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# Closing the STEM Gap: A University, P-12 School District Partnership to Engage Sixth Grade Students in Integrated Computing Activities

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# Closing the STEM Gap: A University, P-12 School District Partnership to Engage Sixth Grade Students in Integrated Computing Activities

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Abstract: This article describes how participating in a computing program positively impacted young adolescents from underrepresented populations in STEM attitude toward STEM and interest in STEM-related careers. Nineteen sixth-grade students attending a rural, Title I middle school participated in the study. Five computing lessons were taught by undergraduate interns majoring in computer science, middle-level mathematics and science teacher education, and secondary mathematics teacher education. Analysis of quantitative and qualitative data provide convincing evidence that students' attitudes toward STEM improved and interests in STEM-related careers increased because of participating in the computing program.

*Keywords*: STEM education, STEM education equity, underrepresented minorities in STEM, STEM attitude, STEM career interest, computing activities

## Introduction

STEM education involves learning and teaching in the fields of science, technology, engineering, and mathematics using an interdisciplinary approach (Gonzalez and Kuenzi, 2012). In STEM education, the four fields in question are adapted to the subject or one of the disciplines is focused on and the other fields are used as context to teach the subject of the field in focus (Moore et al., 2014). STEM education develops students' problem solving, critical thinking, and analytical thinking skills (Koyunlu Unlu, Dökme & Unlu, 2016) and seeks to create innovative individuals who possess an interdisciplinary point of view while approaching problems (Bybee, 2013; Clark and Button, 2011). Additionally, STEM education provides students an opportunity to engage with real-life problems and use questioning, problem solving, collaboration, and practical activities to find solutions, by focusing on student-centered education (Soylu, 2016).

One of the major purposes of STEM education is to encourage students to obtain careers in science, technology, mathematics, and engineering. For the past 30 years, research indicates that while the need for individuals employed in STEM-careers increases, the number of individuals interested in STEM-careers constantly decreases. An even greater national concern is the lack of underrepresented populations including women, African-Americans, Latinos, Native Americans, and individuals with disabilities entering STEM professions. A group is underrepresented in STEM when its numbers in each career are disproportionately lower than its numbers in the general population. According to the National Science Board Science and Engineering Indicators (2018), African-Americans, Latinos, and Native Americans continue to remain underrepresented in receiving science and engineering bachelor's degrees compared to their percentage of the population, (15%, 21% and 0.9%, respectively).

Research indicates that the STEM issue becomes prevalent during young adolescence as many students lose their interest in science and mathematics while enrolled in middle school (Museus, Palmer, Davis & Maramba, 2011; Turner & Ireson, 2010). In addition, youth generally determine career paths by the age of 13 (Tai et al., 2006; Bernstein et al., 2019; Shet & Tremblay, 2019). Therefore, if we are to increase the STEM-pipeline, educators must provide opportunities for middle school students to engage in STEM-based activities which will increase students interests in STEM disciplines and improve their interests in STEM-related careers.

## The Partnership

The university, a Minority Serving Institution (MSI), received a grant funded by the Department of Energy (DOE) which allowed the university to establish a Minority Serving Institution Partnership Program (MSIPP). Facilitated by various consortiums, MSIPP's mission is to increase STEM participation of underrepresented minorities in educational and workforce opportunities throughout the United States. The grant initially established a three-way partnership between the funding agency, university, and a local P-12 school district. To

facilitate the grant's goals, a second three-way partnership was developed between the university's Department of Computer Science, the university's School of Education, and the P-12 school district. The university partnership allowed undergraduate computer science and pre-service teacher education majors serving as interns to teach STEM-based computing activities to middle school students enrolled in the local P-12 school district.

## The Computing Program

The semester-long computing program was facilitated by the researchers and nine undergraduate interns. The researchers consisted of a computer science professor with previous DOE experience and an education professor with experience as a high school science teacher and science instructional coach. Of the nine interns, three were computer science majors, three were secondary mathematics education majors, and three were middle-level mathematics and science education majors.

Prior to teaching the lessons, interns attended four professional development sessions facilitated by the researchers to enhance their pedagogical knowledge. Session topics included This We Believe, Sixth- Grade College and Career Ready Standards for mathematics and science, International Society for Technology in Education (ISTE) Standards, integrated curriculum, writing lesson plans, and classroom management. Once the professional development sessions ended, undergraduate students were divided into three groups with each group consisting of one student majoring in computer science and two students majoring in education. Each group of interns created a minimum of two integrated, engaging, hands-on computing lesson plans which were approved by the researchers prior to sixth-grade students participating in the computing program.

The computing program included eight interdisciplinary, engaging, hands-on activities aligned with the state's sixth-grade Computer Science and Digital Literacy Standards as indicated in Table 1.

Table 1
*Computing Program Activities*

| **Title of Activity** | **Computer Science and Digital Literacy Standards** |
|---|---|
| Are You Safe? | Understand the risks and responsibilities of being a digital citizen. |
| Cyber War | Analyze the use of computing to solve relevant problems. |
| Cyberbullying | Understand the risks and responsibilities of being a digital citizen. |
| Introduction to Problem Solving | Design, evaluate, and modify simple algorithms. |
| Making Data and Sending Data | Analyze how data is collected with both computational and non-computational tools and processes. |
| Introduction to Problem Solving | Design, evaluate, and modify simple algorithms. |
| Making Data and Sending Data | Analyze how data is collected with both computational and non-computational tools and processes. |
| Introduction to Scratch | Examine how computing devices function. |
| Making Data and Graphing Data: Distance, Time, and Data | Analyze how data is collected with both computational and non-computational tools and processes. |
| Processing | Design, evaluate, and modify simple algorithms. |

The purpose of the computing program was to determine how participating in computing activities increased sixth-grade students' interest in STEM and improved their attitudes toward STEM-related careers. To answer the research questions, students completed the Engagement Survey at the conclusion of each session, the STEM Semantics Survey at the culmination of the program and participated in a focus group conducted by the researchers. The research questions which guided the study were:

1. How does participation in a computing program affect students' attitude toward STEM?
2. How does participation in a computing program affect students' interest in STEM- related careers?
3. What is the experience of sixth-grade students participating in a computing program?

## The Students

Nineteen sixth-grade students from underrepresented populations in STEM attending a public, rural, Title I middle school participated in the study. Of the 19 participants, 11 were male, eight were female, 17 were African-American, one was Latino, and one was Caucasian. The Caucasian student was female. The students attended a rural Southeastern middle school with an enrollment of 443 students in grades six through eight. Of the 443 students attending the school, 95% received free or reduced lunch and 1.6 % participated in the gifted and talented program.

## Instruments for Data Collection

The Engagement Survey was designed to be completed by young adolescents ages 10-14 immediately after completing a science activity to investigate motivation and interest in STEM. The Engagement Survey is comprised of eight questions based on a 4-point Likert scale which includes three subscales: behavioral, cognitive, and affective. To answer each question, respondents reply YES (four), yes (three), no

(two), or NO (one). The survey provides an overall engagement score, a behavioral/cognitive score (questions four through eight), and an affective score (questions one through three).

The behavioral engagement subscale evaluates whether students are on or are off-task while completing the assigned activity. The cognitive engagement subscale measures whether students' thought processes and attention are directed towards meaningful processing of information involved in completing the assigned activity. The affective engagement subscale assesses whether students' emotions that occur as part of completing the assigned activity are positive and high arousal rather than negative and low arousal. Questions answered by respondents completing the Engagement Survey include: 1) "During this activity: Time went by quickly" (behavior); 2) "During this activity: I was focused on the things we were learning most of the time" (cognitive); and 3) "During this activity: I felt bored" (affective). The Engagement Scale is a valid and reliable instrument with Cronbach's and polychoric alpha of .80 and .85, respectively.

The STEM Semantics Survey developed by Tyler-Wood, Knezek and Christensen (2010) was created for use with middle school, high school, and college students to measure interest in science, technology, engineering, mathematics, and interest in STEM-related careers. The STEM Semantics Survey consists of 25 questions, divided into five subscales, with five semantic perception adjective pairs per subscale, (fascinating/ordinary, appealing/unappealing). Scores on the survey, range from five, indicating a poor attitude per subscale, to 35 demonstrating a high attitude per subscale. Content validity of the STEM Semantics Survey evaluated by researchers at the University of North Texas (Tyler-Wood et al., 2010) reported internal consistency reliabilities of the five subscales ranging from Cronbach's alpha of .84 to .93.

## Results

Results are reported in two sections. The first section reports quantitative results from the Engagement Survey and the STEM Semantics Survey. The second section provides qualitative results and summarizes the focus group themes. Although students attended five sessions, qualitative results are only reported for three sessions due to session three being a continuation of session two and low participation during session four.

### *Quantitative Results*

Quantitative results obtained from the Engagement Survey demonstrated that participating in the computing program positively affected students' attitude toward STEM and results from the STEM Semantics Survey indicated that the computing program positively affected students' interest in STEM-related careers. Of the various activities completed, students indicated that Introduction to Problem Solving, and Making/Sending Data were their favorite, earning a mean score of 3.67 on the total scale, $\mu = 3.64$ on the behavioral/cognitive subscale and $\mu = 3.70$ on the affective subscale of the Engagement Survey.

Table 2
*Engagement Survey Means per Session*

| Session | Engagement Survey Means | | |
|---|---|---|---|
| | Total Scale | Behavioral/Cognitive Subscale | Affective Subscale |
| One | 3.39 | 3.30 | 3.56 |
| Three | 3.67 | 3.64 | 3.70 |
| Five | 3.52 | 3.42 | 3.71 |

STEM Semantics Survey data indicated that of the five subscales, students achieved the highest score on the technology subscale (31) and lowest score on the engineering subscale (27). Students scored two points higher on the science subscale (30) than on the math subscale (28). Additionally, students scored 28 on the career subscale indicating that overall, the majority of the students were interested in obtaining a career in a STEM-related field.

Table 3
*STEM Semantics Survey Scores per Subscale*

| Subscale | Scores |
|---|---|
| Science | 30 |
| Math | 28 |
| Engineering | 27 |
| Technology | 31 |
| Career | 28 |

### *Qualitative Results*

Researchers used a constant comparative method (Glaser & Strauss, 1967; Miles & Huberman, 1994; Yin, 2003) to code qualitative data obtained from conducting a focus group with sixth-grade participants. Four themes that emerged from the data included: 1) students enjoyed the computing activities; 2) students wanted to participate in additional computing activities; 3) students enjoyed being taught by interns (college students); and 4) students expressed interest in STEM-related careers. Of the 19 students participating in the focus group, 17 students expressed interest in a STEM-related career and two students were disinterested in STEM-related careers.

When asked how they enjoyed being taught by college students, one student replied, "The interns were a major influence on me and made me want to attend college to major in STEM." Another student replied, "I felt comfortable with the college students; they made learning fun and were entertaining. For a few minutes they were cool, but then made us get back to work." When asked about the activities, one student responded, "The activities were challenging yet fun and interesting. They required us to put forth a great deal of thought."

## Discussion

By the time students are enrolled in middle school, many students perceive science as difficult, boring, and irrelevant to their lives (Guthrie, Klauda, & Morrison, 2012). Decreased motivation during adolescence is often more pronounced in math and science than in other subjects, (Wigfield, Eccles, Fredricks, Simpkins, Roeser, & Schiefele, 2015). Research indicates that it is absolutely imperative that middle school students are afforded opportunities to engage in STEM-based activities to increase the STEM pipeline. Additionally, educators need to discover opportunities to increase the number of underrepresented minorities in STEM-related careers. One strategy an in-service teacher can utilize to provide STEM-based learning activities to their middle school students is to collaborate with local colleges and universities.

This paper provided evidence regarding a collaboration between the DOE, a university's Department of Computer Science, a university's School of Education, and a P-12 school district. The collaboration allowed sixth-grade students identified as underrepresented minorities in STEM-related careers an opportunity to engage in computing activities taught by college interns majoring in computer science and STEM education. Quantitative data indicated that participating in the computing program positively affected students' attitude toward STEM and positively affected students' interest in STEM-related careers. Qualitative data provided evidence that participants exhibited an overall positive experience while participating in the computing program.

## Limitations

While we found participating in the computing program improved students' attitude toward STEM and increased their interest in STEM-related careers, we acknowledge that this study was limited in scale and should not be generalized beyond our context. The study included 19 participants residing in a rural area located in the Southeastern region of the United States. Additionally, participants were from low-income households and identified as minorities underrepresented in STEM fields. Despite the addressed limitations, this study is significant in the contribution it makes to STEM-education research regarding middle school students by providing evidence that participating in a computing program positively impacted students' attitude toward STEM and interest in STEM-related careers.

## Funding

The research reported was funded through a grant from the U.S. Department of Energy.

***The Successful Middle School: This We Believe* characteristics:**

- Curriculum is challenging, exploratory, integrative, and diverse.
- Instruction fosters learning that is active, purposeful, and democratic.
- Leaders are committed to and knowledgeable about young adolescents, equitable practices, and educational research.

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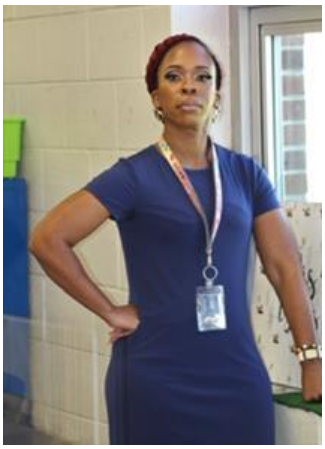
## About the Authors

Dr. Michiko B. McClary is a seasoned educator with 16 years of experience in K-12 education and 8 years of experience in higher education. Prior to employment in higher education, she taught middle school and high school science in South Carolina and California; served as a High School Science Instructional Coach; and worked as an Elementary and Middle School Science Interventionist. Currently, Dr. McClary is the Director of Teacher Education at Morris College in Sumter, South Carolina and previously served as the Coordinator of Assessment and Accreditation at Claflin University in Orangeburg, South Carolina. She has taught undergraduate and graduate education courses utilizing face-to-face and online modalities. Dr. McClary is passionate about preparing the next generation of exemplary educators and providing STEM educational opportunities to increase the number of minorities in STEM careers. To achieve this goal, she collaborates with STEM professionals to conduct research which provides opportunities to improve K-12 students' attitude toward STEM and increase their interest in STEM with a focus on pre-service teachers and underrepresented minorities in STEM. Additionally, Dr. McClary conducts research to improve the self-efficacy of pre-service teachers.

Dr. Deidra Morrison is a Technical R&D Consultant and Freelance Developer. She has conducted research in the area of STEM education, cybersecurity and human centered computing; specifically, the development of digital interventions to abnormal behaviors supported through socially affording technologies. As an Assistant Professor of Computer Science, her university instructional experience includes programming languages, software development, web and mobile application development, cybersecurity and undergraduate research skills development.

Kamilah Brown is the Founder and CEO of STEAME Logic LLC and STEAME Logic Non-Profit. STEAME Logic focuses on K-12 engagement in the subject areas of Science, Technology, Engineering, Arts, Mathematics and Exercise to help fight childhood obesity. Kamilah started her career in technology over 10 years ago while in undergrad, working within the college IT department. This jumpstarted her career in technology working with various organizations in the public and private sectors. In 2014, Kamilah started her career as a K-12 STEM Education consultant. This led to the start of STEAME Logic. Currently, she is working with various school districts, universities and government partners to expand exposure in STEM focused fields within the K-12 arena while developing outreach programs to increase STEM participation amongst underrepresented and underserved groups. Kamilah is a certified Microsoft IT Professional and has spoken at various events, with highlights serving as a panelist during the NICE conference in 2015 and the Capital PKAL Reginal Network Conference in 2019. Collegiately, she received her undergraduate degree from Voorhees College in Accounting, and her graduate degree in Cybersecurity from Norfolk State University.



Ms. Yolanda R. Bennett attended South Carolina State University as an 1890 USDA Scholar sponsored by National Resources Conservation Services. She is a 17-year teaching veteran whose endorsements include Middle Level Science, Middle Level Mathematics, Secondary Science, Business Education, Gifted and Talented and a Literacy Coach Certification. During her tenure, she has served Fairfield County School District, Richland One, Orangeburg 3, 4 and 5 (now Orangeburg Consolidated). She has served as a classroom instructor, Title One Coordinator and Technology/Instructional Coach. It is her belief that those educators who find the most joy in the profession are those who have honed the art of being a reflective practitioner, are committed to continual learning and live transparently to guide the actions of others.

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