys
Mathematics and science instruction and tutoring	University faculty program support	Increased academic achievement	% of students with improved academic performance based on comparative analyses of school records
Entrepreneurship Workshops	Support from the Business Community	Increased attendance at school	% of students with improved attendance based on comparative analyses of school records
Professional development events and Mentoring Training from the National CARES Mentoring Network	Professional Development and Workshops for Teachers and Mentors	Increased teachers' understanding of STEM instruction	% of teachers and mentors who report increased understanding of STEM instruction based on comparative analyses of pre-post teacher/mentor surveys and focus groups

Participants

Participants were recruited from 56 middle schools in four states for the summer pilot and were primarily African American (87% - 97% of attendees at each location). In order to achieve the project objectives, 480 middle school boys were provided with instruction or programming in the summer of 2015. College faculty or graduate students at the host university provided instruction to participants. Additionally, over 30 graduate and undergraduate students served as mentors, providing near-peer mentoring. Program details are outlined in Table *3*.

Table 3: 2015 Summer Minority Male Maker program demographics[30]

Location	Program Length	Minority Students Served	Teachers, Faculty and Mentors
Jackson State University	One week (Four sessions)	30	16
Kentucky State University	Three weeks	86	6
Morgan State University	Four weeks	38	10
North Carolina A & T University	One-week (Four sessions)	326	20
Total Participants Reached		**480**	**52**

Minority Male Maker Program Evaluation Design

An evaluation framework was developed by the Evaluation Team from SRI International that includes a description of project activities, inputs, output and outcomes, data to be collected and methods of analyses (see Table 2). The evaluation was designed to address the following research question; To what extent does participation in the MMM Program increase students' interest in STEM content, STEM careers, and college attendance? Student surveys were collected at each program site. One survey used to measure career interest and interest in STEM subjects was the Student Attitudes toward STEM (S-STEM) Survey, which invites students in grades 6-12 to give information about their attitudes toward science, technology, engineering, and mathematics subjects, 21st Century skills, postsecondary pathways, and career interests [31]. Additional questionnaires that targeted similar topics were also created by program staff at each site and included questions that targeted technology proficiency, and program satisfaction. Data analysis methods for analyzing survey data included comparative analyses and descriptive statistics. Teacher, Mentor, and Parent Surveys and interview/focus group protocols were created by SRI for use at all four sites at the end of Year 1 of the program. A plan was developed in collaboration with participating local schools to collect end-of year academic achievement data (grades, summative test scores) and attendance data.

Preliminary Results

Initial results have been very encouraging with respect to recruitment of middle schools, recruitment of minorities, ability to deliver instruction over the summer, provide near-peer mentoring and involvement of students in the development of 3D design and mobile applications and attendance at an entrepreneurship workshop[30]. In addition to instructor-guided design, students developed their own 3D designs including key chains, a chess set, game controllers and 3D models of their artwork. The students also developed mobile applications that included images, sound, and Internet links. To link instruction in CAD, programming, and entrepreneurship at one site, teams of students pitched ideas for new businesses that integrated all the skills they had learned.

Preliminary results at the end of the summer of 2015 support the hypothesis that participating students increased their interest in STEM subjects and activities that are related to STEM careers. Three universities conducted pre- and post-surveys of students for their summer program. The data from NCAT represents student responses from a one-week session, JSU data is from four one-week sessions while MSU data is after a four-week session. All universities will conduct evaluations at the end of the academic year program, providing additional data points for more in-depth analysis. Results from several questions on the initial survey are listed below. For Table 4, a five-point Likert scale was used, with the question: *What is your interest in taking classes in the following subjects in the future?* Results at MSU indicated increased interest in science, technology, engineering and design courses, while NCAT results indicated increased interest in engineering. JSU results (Table 5) indicated increased interest in careers in science, technology, engineering, mathematics and design. In addition to questions on interest in STEM classes, MSU used a three-point Likert scale with the following prompts for two questions (Table 6): 1) *Technology usage: I've used or created these technologies before;* and *2) Design: Please mark the circle that best describes your response. I like to imagine creating new products*. Results indicate increased interest in technology and engineering at all three sites. Interested in science, mathematics and design increased or decreased slightly at all three universities. Additionally, at MSU, very few participants reported using a 3D printer (21%) or developing a mobile app (0%) prior to the program. More students (59%) reported that they enjoyed imagining creating new products.

Although all institutions utilized internal survey instruments customized to their MMM programs, another survey that has been administered to over 10,000 4th to 12th grade students can be used to provide a perspective on the MMM results. Interest in STEM careers reported on the Student Attitudes towards STEM survey ranges from 30% for careers in physics to 51% for careers in veterinary work[32]. The MMM participants reported a 66% - 94% increase in science and design classes at MSU and JSU. We hypothesize that increases in students' interest in STEM related subjects and activities may be a precursor to increased interest in the pursuit of STEM careers. Students at JSU reported increases in interest in furthering their education (see Table 7). This will be further examined through secondary analysis of Year 1 data and throughout Year 2 of the project. Findings indicate promise in regard to extending this program to more minority youth across the country.

Table 4: Interest in pursuing STEM classes

	MSU		NCAT	
	Pre-survey	**Post-survey**	**Pre-survey**	**Post-survey**
Interested in science classes	60%	78%	44%	40%
Interested in technology classes	81%	87%	74%	75%
Interested in engineering classes	53%	60%	59%	69%
Interested in mathematics classes	60%	52%	55%	52%
Interested in design classes	66%	78%	68%	63%

Table 5: Interest in pursuing STEM careers

	JSU	
	Pre-survey	**Post-survey**
Interest in a career in science	24%	56%
Interest in a career in technology	55%	81%
Interest in a career in engineering	38%	75%
Interested in a career in mathematics	48%	63%
Interested in a career in design	62%	94%

Table 6: Initial assessment results of technology use and creativity

	MSU	
	Pre-survey	**Post-survey**
3D printer usage	21%	75%
Mobile app development	0%	88%
Imagine creating new products	59%	75%

Table 7: Initial assessment results of interest in furthering education

	JSU	
	Pre-survey	**Post-survey**
Interest in attending a four year college	45%	73%
Interest in attending community college	24%	60%
Interest in graduating from high school	72%	87%
Interest in going to high school	79%	93%
Unsure of Plans	34%	33%

Discussion

The research question for this project is: To what extent does participation in the MMM Program increase students' interest in STEM content, STEM careers, and college attendance? Preliminary data analysis shows increases in participants' interest science and design courses and engineering careers. Ongoing efforts to collect and analyze academic year data and conduct multi-institutional comparisons will address the project research questions in more depth. Focus groups with parents, teachers, mentors, administrators and students, that were conducted by SRI in the spring of 2016 revealed highlights and challenges of program activities that will be considered during planning for the 2016 Summer Programs. Examples of highlights include reports by students that they have benefited from the social interaction with like-minded peers while participating in the MMM project and that participation in the program helped improve the students' self-confidence and sense of belonging. Challenges reported by parents include the need to improve communication about what students are doing and increasing access to hands on materials (such as raspberry pi). Working collaboratively, program administrators are meeting monthly to discuss ways to improve the program and promote success in achieving project goals. There is a plan to scale up the program to include eight additional minority serving institutions.

Bibliography

1. National Science Foundation, National Center for Science and Engineering Statistics. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2015 Digest*.; 2015. doi:Special Report NSF 11-309.
2. Smith C. *Pre-College Challenges for URMs in Engineering*. Washington, D.C.; 2014. http://www.nacme.org/images/pdfs/research/PreCollege_Challenges_URMS_Engineering.pdf.
3. White House Council of Economic Advisers. *Economic Costs of Youth Disadvantage and High-Return*.; 2015. https://www.whitehouse.gov/sites/default/files/docs/mbk_report_final_update1.pdf.
4. The White House. My Brother's Keeper. https://www.whitehouse.gov/my-brothers-keeper. Published 2016.
5. ACT and National Council for Community and Eduation Partnerships. *The Condition of College and Career Readiness - Students from Low-Income Families*.; 2015. www.act.org/readiness/2015.
6. Kentucky Department of Education. Kentucky School Report Card. Kentucky Performance Rating for Educational Progress (K-PREP). http://applications.education.ky.gov/SRC/AssessmentByState.aspx. Published 2014. Accessed January 28, 2016.
7. Strayhorn TL, Long III LL, Kitchen JA, Williams MS, Stentz M. Academic and Social Barriers to Black and Latino Male Collegians' Success in Engineering and Related STEM Fields. In: *120th ASEE Annual Conference*. ; 2013.
8. Kolb DA. *Experiential Learning: Experience as the Source of Learning and Development.* Englewood Cliffs, N.J.: Prentice-Hall, Inc.; 1984.
9. Syed M, Goza BK, Chemers MM, Zurbriggen EL. Individual Differences in Preferences for Matched-Ethnic Mentors Among High-Achieving Ethnically Diverse Adolescents in STEM. *Child Dev*. 2012;83(3):896-910. doi:10.1111/j.1467-8624.2012.01744.x.
10. Blake-Beard S, Bayne ML, Crosby FJ, Muller CB. Matching by race and gender in mentoring relationships: keeping our eyes on the prize. *J Soc Issues*. 2011;67:622-643.
11. Trilling B, Fadel C. *21st Century Skills: Learning for Life in Our Times*. John Wiley & Sons; 2009.
12. Binkley M, Erstad O, Herman J, et al. Defining twenty-first century skills. In: *Assessment and Teaching of 21st Century Skills*. Netherlands: Springer; 2012:17-66.
13. Woffinden S, Packham J. Experiential learning, just do it! *Agric Educ Mag*. 2001;73(6):8-9.
14. Wingert K. STEM practices and model-based reasoning: An ISE research brief discussing Lehrer & Schauble, "Origins and evolution of model-based reasoning in mathematics and science." http://relatingresearchtopractice.org/article/359 . Published 2014. Accessed March 21, 2016.
15. National Governors Association Center for Best Practices & Council of Chief State School Officers. *Common Core State Standards for Mathematics*. Washington, DC; 2010.
16. National Academy of Engineering. *Standards for K-12 Engineering Education?* Washington, D.C; 2010. http://www.nap.edu/catalog/12990/standards-for-k-12-engineering-education.
17. States NL. *Next Generation Science Standards: For States, By States*. Washington, DC; 2013.
18. Zirkel S. Is There A Place for Me? Role Models and Academic Identity among White Students and Students of Color. *Teach Coll Rec*. 2002;104(2):357-376. doi:10.1111/1467-9620.00166.
19. Capobianco BM, French BF, Diefes-Du HA. Engineering Identity Development Among Pre-Adolescent Learners. *J Eng Educ*. 2012;101(4):698-716. doi:10.1002/j.2168-9830.2012.tb01125.x.
20. Markus H, Nurius P. Possible selves. *Am Psychol*. 1986;41(9):954-969.
21. Shavelson RJ, Marsh RW. On the structure of self-concept. In: Schwarzer R, ed. *Self-Related Cognitions in*

Anxiety and Motivation. Hillsdale: Lawrence Erlbaum Associates, Inc; 1986:305-330.

22. Brown Q, Burge JD. MOTIVATE: Bringing out the fun with 3d printing and e-textiles for middle- And high-school girls. In: *ASEE Annual Conference and Exposition, Conference Proceedings*. ; 2014:24.915.1-24.915.12.
23. Lyon GH, Jafri J, St. Louis K. Beyond the Pipeline: STEM Pathways for Youth Development. *Afterschool Matters*. 2012;(16):48-57.
24. Deckard C, Quarterfoot D, Csanadi K. Analysis of a Short-Term STEM Intervention Targeting Middle School Girls and Their Parents (Research to Practice). In: *121st ASEE Annual Conference & Exposition*. ; 2014:24.179.1-24.179.42.
25. Hira A, Hynes MM. Broadening participation in engineering: Making in the K-12 Classroom following an interest-based framework. In: *122nd ASEE Annual Conference Proceedings*. ; 2015:26.294.1-26.294.10.
26. Department of Agriculture. Child Nutrition Programs—Income Eligibility Guidelines. *Fed Regist*. 2015;80(190):9-10.
27. Department of Agriculture. National School Lunch Program. 2013. http://www.fns.usda.gov/sites/default/files/NSLPFactSheet.pdf.
28. P21 Partnership for 21st Century Learning. *P21 Framework Definitions*.; 2015. http://www.p21.org/storage/documents/docs/P21_Framework_Definitions_New_Logo_2015.pdf.
29. Buhler AG, Gonzalez S, Bennett DB, Winick ER. 3D Printing for Middle School Outreach : A collaboration between the science library and the Society of Women Engineers. In: *122nd ASEE Annual Conference & Exposition*. ; 2015:26.14.1-26.14.7.
30. Ziker C, Javitz H. *Minority Male Maker Case Study Research Brief: A Review of the 2015 Summer Program*. Menlo Park; 2016.
31. Friday Institute for Educational Innovation. *Middle and High School STEM-Student Survey*. Raleigh; 2012.
32. Faber M, Unfried A, Wiebe EN, Corn J, Townsend LW, Collins TL. Student Attitudes toward STEM : The Development of Upper Elementary School and Middle / High School Student Surveys Student Attitudes toward STEM : The Development of Upper Elementary School and Middle / High School Student Surveys. In: *120th ASEE Annual Conference and Exposition*. Atlanta; 2013.