UNDERSTANDING GENDER-BASED ATTITUDES IN STEM ENVIRONMENTS

by
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Abstract

Women have sustained an underrepresentation in science, technology, engineering, and math (STEM) courses, majors, and careers. This trend was observed among programming and robotics students enrolled in an after-school program in a poverty demographic in an urban setting in the Northeast United States. Factors of applicable math, stereotype threat, and the unmet need for advanced programming course offerings emerged from the needs assessment and were addressed though the intervention of a scalable, open, online course (SOOC) to develop a game using MIT App Inventor, followed by a face-to-face Hack-A-Thon. Data collection included a pre-and post survey of STEM attitudes, and qualitative interviews in a convergent, mixed-methods research approach to discover gender-based attitudes in STEM environments.

Keywords: advanced programming courses, applicable math, STEM attitudes, stereotype threat, MIT App Inventor

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Dedication

This dissertation is dedicated to my family:

- To my husband, Frederick G. Mistretta, who provided continuous encouragement and support throughout my doctoral studies.
- To my daughters, Michelle and Suzanne Mistretta, who inspire me with their intelligence and loving ways.
- To my forever proud parents, Caroline and Arthur Tassely, who are in Heaven and are constantly at my side.

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Executive Summary

Women exhibit a continued underrepresentation in course selection, college majors, advanced degrees, and professional practice in computer science, engineering, and math-intensive science fields (Beyer, 2014; Ceci, Williams, Ginther, & Kahn, 2014; Cheryan, Ziegler, Montoya, & Jiang, 2017). Females have made some gains to reach parity in the fields of life, and social science (Beyer, 2014) whereas computer science, physics, and engineering remain male-dominated fields (Cheryan, Ziegler, Montoya, & Jiang, 2017). The National Center for Science and Engineering Studies has accumulated statistics of intended college majors of incoming first-year students by science, technology, engineering, and math (STEM) fields, ethnicity, race, and gender from 1995 through 2010. These data revealed that the percentage of males planning STEM majors and careers outnumbers the proportion of females in every category, regardless of ethnicity or race (National Center for Science and Engineering Statistics, 2012). Females tend to avoid upper-level science and math courses in high school that provide the foundational knowledge to sustain STEM course work in college (Nugent et al., 2015; Riegle-Crumb, King, Grodsky, & Muller, 2012; Spitzer & Aronson, 2015; Wang, 2013).

In 2015, women held one in four jobs in technology (National Center for Women & Information Technology, 2016). The trend of bypassing math electives is evident in the empirical research spanning 3 decades (Berryman, 1983; Ellis, Fosdick, & Rasmussen, 2016). Communal STEM careers, which are typically pursued by females, include opportunities to work with and help others (Diekman, Steinberg, Brown, Belanger, & Clark, 2016). Eccles and Wang (2016) conclude that females are less likely to select science, technology, engineering, and math (STEM) careers, however, if they do, they prefer to work in health, medical sciences, or biology that they perceive as helpful to humanity. Adolescent females continue to select communal

STEM courses in the researcher's teaching practices located in the Northeast United States (New York and New Jersey). Through this study, the researcher aimed to develop an understanding of female underrepresentation in STEM courses and majors to determine whether females' attitudes toward communal versus agentic careers contributed to the avoidance of more rigorous coursework.

Theoretical Frameworks

Bronfenbrenner and Morris's (2006) ecological systems theory (EST) provided the overarching structure of this study to examine factors and underlying causes that contributed to the underrepresentation of women in foundational courses that could lead to females' selection of sustained STEM majors resulting in careers in science, technology, engineering or math careers. Bronfenbrenner and Morris (2006) defined an EST microsystem as a girl's immediate environment that provided her with proximal processes, which the researchers deemed crucial to human development. These proximal processes include the girl, her family, peers, teachers, and her school environments. Together, the proximal processes comprise the EST mesosystem of important factors that influence a girl's decisions. The EST exosystem contains opportunities encountered in a girl's life that the EST macrosystem can influence through cultural norms.

Gee (2008) defined the opportunities to learn as affordances and effectivities. Gee defined affordances a person's perception of the feasibility of acting upon something in their environment and effectivities as something upon which they could choose to enact. Eccles (1994) provided a model of achievement-related choices (MARC) to guide future researchers to determine why women made certain choices regarding their expectations for success and perceptions of the value of available options that influenced those decisions. Gee's (2008) affordances represent options to females, and the transition to following through with effectivities is at the heart of this study.

Vygotsky (1979) defined the zone of proximal development (ZPD) as the distance between what a girl already knew and what she could achieve when collaborating with her peers. The ZPD is particularly important in technology fields during problem-based learning where girls in STEM courses could collaborate with more capable peers and teachers. Gee (2008) posited that students could resist learning due to perceived threats to their self-perceptions. Stereotype threats, gender biases, family attitudes, peer perceptions, and math anxieties might pose threats to girls' self-perceptions. If a female student can establish a sense of belonging in STEM and overcome these threats, then she can act on this opportunity to learn (Wilson et al., 2015). Family, teachers, and peers can assist female STEM students in pairing the affordance of rigorous course offerings and the effectiveness of acting upon sustaining their studies (Oliver, Woods-McConney, Maor, & McConney, 2017).

Literature Review

The synthesis of literature begins with the broadest topic regarding the inception of the STEM acronym. Key factors examined in the literature synthesis include stereotype threat, the attributes of STEM careers, family and maternal influences, role models, math anxiety, teachers, and peer influences. The literature synthesis culminates with an analysis of how the key factors impact Gee's (2008) affordances and the follow through to effectivities in a girl's STEM decisions.

Among the over 270 resources referenced in this study, the researcher found three pivotal works to guide the understanding of women's STEM choices. The first was Eagly (2013) and her definition of agentic versus communal careers. Women prefer communal careers that have a connotation of helping others and offer a better work-life balance, while men seek rigorous, math-intensive, agentic fields with greater advancement opportunities. The second was a study conducted by Kayumova, Karsli, Allexsaht-Snider, and Buxton (2015) regarding how the cultural norms of race and ethnicity influenced women. Kayumova et al. introduced the concept of *ways of knowing* that referred to Hispanic mothers' education of their daughters regarding prejudicial treatment by society. The third was a study by Hargrave (2015) who posited that after-school programs were *counter spaces* that provided students, especially African Americans, with an opportunity to become successful in a setting other than school, where they might be labeled as disinterested or not motivated in education.

Needs Assessment

The needs assessment employed a mixed method approach that revealed three actionable factors to guide the research of the problem of practice regarding the underrepresentation of women in STEM courses, majors, and careers. The three actionable factors of this study included (a) the unmet need for computer programming course offerings, (b) stereotype threat, and (c) the opportunity to apply math skills in authentic contexts. Participants in the needs assessment shared that they wanted to take more computer courses, but their schools did not offer classes in their curriculum. Female students conveyed that they lacked a sense of belonging in male-dominated classes where males mistrusted their contributions in coed teamwork settings. All participants expressed frustration that their math coursework did not include authentic, applicable examples that they could logically solve.

Intervention Theoretical Framework

The overarching theoretical framework that guided the intervention conducted in this study was critical theory. The core concept of critical theory is immanent critique (Antonio, 1981). This type of critical approach seeks the contradictions of a social reality from within rather than a transcendent approach that is evoked from the outside of circumstances (Fornas, 2013). The word *critical*, used in combination with the word *theory*, does not have a connotation of fault-finding. Rather, the critique is evaluative in nature to question the norms from within a social construct (Fornas, 2013; Sarkela, 2017).

Educational Philosopher John Dewey employed the tenets of critical theory when he highlighted the need to critique a social system from within (Laitinen, 2017). Dewey defined habits as patterns of individual behavior that could be regarded as custom by humans in social settings, which became a tradition if absorbed into a system (Wang, 2012). Looking through the lens of Dewey's viewpoint on behaviors, customs, and traditions, the math-intensive STEM fields of physics, engineering, and computer science are traditionally male dominated (Cheryan et al., 2017). Women exhibit patterns of behavior in bypassing upper-level math and science high school electives that provide foundational knowledge in STEM college majors (Nugent et al., 2015; Riegle-Crumb et al., 2012; Spitzer & Aronson, 2015; Wang, 2013). Kellner (2003) noted a contemporary call for a critical theory of education and suggested the work of Dewey as a foundation to meet the challenges of the ever-evolving, multicultural, technological, and global models of present-day educational settings.

Intervention Research Questions

The researcher developed the following intervention research questions to provide a foundation for the exploration of gender-based attitudes in STEM environments. The research questions queried students' STEM attitudes regarding the three factors that emerged in the needs assessment (see Mistretta, 2017a). Each research question also probed for differences in STEM attitudes along gender groupings.

Intervention Research Question 1 (IRQ1): Interest in Programming Electives

What are students' attitudes toward increasingly advanced programming offerings? In what way does gender influence persistence in achieving higher programming skill levels?

Intervention Research Question 2 (IRQ2): Students' Perceptions of Stereotype Threat

What are students' perceptions regarding a sense of belonging in a coed STEM environment? In what way does gender influence perceptions of belonging?

Intervention Research Question 3 (IRQ3): Applicable Math

What are students' experiences regarding applicable math during the intervention? In what way does gender explain differences in willingness to apply math in real-world applications?

The research questions addressed the social reality or norms regarding perceptions of males as better at math, nonapplicable math instruction in traditional course settings, and females' perceptions of a chilly climate in STEM environments. Drawing on Kellner's (2003) contemporary call for a critical theory of education, the researcher explored students' gender-based attitudes by addressing the contradictions of social reality from within an advanced programming course offering, rather than a transcendent approach evoked from outside circumstances (see Fornas, 2013).

Intervention

To examine the underrepresentation of women in STEM courses majors and careers, the researcher conducted the intervention in an after-school program (ASP) in a poverty demographic in the Northeast United States. ASP enrolls up to 100 students in elementary, middle, and high school. The students in this program continue to fall well below the Level 4, meeting or exceeding expectations, on PARCC standardized tests results (Shafer & Peron, 2018).

Within this poverty demographic, the study took place during the October 2018 through November 2018 timeframe.

To assist in the implementation of the intervention, called “Android Inventor” at ASP, the researcher received IRB approval to add an intern to the study team (see Appendix BB). The intern, a female college freshman majoring in computer science, assisted in the maintenance of a password-protected master list of students, communicated with the parents in Spanish, and organized the study participants during the 23 days that the Android Inventor sessions occurred. The intern contributed to the researcher’s Evernote journal to record qualitative data regarding the participants of the study in their day-to-day program activities. The researcher and intern met with the principal investigator each Thursday during the intervention via Zoom to discuss the progress of the study.

Recruitment

The Education Department of ASP and the researcher agreed on the program name “Android Inventor” to provide enrolled students the opportunity to learn to program using the MIT App Inventor online development environment. The recruitment of participants aligned with a 2-day Back to School Boutique during August 2018. ASP invited students and their parents to receive school supplies and backpacks for the upcoming school year. The researcher attended the 2-day event to meet the families and explain the Android Inventor program. During this time, 25 students in fourth through ninth grades completed assent forms. Students’ parents filled out informed consents (see Appendix S) and completed a demographic survey in English or Spanish (see Appendix R). The researcher used purposeful recruitment to seek female students to provide data to inform the focus of the study regarding the underrepresentation of women in STEM courses, majors, and careers. The Back to School Boutique recruitment resulted in 15 girls and 8 boys for a total of 23 students that provided a 2:1 ratio of girls to boys thus fulfilling the intended purposeful recruitment.

Methods

The intervention addressed the unmet need of advanced programming courses in an underserved population of coed students in fourth through seventh grades in an after-school program in the Northeast United States. The course provided male and female students with an opportunity to learn MIT App Inventor in a self-paced scalable, open online course, before convening at a 1-day Hack-A-Thon to develop an authentic STEM mobile application in a team event. This intervention sought to understand better gender-based attitudes in STEM environments.

The research design was a convergent, mixed method approach that included the purposeful recruitment of females in a sample of students without employing a randomized experimental or nonrandomized, quasi-experimental control group. The sample size of 17 consisted of 10 girls and seven boys who participated in the program and fulfilled the purposeful recruitment of females to examine their attitudes in STEM environments. During the Android Inventor Intervention, all 17 participants in the sample received the treatment of up to 28 small-skill, worked-example videos. Fourteen of the 17 students participated in the culminating, 1-day team Hack-A-Thon event.

Quantitative measures included an S-STEM (Unfried, Faber, Stanhope, & Wiebe, 2015) pre and post survey that queried student attitudes toward each subject area of the STEM acronym, as well as viewpoints regarding 21st century skills and future career aspirations (see Appendix AA). The research included a parent survey (see Appendix R) at the beginning of the intervention. The program awarded up to 28 consecutively numbered digital badges that served to quantify students' progress through the intervention.

Qualitative measures included student interviews and a focus group after the Hack-A-Thon. The researcher and STEM intern conducted member checking to clarify students' viewpoints recorded during the focus group/interview process. The convergent mixed methods approach prioritizes the quantitative and qualitative data equally, analyzes findings separately, and then combines the data into one database to triangulate and enrich analysis.

Results - Students' Interest and Persistence in Advanced Programming Electives

Based on the data, the findings indicated that gender *did* influence persistence in students' attitudes toward increasingly advanced programming electives. Achievement of digital badges indicated that boys persisted at a 54% completion rate of small-skill videos to the girls' 36% (see Table 8). The researcher looked for Likert scores of 4 = *agree* or 5 = *strongly agree* in the post-STEM survey regarding math. After exposure to a math-intensive, advanced programming course, only one of 10 females indicated 4 = *agree* with her math abilities (see Table 10), with four females showing a change in math attitudes pre-to post intervention (see Table 11). Three of seven boys indicated agreement with math abilities, while four males remained in the neither agree nor disagree category (see Table 10).

The researcher looked for Likert scores of 4 = *agree* or 5 = *strongly agree* in the post-S-STEM survey regarding engineering and technology (ET). Regarding post intervention post intervention ET Likert scores, six females revealed a change in ET attitudes after participating in an advanced programming experience (see Table 14). All males remained in a neither *agree* nor *disagree* range or in agreement of ET abilities with one male scoring a 5 = *strongly agree* (see Table 13).

Results - Students' Sense of Belonging in STEM Environments

Based on the data, the findings indicated that students based their perceptions of belonging in a STEM environment on the Android Inventor and Hack-A-Thon events. The participants had no prior knowledge of the STEM acronym. Overall, STEM attitudes for both genders remain in the neutral, 3 = *neither agree nor disagree* range that reflected the lack of prior knowledge of advanced programming attitudes. The interview data indicated that students enjoyed the Android Inventor program with the opportunity to collaborate in the Hack-A-Thon event. Keywords of "amazing," "cool," and "fun" reflected participants' first exposure to an advanced programming course. Most students requested more opportunities to join future programming courses at ASP.

Results – Applicable Math

Based on the data, the findings indicated that the Android Inventor Intervention and Hack-A-Thon were students' introductory experiences to a real-world, applicable math example to produce a game application on a mobile device. Students' attitudes toward math reflected a school system that used well-structured problems with one right answer, rather than ill-defined problems that students must apply math skills to arrive at solutions. Taking the results of the math section of the post-S-STEM survey into consideration, nine females were neutral in the 3 = *neither agree nor disagree* range of math abilities (see Table 10). Of the 7 boys, 3 were neutral in math abilities with a 3 = *neither agree nor disagree* response. The remaining 4 boys indicated a 4 = *agree* in math abilities in the Post-S-STEM survey (see Table 10).

Taking the boys' post intervention math results (see Table 10) plus males' persistence in achieving increasingly advanced programming levels (see Table 8), and the girls' neutrality regarding math, this finding indicated that boys were more willing to take on math challenges.

Interview data indicated that participants struggled with math homework in the presence of the researcher and intern during the homework sessions of the Android Inventor program. The one exception was Inventor 17, a female who completed homework without asking for help and progressed seamlessly to the programming sessions each day of the study. When asked about future careers, only 2 of the 10 girls and 2 of the 7 boys indicated future STEM careers. Lack of interest in agentic careers aligned with the participants' lack of knowledge of the STEM acronym. Apart from a brief explanation of each career in the S-STEM survey, this survey might be their first exposure to information regarding STEM careers in the workforce. Only one student, a fourth-grade female, indicated that she knew about STEM because it was mentioned in the survey.

Study Conclusions

This study examined the problem of the underrepresentation of women in STEM courses, majors, and careers to improve enrollment of females in programming classes through an opportunity to participate in an advanced course offering at an after-school program in a poverty demographic. Three research questions guided the examination of gender influences on increasingly advanced programming course offerings, the sense of belonging in STEM environments, and a willingness to apply math in real-world applications. The following sections summarize conclusions by research question.

Students' Interests and Persistence in Advanced Programming Electives Conclusion

Based on the data, the findings indicated that gender *did* influence persistence in students' attitudes toward increasingly advanced programming electives. Males exhibited a 54% achievement of digital badges that reflected increasingly difficult math concepts to females 36%. One of 10 females (10%) revealed positive attitudes toward her math abilities post intervention, while 42% of males expressed math confidence. Males expressed positive attitudes in engineering and technology (ET), while females initially expressed confidence in ET pre-intervention, but 60% recorded a change in ET attitudes post intervention.

Students' Sense of Belonging in STEM Environments Conclusion

Based on the data, the findings indicated that students did not have prior knowledge of the STEM acronym. They did not possess a preconceived notion of attitudes regarding STEM environments or established gender roles. Overall, STEM attitudes for both genders remain in the neutral, 3 = *neither agree nor disagree* range that reflected the lack of prior knowledge of the acronym as an integrated field of study. Students either indicated that STEM was a part of a plant or they did not know the answer. One female student offered an accurate description of the component subjects but reported that she learned of the meaning of STEM during the pre-survey.

The post intervention STEMAttitudes variable that was an average of students' MeanMath, MeanScience, MeanET, and Mean21st variables (see Table 6) reflected participants' interview responses regarding no prior knowledge of STEM, with 13 of the 17 students reporting in the neutral, 3 = *neither agree nor disagree*, range.

Applicable Math Conclusion

Based on the data, the findings indicated that boys were more willing to apply math in real-world contexts. The SOOC and Hack-A-Thon were students' introductory experiences to a real-world, applicable math example to produce a game application on a mobile device. Both genders reported positive attitudes in interview discussions regarding enjoyment of both the SOOC and Hack-A-Thon. Most students made a request for more programs, such as Android Inventor. Post intervention survey data indicated that females were neutral in their attitudes today math abilities, whereas 57% of the boys reported positive attitudes toward math. All male participants indicated positive attitudes toward agentic, math-intensive careers during the post intervention survey. Half of the 10 girls revealed interest in agentic careers with one responding 4 = *very interested*.

Future Research

Future research regarding the underrepresentation of STEM course, majors, and careers could examine the medium-term outcomes of the logic model (see Appendix I) through reenrollment of students in future course offerings at ASP. The same S-STEM survey (Unfried et al., 2015) could show a shift in students' overall attitudes toward STEM. Regarding distal, long-term outcomes, the researcher could interview the participants to determine if the students enrolled in STEM high school courses.

Chapter 1: Understanding the Problem of Practice

The role of women in the workforce has fluctuated based on social expectations. The U.S. Census Bureau (1907) reported that 20.6% of women were the primary wage earner of their families. However, White women who reached a marriageable age often set aside work to take care of home and family, thus relinquishing their economic support to their husbands (U.S. Census Bureau, 1907). According to the U.S. Census Bureau (1907), the percentage of female Black and European immigrant primary wage earners remained constant through the rest of their lives, regardless of marital statuses.

Women's work mirrors birth patterns and subsequent increases or decreases in the population entering employment. Toossi (2002) indicated a birth dearth in the 1920s and 1930s, which resulted in 1 million fewer individuals entering the workforce in the 1950s and 1960s; however, 51.0% of the 1950s to 1960s workforce were women. The "baby boom," lasting from 1946 through 1964, provided nearly 17 million people entering the workforce from 1960 through 1980. Women represented 52.8% of the workforce in 1960 through 1980. A "baby bust" in the late 1970s resulted in a "baby-boom echo," which continued until the early 1990s, providing 52.0% of the civilian workforce (Toossi, 2002).

Female Employment

The most common female employment roles listed in the 1900 U.S. Census included servant, waitress, teacher, nurse/midwife, and textile worker (U.S. Census Bureau, 1907). Similar primary female wage occupations remain listed 108 years later in the 2015 U.S. Census, with servant transitioning to sales agents (U.S. Census Bureau, 2015). The jobs occupied by 80% or more female workers were at the lower end of the wage-earning spectrum, while jobs held by 80% or more male workers were higher-paying technology roles (U.S. Census Bureau, 2015).

Researchers of the United Nations Entity for Gender Equality and the Empowerment of Women defined women's empowerment as the opportunity for women to participate fully in all levels of economic life and activities (Hawk, Mills, Wynhoven, & Gula, 2011). U.S. women are not paid the same as their male counterparts doing the same job (National Women's Law Center, 2016). Legislators have mandated equal pay with the Equal Pay Act of 1963 (U.S. Department of Labor, 2016) and the Lilly Ledbetter Fair Pay Act of 2009 (U.S. Equal Employment Opportunity Commission, 2013). A Bureau of Labor Statistics (2016) report provided median statistics that did not account for job characteristics, such as skills, responsibilities, or experiences, but these were representative of the difference in income. The Bureau of Labor Statistics showed that White women still earned only $0.82 for every $1.00 of a White male's median wage. Black and Asian women were paid $0.69 and $0.95, respectively, whereas Hispanic women only garnered $0.61 to every White male dollar.

In 2015, one of every eight women in the United States lived at the poverty level, and four million of these women were single parents (Proctor, Semega, & Kollar, 2016). Closing the wage gap for all women in the United States would allow women to purchase 1.5 more years of food, 15 additional months of child care, 7 more months of mortgage payments, or 11 months of rental housing (National Partnership for Women and Families, 2017).

The average wage percentage for women in STEM careers lags behind the average male compensation (U.S. Census Bureau, 2015). Half of all college-educated individuals in the United States workforce are women, but they occupy only approximately 29% of engineering and science jobs (National Girls Collaborative Project, 2016). The lack of female role models in those jobs may result in fewer women choosing courses, majors, and subsequent STEM careers (Fuesting & Diekman, 2017; Herrmann et al., 2016). In the next sections, the researcher attempts to address how the differences between men and women are not always accounted for in today's design manufacturing.

Health Industry

The U.S. National Institutes of Health released new guidelines for preclinical research. Before 2015, scientific research did not consider sex as a biological research variable. Thus, researchers used male test animals, which often led to erroneous results and undermined the applicability to human subjects in clinical trials (Miller et al., 2017).

This preference for males also influenced research and product development. Scientists have developed artificial heart devices since 1969, but these devices remain more compatible with a larger male's thoracic cavity (Carpentier et al., 2015), while heart disease is the leading cause of death of women in the United States (Centers for Disease Control and Prevention, 2014). Female biomedical engineers could influence the design of devices to be compatible with female physiology early in the stages of development. The influence of female leaders in the health industry may be seen through the work of Elizabeth Dole, director of the Red Cross, who made significant safeguards to maintain blood supplies by standardizing the testing and storing of donor blood to prevent the spread of AIDS (Frantz, 1996).

Global Climate Change

Residential and office buildings account for approximately 30% of the total emissions of carbon dioxide into the atmosphere (Kingma & vanMarken, 2015). Greenhouse gasses contain 81% carbon dioxide, which adversely contributes to global climate change (U.S. Environmental Protection Agency, 2014). Office temperature settings default to standards developed in the 1960s for male metabolic rates of comfort; developers of these standards do not consider that women have a 35% difference in air conditioning needs than men (Kingma & vanMarken, 2015).

Female environmental design and engineering professionals could advocate for indoor climate measures that meet all workers' needs, while decreasing emissions that harm the environment. For example, Zandile Gumede, the first female mayor of Durban South Africa, ran a platform of finding solutions to the problem of women being more vulnerable to extreme weather because they perform more of the daily chores of collecting water and food (Tugend, 2017). Women become vulnerable in countries with scarce arable land, such as Uganda, where parents marry off their daughters in "famine marriages" to obtain dowries, so remaining family members can survive (Mutunga & Hardee, 2010).

Safety in the Automotive Industry

The design of automotive seatbelts protects the physical size of the average male driver (Bose, Segui-Gomez, & Crandall, 2011). A female driver who experiences an accident while being properly belted into the driver's seat is 47% more prone to serious injuries compared to a man (Bose et al., 2011). Female automotive engineers may bring a unique perspective to the design of cars for all occupants; for example, the first female scientist hired by General Electric, Katharine Blodgett, contributed to the safety of automobiles by inventing the nonreflective glass for drivers to see clearly through car windshields (Whelen & Reilly, 2014).

New Career Paths

A woman's career path can exhibit nonlinear patterns necessitated by opting in and out of work outside of the home due to raising children (Zimmerman & Clark, 2016). The National Institutes of Health (2016) initiated research grants to fund reentry into the biomedical and behavioral careers for all individuals who opted out of their careers to raise their families or take care of their parents. Blickenstaff (2005) used the metaphor of "a leaky pipeline" to describe females on a STEM trajectory transitioning through high school, college, and career who chose to switch out of STEM fields. Women who could serve as role models to rising students of science could now "plug the leak" in the STEM pipeline (Ceci et al., 2014), and research in science fields could benefit from the expertise of women returning to the workplace.

Problem of Practice

Women exhibit a sustained underrepresentation in college majors, advanced degrees, and professional practices in computer science, engineering, and math-intensive science fields (Ceci et al., 2014). Females have made some gains to reach parity in certain STEM fields, such as life and social sciences (Beyer, 2014). However, computer science, engineering, and physics remain male-dominated fields (Cheryan, Ziegler, Montoya, & Jiang, 2017). The National Center for Science and Engineering Statistics (2012) accumulated statistics of intended college majors of incoming freshmen by STEM field, race, ethnicity, and gender from 1995 through 2010. These data indicated that the percentage of males planning STEM majors and careers outnumbered the percentage of females in every category, regardless of race or ethnicity.

In 2015, women held one in four jobs in technology (National Center for Women & Information Technology, 2016). Females tend to avoid upper-level math and science courses in high school that provide the foundational knowledge to sustain STEM course work in college (Nugent et al., 2015; Riegle-Crumb et al., 2012; Spitzer & Aronson, 2015; Wang, 2013). The trend of bypassing math electives is evident in the empirical research spanning 3 decades (Berryman, 1983; Ellis et al., 2016).

Communal STEM careers, typically pursued by females, include opportunities to work with and help others (Diekman, Steinberg, Brown, Belanger, & Clark, 2016). Adolescent females continue to select communal STEM courses in the northeastern United States (New York and New Jersey) context. Through this study, the researcher aimed to improve the understanding of female underrepresentation in STEM courses and majors to determine whether females' underlying perceptions of communal versus agentic careers contributed to the avoidance of more rigorous coursework.

Theoretical Framework

The Ecological Systems Theory

The ecological systems theory (EST) provided an overarching structure for the review of literature regarding the underrepresentation of women in STEM courses, majors, and careers (see Bronfenbrenner & Morris, 2006). The five interacting levels of EST include the microsystem, mesosystem, exosystem, macrosystem, and chronosystem (Bronfenbrenner, 1977; Bronfenbrenner & Morris, 2006). The microsystems encompass a girl's immediate environment, emanating from multiple settings, which form a mesosystem together (Bronfenbrenner & Morris, 2006). The microsystems provide proximal processes, which Bronfenbrenner and Morris (2006) regarded as crucial to human development. The mesosystem includes the microsystem factors of family (Short-Meyerson, Sandrin, & Edwards, 2016), peers (Liben, 2016), school (Bruce-Davis et al., 2014), and teachers (Rice & Alfred, 2014). Bronfenbrenner (1977) described exosystems as extensions of the mesosystems. At the exosystem level, opportunities to learn in school and education policies include the possibilities and capacities for action in a female's environment (Gee, 2008). The macrosystem's factors of a female's career goals are concrete manifestations of the interacting levels of the microsystem, mesosystem, and exosystem (Bronfenbrenner & Morris, 2006). The chronosystem level signifies the passage of time when a girl navigates through her microsystem environments to reach her goals at the exosystem and macrosystem levels (Neal & Neal, 2013).

Model of Achievement-Related Choices

The Eccles (1994) MARC was an applicable framework for the analysis of the underrepresentation of females in STEM. The most important MARC concept in this framework centered on Eccles's (2011) rephrasing of the question, "Why aren't women more like men?" to the question, "Why do women and men make choices they do?" (p. 196). Individuals make numerous choices every day; according to Eccles (1994), one's expectations for success and perceptions of the value of available options influence those decisions. Rather than focusing on male agentic versus female communal stereotypes (Eagly, 2013), MARC considers the complex underlying factors that shape an individual's choices. Males and females perceive tasks based on personal achievement beliefs (Eccles, 1994). In the literature synthesis section, the researcher elaborates on the MARC belief systems of causal attributions (Sekaquaptewa, 2011), parental input (Gunderson, Ramirez, Levine, & Beilock, 2012), teachers (Beilock, Gunderson, Ramirez, & Levine, 2010), peers and gender role beliefs (Grunspan et al., 2016), self-perceptions (Eccles & Wang, 2016), and self-concepts (Sax, Kanny, Riggers-Piehl, Whang, & Paulson, 2015). Individuals interpret their perceptions of available task options based on their personal achievement beliefs (Eccles, 2011).

Synthesis of Literature

To understand fully how the theoretical frameworks of EST and MARC provide the structure for this literature review, the researcher first discusses the broadest topic of STEM itself. At the acronym level, STEM is science, technology, engineering, and math. Coined in 2001 by Judith Ramaley, the education director of the National Science Foundation, STEM has become a focal point for educational policies (Breiner, Harkness, Johnson, & Koehler, 2012).

The National Commission on Excellence in Education published a report 18 years before the STEM acronym was coined (Gardner, 1983). The U.S. Department of Education tasked the resulting committee to measure the quality of high-school education in the United States in comparison to other countries (Stedman, 1983). The commission's findings showed the state of U.S. high school education as mediocre, without a central purpose, lacking in rigor, and placing the United States at risk of losing its position as a competitor in the world economy (Gardner, 1983).

The American Association for the Advancement of Science established Project 2061 in 1985 and published *Science for all Americans* in 1989 (Rutherford & Ahlgren, 1989). Leaders of the association determined benchmarks for implementing Project 2061 directives in 1993 (Roseman, 1997). However, leaders made changes to the educational system based on the Project 2061 benchmarks, but they failed to consistently implement these guidelines (Breiner et al., 2012).

Due to U.S. legislation, such as No Child Left Behind (2002), administrators have instituted standardized testing as the norm to evaluate the effectiveness of individual school district curricula, teaching, and student achievement (Mulvenon, Stegman, & Ritter, 2005). Differential item functioning, a measure of test question bias on standardized tests (Osterlind, Everson, & Osterlind, 2009), favors male math test takers and decreases the likelihood of female achievement (Albano & Rodriguez, 2013). Instructors frequently deemphasize science to concentrate on improving students' scores in reading and math (Dejarnette, 2016; Scogin, Kruger, Jekkals, & Steinfeldt, 2017). The EST macrosystem contains the ideologies of institutions (Bronfenbrenner, 1977), such as government laws, school district mandates regarding standardized tests, and curriculum decisions made by school administrators (Breiner et al., 2012).

The MARC concepts of beliefs and choices are not yet within the reach or control of the female student regarding standardized testing. Even if a microsystem parent chooses to opt out of standardized testing, the daughter has no choice within an established reading and math curriculum centered on test preparation (Mitra, Mann, & Hlavacik, 2016). Two microsystems within a girl's mesosystem are her family and teachers (Bronfenbrenner, 1977). Parents can opt out of standardized testing if they perceive that their daughter faces test anxiety; however, opting out eliminates an indicative math assessment that teachers can use to improve math outcomes (Mulvenon et al., 2005). The EST microsystem includes teachers who face poor standardized test performance that impacts tenure (Thibodeaux, Labat, Lee, & Labat, 2015). High-stakes tests take away time from teaching STEM subjects in favor of test preparation of math and language arts (Dejarnette, 2016).

The EST indicates an overarching construct called the chronosystem of time that influences changes and continuities in a person's collective environments (Neal & Neal, 2013). Over 3 decades have elapsed since the publication of *A Nation at Risk* (Gardner, 1983). Additionally, STEM subjects have been influenced by an EST exosystem of government laws, school district directives, and administrative curriculum decisions that have limited students' STEM-related opportunities (Ramaley, 2004).

Stereotype Threat

Researchers have consistently cited men regarding women in STEM as a stereotype threat (Barth, Guadagno, Rice, Eno, & Minney, 2015; Brown & Leaper, 2010; Cheryan et al., 2017; Liben, 2016; Sekaquaptewa, 2011). This pervasive, EST macrosystem, MARC cultural norm depicts males as being better at math and science compared to females (Albano & Rodriguez, 2013; Danaher & Crandall, 2008; Enderson & Ritz, 2016). Females can accept this gender stereotype as early as 6-years-old (Bian, Leslie, & Cimpian, 2017; Eccles, 1994). The stereotype of males as being better at math and science is pervasive through college (Grunspan et al., 2016) and career trajectories (Blickenstaff, 2005; Deemer, Thoman, Chase, & Smith, 2014; Eccles, 2011; Steele, 1997). The EST peer microsystem can either be subtractive (Brickhouse, Lowery, & Schultz, 2000) or collaborative (Bruce-Davis et al., 2014; Hall & Miro, 2016; Wallace & Webb, 2016). An additional layer of stereotype threat is present when a female student's family is at a lower-income or poverty level (Tine & Gotlieb, 2013).

Researchers have described the impact of stereotype threat with the term *leaky pipeline* (Barth et al., 2015; Falk, Rottinghaus, Casanova, Borgen, & Betz, 2016; Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013; Rincon & George-Jackson, 2016). A leaky pipeline refers to females who attempt STEM majors or careers but later opt out of the field. A STEM attrition study indicated that over half of students of both genders who declared a STEM major as a freshman did not graduate with a STEM degree (Chen, 2013).

Researchers use the term *chilly climate* regarding women in STEM who perceive MARC causal attributions in the form of prejudices, input of socializers, and gender role beliefs concerning belonging in STEM fields (Marra, Rodgers, Shen, & Bogue, 2012; Walton, Logel, Peach, Spencer, & Zanna, 2015). Even before a young female student can make choices about courses and careers, the EST exosystem contains an established work environment (Bronfenbrenner, 1977). This environment is not welcoming to a woman seeking a place in STEM.

STEM Careers

Chen (2013) cited a wealth of research existed in the literature regarding women and STEM careers. Students' interests in science and engineering fields can begin in middle school

(Guzey, Moore, Harwell, & Moreno, 2016; Knezek, Christensen, Tyler-Wood, & Gibson, 2015). Researchers have been consistent in highlighting girls' interests in science and math at the third- through eighth-grade levels, but most have concluded that school administrators do not foster or sustain this preference (Berryman, 1983; Nugent et al., 2015). The crucial skills that prepare students for STEM careers include the ability to think critically and solve new problems (Sondergeld, Johnson, & Walten, 2016); however, there is a dichotomy between the way students apply knowledge in schools and the way one uses knowledge with events and objects in the workplace (Resnick, 1987). Fostering science identity in girls reveals that skills can be constructed to bridge the transitions from the EST microsystem of a school where the formation of MARC task perceptions takes place to successful careers in the EST exosystem of the workplace (Brickhouse et al., 2000).

Females considering STEM careers are more likely to choose fields that are communal, with better family work-life balance, while males are more interested in agentic, rigorous fields with greater advancement potential (Ceci et al., 2014; Diekman & Eagly, 2000; Eagly, 2013; Speer, 2017). Even when presented with available family friendly occupations, women consistently choose communal careers with work-life balance over agentic family-friendly careers (Barth et al., 2015). Female students considering STEM careers view masculine stereotypes as chilly climates of male dominated EST exosystem fields, such as engineering as deterrents (Eccles, 2011; Walton et al., 2015). Females who do enter college as an engineering major may drop out due to poor teaching, demanding curricula, or a sense of not belonging in the field (Marra et al., 2012). Iskander, Gore, Furse, and Bergerson (2013) identified a lack of advanced math electives to sustain STEM course work as one reason females did not persist in these degrees (Blickenstaff, 2005).

Females who do achieve an engineering degree are prone to drop out of their STEM careers for a variety of reasons, including the persistence of chilly, male-dominated environments (Buse, Bilimoria, & Perelli, 2013). Women have exhibited a kaleidoscope model of opting in and opting out of careers (Stephens & Levine, 2011), depending on their present family obligations to achieve a better work-life balance (Zimmerman & Clark, 2016). Women regard STEM careers and advancement as achievable but not necessarily as desirable (Gino, Wilmuth, & Brooks, 2015). The researcher explores this viewpoint further in relation to the literature regarding family and maternal roles.

The Family and Maternal Roles

Female students consider STEM fields within the EST microsystems of family, peers, school, teachers, MARC self-concept, and self-perceptions of their present environments. Mothers may not believe that their daughters can succeed in a career that is math-related, which influences female students' personal beliefs associated with achievement (Cheryan et al., 2017; Diekman et al., 2016; Eccles, 1994). Parents may discourage their daughters from taking harder courses compared to their sons (Tenenbaum, 2009), and they may often praise boys' problem-solving skills in math and science more than they do girls' achievements (Gunderson et al., 2012; Short-Meyerson et al., 2016). However, mothers can be influential in encouraging their daughters to pursue STEM careers (Bahar & Adiguzel, 2016; Kayumova et al., 2015).

Females' self-concept can impact their performances in their schools and future career choices (Adelman et al., 2016). Expectations of a future role as a mother with a family can influence their future self-perceptions (Barth et al., 2015; Eccles & Wang, 2016; Lips, 1992). Females adopt a kaleidoscope career path of opting in and opting out of full time employment to work around having children (Zimmerman & Clark, 2016).

The National Institute of Health (2016) developed grants to encourage women in STEM careers to return to the workforce after an opt-out phase. The U.S. House of Representatives Committee on Science, Space, and Technology analyzed the way that gender was reported in grant applications to make the playing field more equitable to women returning to the workforce (Johnson, DeLauro, & Slaughter, 2015).

Consistent with the U.S. Census Bureau (1907) data that the researcher discussed in the introduction, Black women were still more likely than White women to continue with full-time employment after having children and to seek out childcare options among family and friends (see Dow, 2016). Fathers who seek to act as equal partners in their children's childcare needs also experience similar stereotype threats when they seek communal rather than agentic careers (Croft, Schmader, & Block, 2015). As female students look to the future for potential EST exosystem careers versus the microsystem of their family obligations, role models play an important part in their MARC beliefs for success and perceptions of options.

Role Models

One factor perpetuating the underrepresentation of women in STEM courses, majors, and careers is a lack of female STEM role models (Beyer, 2014; Diekman et al., 2016; Farland-Smith, 2012). The observation of successful women in STEM careers can increase female students' MARC self-perception in a future STEM field (Stout, Dasgupta, Hunsinger, & McManus, 2011; van Langen, 2015). Female role models in STEM careers can connect the communal goals preferred by women to facets of science, technology, engineering, and math (Fuesting & Diekman, 2017). Female workplace mentors improve female retention in engineering and technology fields, especially among Black women (Rice & Alfred, 2014). Women in STEM college courses who receive encouragement from a female role model can get past initial feelings of not belonging or doubt about their abilities in math and science (Ceci et al., 2014; Herrmann et al., 2016).

STEM subject teachers can serve as role models; provide high-quality, project-based instruction; and contribute to students' decisions to continue in STEM coursework (Bahar & Adiguzel, 2016). Female students are less likely to sustain computer programming electives when they have taken a course with a male teacher (Beyer, 2014; Cheryan et al., 2017). Continued programming courses will expose female students to computational thinking, which is a skill used in tandem with mathematics and is needed to succeed in all STEM fields (Peters-Burton, Cleary, & Kitsantas, 2015). The maternal role model is a girl's most proximal EST microsystem, and a working mother can elicit a sense of pride among daughters (Motro & Vanneman, 2015). Female students' MARC experiences, aptitudes, and beliefs associated with achievement also relate to the factors of math anxiety, course selection, and subject teachers.

Math Anxiety, Course Selection, and Subject Teachers

The literature is prevalent with the notion that males are better at math compared to females (Bian et al., 2017; Danaher & Crandall, 2008; Gunderson et al., 2012; Halpern & LaMay, 2000). Math anxiety can affect working memory (Ramirez, Gunderson, Levine, & Beilock, 2013) and was often cited as a barrier to females sustaining STEM coursework in engineering majors (Ellis et al., 2016; Gilbert, O'Brien, Garcia, & Marx, 2015). Female students are less likely to take the advanced placement mathematics courses needed to participate in more rigorous STEM fields (Beekman & Ober, 2015; Cheryan et al., 2017; Enderson & Ritz, 2016). Wang (2013) indicated that math electives in the 12th grade were particularly important to the sustainment of STEM college majors.

Teachers play a pivotal role in preparing students for STEM related fields, yet female teachers' math anxiety and doubt about their abilities can transmit to students and impact outcomes (Beilock et al., 2010; Marx, Monroe, Cole, & Gilbert, 2013). According to the National Science Foundation (2017), male faculty outnumber female teachers in all U.S. STEM course offerings. When female math faculty exhibit confidence, they provide positive representation to foster female students' success (Keiser, Wilkins, Meier, & Holland, 2002).

The MARC belief of aptitude can influence female students' achievement in STEM (Sax et al., 2015). Lack of confidence in math abilities is particularly strong among Latina girls (Brown & Leaper, 2010). At the microsystem level, teachers can modify their teaching practices by revising their math assessment questions to reduce cognitive load and improve student outcomes (Gillmor, Poggio, & Embretson, 2015). Teachers who are in tune with the gender differences in problem-solving can make modifications to improve female outcomes (Che, Wiegert, & Threlkeld, 2012).

The EST microsystem of peers reveals that males have a higher regard for their math and science MARC aptitudes compared to their female classmates (Sikora & Pokropek, 2012). The EST microsystem of peer influences is the focus of the next factor in the underrepresentation of females in STEM courses, majors, and careers.

Peer Influences

Classmates of both genders regard males as having higher MARC aptitudes for math and science (Grunspan et al., 2016). The gender bias of boys being better than girls in STEM subjects is a central theme in international literature (Sikora & Pokropek, 2012). MARC gender role beliefs are strong, and children apply gender roles in peer groups (Liben, 2016). One's sense of belonging to a social group, such as a STEM classroom, can impact one's achievement in that environment (Spitzer & Aronson, 2015). Teachers in the EST school microsystem can institute changes by introducing gender-balanced project-based learning (Wallace & Webb, 2016). The gender-balanced team aligns with the EST workplace exosystem (Resnick, 1987); such a team can provide students with the necessary skills to complete college courses that employ STEM collaborative methods (Hall & Miro, 2016).

The EST school microsystem is improved by school district exosystems that establish STEM-focused high schools, which embrace project-based learning with peer and faculty collaboration (Bruce-Davis et al., 2014; Ejiwale, 2014; Hall & Miro, 2016). In a project-based microsystem classroom, teachers and peers form cognitive apprenticeships (Collins, Brown, & Newman, 1989). Vygotsky (1978) defined the ZPD as the distance between what a student already knows and what she could achieve when collaborating with her peers.

Vygotsky (1978) emphasized the social aspect of learning. Gee (2008) utilized the social aspects of learning that Vygotsky (1978) posited to situate an individual's learning and knowledge in a relationship with the person's environment. According to Gee (2008), one’s environment contains affordances, which are defined as one’s perception of the feasibility of acting on something in the environment (Gee, 2008; Greeno, 1994). An effectivity is something contained in an environment that can be acted on (Gee, 2008). The next factor that the researcher examines is the pairing of affordances and effectivities (Gee, 2008), which comprise the opportunity to learn.

Affordances and Effectivities

Gee (2008) posited that students resisted learning due to perceived threats to their self-perception. Stereotype threat, gender bias, family attitudes, peer perceptions, and math anxiety have already been synthesized as potential threats to self-perception. If a female student can establish a sense of belonging in STEM and overcome these threats, then she can act on this opportunity to learn (Wilson et al., 2015). Family, teachers, and peers can assist female STEM students in pairing the affordance of rigorous course offerings and the effectiveness of acting upon sustaining their studies (Oliver et al., 2017).

Bandura (1977) assigned a central role to self-efficacy in overcoming fears and change behavior. Females must take advantage of STEM opportunities afforded in middle school to maintain their self-efficacy as they transition to high school (Dare & Roehrig, 2016; Lofgran, Smith, & Whiting, 2015; Yeager et al., 2016). Researchers have shown early exposure to computer science education at the K-12 level can increase the participation of underrepresented populations in subsequent courses (Aguar, Arabnia, Gutierrez, Potter, & Taha, 2016). Researchers have associated strong self-efficacy with improved decision-making regarding career follow-through (Lent, Ireland, Penn, Morris, & Sappington, 2017).

Females report lower confidence levels in STEM courses (Falk et al., 2016; Hutchison, Follman, Sumpter, & Bodner, 2006; Litzler, Samuelson, & Lorah, 2014; Raelin et al., 2014; Robnett, 2016). Confidence levels can be improved by exposing students to role model examples of overcoming difficulties in course work (Lin-Siegler, Ahn, Chen, Fang, & Luna-Lucero, 2016). Dunn and Lo (2015) suggested that a focus on learning goals could improve students' self-efficacy. Female students' goals have not been matched to the pursuit of careers in computer programming (Beyer, 2014). Thus, the focus of this study was the significant underrepresentation of women in the computer programming field.

Summary

A negative image of a computer scientist as male, unsociable, isolated, nerdy, and intensely smart has permeated information technology careers. This image may dissuade women from feeling that they belong in this field (Aguar et al., 2016; Beyer, 2014; van Tuijl & van der Molen, 2016). Early exposure to computer science classes can dispel the notion that information technology is just for boys (Master, Cheryan, & Meltzoff, 2016). School environments can be modified to provide settings where technology is less oriented to masculine, equipment-filled computer rooms to classrooms that exude a creative environment that is more welcoming to women (Master et al., 2016). Doube and Lang (2012) considered courses focused on creative 3D design and multimedia as ways to increase female retention in computer science fields.

In 2001, Judith Ramaley coined the term STEM as an integration of disciplines to foster the success of students representing the United States in the global economy (Breiner et al., 2012). Ramaley (2002) credited knowledge of science and technology as the keys to success in sustaining global competition. Ramaley (2009) posed an imperative to reevaluate undergraduate education to engage and sustain students in STEM courses and careers. The focus of the current needs assessment was the underrepresentation of females in high school STEM courses and after-school activities.

Chapter 2: Mixed Methods Needs Assessment

The context of STEM practices were described using a Venn diagram (see Appendix A). At the time of this study, HSI was a Hispanic Serving Institution in the northeast. This college served a socioeconomic demographic of low- to middle-income students in seventh through 12th grades. Students attending the coding and robotics program were primarily male, Black, or Hispanic from the Yonkers, NY school district. ASP was an after-school program in Paterson, NJ that served women and their children. Coding and robotics were taught during the after-school program to fourth through 12th grade students. All elementary and middle school children built and programmed WeDo and Lego robots. High school students were invited to join a FIRST Robotics team. A predominantly male Orbiters robotics team built and programmed Tetrix robots for competition. Team Artemis (XPRIZE, 2015), an all-girls high school robotics team, placed in the top 30 of the 2015 Google MOONBOTS competition. The Artemis alumni of this middle to high socioeconomic demographic were high school and college girls who continued to serve as teachers' assistants at HSI and ASP. The college girls returned to these programs after coming home from their engineering or economics studies to stay connected throughout the year.

The observed problem centered on the prevalence of males in the coding and robotics programs at HSI and ASP. The recent HSI programs had male to female ratios of 9:3, 10:4, 12:1, and 11:4. At the time of this study, the ASP robotics team had a male to female ratio of 5:2. Team Artemis alumni were deeply interested in STEM and plan programming and engineering majors in college. The Google MOONBOTS alumni, who were in college at the time of this study, all participated in interviews during this needs assessment. Two of the four college girls already left their STEM computer programming majors—one for manufacturing engineering and the other for economics. The next section is a summary of results containing these students' reasons for departure from programming majors.

The researcher designed this needs assessment to discover and confirm the factors identified in the body of literature regarding the persistence of a higher ratio of males to females in technology courses and after-school activity offerings. Through the needs assessment, the researcher intended to illuminate factors revealed by college students with perspectives on high school preparation and STEM college course offerings.

Systems Approach

The overarching theoretical frameworks that the researcher selected to support the problem of practice included Bronfenbrenner's (1977) ecological systems theory (EST; Bronfenbrenner & Morris, 2006; Neal & Neal, 2013), Eccles's (1994) model of achievement-related choices (MARC), Vygotsky's (1978) ZPD, and Gee's (2008) opportunity to learn (OTL) that paired affordances and effectivities. The supporting frameworks guided the research questions and resulting analysis of needs assessment data.

The needs assessment research questions (see Table 1) highlighted the focus of the needs assessment. In the subsequent data analysis, the researcher sought to illuminate students' preferences in agentic versus communal career goals (see Eagly, 2013), their perceptions of math anxiety (see Ellis et al., 2016), the influence of subject teachers on course selection (see Keiser et al., 2002), the impact of family on career decisions (see Barth et al., 2015; Eccles & Wang, 2016; Lips, 1992), and students' attitudes regarding computer science (see Beyer, 2014).

Table 1

Needs Assessment Research Questions

Number	Question
NARQ1	How do female students' course selections relate to their future career goals?
NARQ1.1	What ways do females' math anxiety impact course selection?
NARQ1.2	How are students' perceptions of subject teachers related to their future course selections?
NARQ2	How do girls' mothers' beliefs on traditional careers impact female students' selection of courses?
NARQ3	How do girls' beliefs on future-self as a mother impact their selection of courses?
NARQ4	How is computer programming self-efficacy demonstrated by female students in secondary schools?
NARQ4.1	To what degree do female students feel confident in considering computer science courses?

NARQ1 probed students' course selections and the alignment of those courses to future career goals. During the literature review, the researcher concluded that females' interests in engineering and science fields could begin as early as middle school (Guzey et al., 2016; Knezek et al., 2015). Yet, scholars have revealed that the EST microsystem of school settings do not sustain or foster this interest (Berryman, 1983; Nugent et al., 2015).

NARQ1.1 queried the relationship between gender and students' math anxieties. Stereotype threat is a pervasive, EST macrosystem cultural norm that depicts males as being better at math and science compared to females (Albano & Rodriguez, 2013; Danaher & Crandall, 2008; Enderson & Ritz, 2016). Female students can accept this gender-based stereotype as young as 6-years-old (Bian et al., 2017; Eccles, 1994). The stereotype of males being better at math compared to females may sustain through college (Grunspan et al., 2016) and pervade career settings (Blickenstaff, 2005; Deemer et al., 2014; Eccles, 2011; Steele, 1997).

NARQ1.2 queried the relationship between gender and students' attitudes toward subject teachers. Subject teachers populate an influential EST microsystem in their students' lives.

Employing Vygotsky's (1978) ZPD, teachers who practice project-based learning with collaborating faculty and capable peers can form cognitive apprenticeships to enhance learning (Collins et al., 1989). Female STEM teachers can act as role models to sustain students' interest in these courses and college majors (Bahar & Adiguzel, 2016; Ceci et al., 2014). However, female teachers can transmit their own math anxieties (Beilock et al., 2010) and doubts of their math MARC aptitudes to female students (Marx et al., 2013).

NARQ2 queried the maternal influence on female students' selection of advanced course offerings. The family EST microsystem—particularly the maternal figure—influences daughters' course, major, and career choices (Cheryan et al., 2017). Parents' beliefs that their daughter can succeed in STEM courses influence female students' MARC self-perceptions and subsequent selections of classes and majors (Cheryan et al., 2017; Diekman & Eagly, 2000; Eccles, 1994). Female students tend to bypass advanced placement math courses that will prepare them for rigorous STEM college majors (Beekman & Ober, 2015; Cheryan et al., 2017; Enderson & Ritz, 2016).

NARQ3 probed participants' career preferences and attitudes toward full-time employment. Previous researchers have concluded that women prefer communal careers that offer a better work-life balance, while men seek rigorous, agentic fields with greater advancement opportunities (Ceci et al., 2014; Diekman & Eagly, 2000; Eagly, 2013; Speer, 2017). Even when agentic fields offer family-friendly work environments, women choose communal careers that are helpful and nurturing to people (Barth et al., 2015). Women also adopt a kaleidoscope method of opting out and opting in to careers based on their roles as mothers (Stephens & Levine, 2011; Zimmerman & Clark, 2016).

NARQ4 probed students' enrollment and attitudes toward computer programming. Early exposure to computer science classes can reduce female students' perceptions that information technology is just for boys (Master et al., 2016). Researchers have noted that the EST microsystem school environments can be modified to provide settings where technology is less oriented to masculine, equipment-filled computer rooms to classrooms that exude creative environments more welcoming to women (Master et al., 2016). Courses focused on creative 3D design and multimedia are recommended to increase female retention in computer science fields (Doube & Lang, 2012).

NARQ4.1 sought students' viewpoints toward individuals in computer science fields, as well as participants' sense of belonging in the field of computer science. In 2015, women held only one in four jobs in technology (National Center for Women & Information Technology, 2016). A negative image of a computer scientist as male, unsociable, isolated, nerdy, and smart has permeated information technology careers and dissuaded women from feeling that they belong in this field (Aguar et al., 2016; Beyer, 2014; van Tuijl & van der Molen, 2016).

Participants

Qualitative method participants. The researcher's original intent was to conduct focus groups with a larger number of high school students at ASP, which served families living in poverty. Most of the ASP parents were immigrants or of refugee status. They did not have email addresses to receive and complete informed consents. In the current U.S. political climate, many ASP parents did not leave the house except for work. Jennifer B. (personal communication, April 28, 2017), the executive director of ASP, indicated that in certain districts of ASP, families must return to their homes by 4:00 PM because of the prevalent gang-related gun violence. The all-female interview participants (see Table 2) included three Black, two White, two Hispanic, and one Asian participants. The socioeconomic status (SES) of the families in the group included one girl at the low-, four at the middle-, and one at the high-level SES. Two girls were in high school, and the remainder were in college. Five girls reported that their mothers worked full-time outside the home, and one girl was being raised by her retired grandmother. The researcher used the maternal employment status data to analyze the participants' perceptions of the maternal role.

Table 2

Interviewee Demographics, Grade, Major, and Maternal Employment

Pseudonym	Gender	Race	Ethnicity	SES	Grade	Major	Maternal Employment
C	Female	Black	Hispanic	middle	13	Mechanical Engineering	Full Time
J	Female	White		high	14	Economics	Full Time
M	Female	White		middle	13	Environmental Engineering	Full Time
S	Female	Asian		middle	13	Manufacturing Engineering	Full Time
R	Female	Black		middle	12	Intending Computer Engineering	Full Time
B	Female	Black	Hispanic	low	9	Intending Business or Medical	Raised by Retired Grandmother

Note. Race is self-identified.

Quantitative method participants. The survey yielded seven completions. This college was a Hispanic Serving Institution in the Northeast, and the college website indicated that the per-credit tuition was one of the most affordable in the United States. Students who attended this school either commuted from home or lived in on-campus dorms. The survey participants included six females and one male (see Table 3). The SurveyMonkey software assigned pseudonyms to each participant based on the order of receipt. The sample included four students: One identified as White, two identified as Black, and one chose not to disclose her race.

Table 3

HSI College Survey Participant Demographics

Pseudonym	Gender	Race	Ethnicity	School
Student 7	Female	White		HSI
Student 13	Female	Chose not to share	European	HSI
Student 14	Female	Black		HSI
Student 19	Female	White		HSI
Student 20	Female	White		HSI
Student 21	Male	White		HSI
Student 22	Female	Black		HSI

Method

In the needs assessment, the researcher used a mixed methods approach. The first method was qualitative and consisted of interviews (see Table 4) with a convenience sample of students in the ASP, in ninth through 12th grades, as well as alumni of the Google MOONBOT robotics team in their freshman and sophomore years of college.

Table 4

Needs Assessment Interview Questions

Number	Interview Question
IQ1	Do you have any questions regarding this research process?
IQ2	What courses are you currently taking?
IQ3	How do you feel when you have an upcoming math test?
IQ4	What type of career do you think you would like to work in the future?
IQ5	How are your current courses preparing you for your career goals?
IQ6	Does your school currently offer technology courses?
IQ7	What is your dream curriculum?
IQ8	Are you interested in taking computer programming courses?
IQ9	If you have children someday, is it your belief that both parent partners will take an equal share in caring for the children and working in a full-time career?
IQ10	Additional thoughts?

Measures

Qualitative measures. The interview data variables, descriptions, and values (see Appendix D) correlated to the research questions. Through the process of memo-writing, an important step in grounded theory methodology (Bryant & Charmaz, 2013), a new theme, which the researcher coded as "applicable math," emerged from the memo-writing process.

Quantitative measures. The survey data variables, descriptions, and values (see Appendix E) correlated to the research questions. The researcher did not collect the variables of SES or maternal employment in the qualitative measure. The researcher paired affordances in the form of future jobs choices (Vilorio, 2014) and effectivities in the form of HSI's available classes, which the researcher analyzed together to determine OTL (Gee, 2008). The researcher provided a list of College Board advanced placement courses in the survey to probe participants' interests in advanced electives. The researcher provided questions regarding communal versus agentic careers, which the researcher evaluated according to selection by gender. The researcher assessed maternal role attitudes regarding the kaleidoscope model (see Zimmerman & Clark, 2016) of opting in and opting out of careers.

Data Collection Methods

Qualitative collection method. The purpose of the qualitative portion of the needs assessment was to gain insights regarding emerging themes by engaging in conversations with the girls. The researcher conducted the interviews either at ASP or via phone conversations with Google MOONBOT alumni from March 3, 2017 to April 6, 2017. The researcher asked the interview questions (see Table 4) to probe for information regarding students' current coursework, attitudes toward math and computer science, careers goals, and future maternal role. The researcher performed coding and analysis of Evernote interview notebooks to discover emerging themes. The researcher coded and keyed the data into an Excel spreadsheet for analysis using pie charts and descriptive statistics (see Appendix F).

Quantitative collection method. College students attending HSI received an email in their student email account that contained the link to the survey. Despite two email requests made by the executive sponsor to HSI faculty associates, only seven students completed the survey. The researcher exported the data from the SurveyMonkey website and uploaded it into SPSS for analysis.

Initial Summary of Results

Qualitative results. Participants answered the needs assessment research questions that focused on three central themes: course selection, maternal role, and computer programming self-efficacy (see Table 1). Regarding math anxiety (NARQ1.1) and perceptions of subject teachers (NARQ1.2), all six girls mentioned the term "applicable" concerning their math courses. They complained that the available high school math courses revolved around formulas and solving for X. All girls indicated that they would prefer math courses with real-life applications to make sense of how to apply the math in new situations. The college students remarked that their high school math classes did not prepare them for the rigors of engineering courses. Regarding math anxiety, NARQ1.1 was unrelated to students' preparation for assessments or beliefs in their math abilities.

All participants expressed a range of levels of math anxiety; however, they attributed math anxiety to assessments that lack real-life applicability, which would give them the opportunity to figure out, rather than plug in, a solution. Students B and R remarked that they knew the math before the test, but they became anxious over the potential of a poor grade. Student C remarked that she attended extra tutoring sessions to stay updated with her fast-paced math classes. Student S remarked that female students in her classes appeared to be struggling the most. Students M, S, and C mentioned that college math professors usually spoke with thick accents, which made the classes and coursework much more difficult to comprehend.

The participants reported that calculus-based physic courses were missing from their high school curriculum. In terms of Gee's (2008) OTL affordances and effectivities, the students remarked that they did not have an opportunity to learn the level of math and physics required by their selected majors. Student M recommended that all female students who were accepted into a college as an engineering major should take a summer course in calculus-based physics to prepare for the fast pace of college engineering classes. Several participants reported that they took extra math classes in the summer or visited the on-campus tutoring center for assistance. Student S must repeat the Project Based Calculus 1 course. The students complained of being tracked by high school guidance counselors and not being permitted to take more math electives.

Regarding their mothers' beliefs on traditional careers and course selection (NRQ2), students reported that all of their mothers had full-time jobs, except for B, who was being raised by a retired grandmother who used to work full-time. All participants indicated that they admired their mothers for holding down full-time jobs and raising their families. About their future-selves as mothers (NARQ3), all participants remarked that they wished to maintain a full-time career and planned to have children someday. The participants were in strong agreement that their future partners would share in career and childcare responsibilities.

Regarding computer programming self-efficacy (NARQ4) and computer science courses (NARQ4.1), all college-aged participants remarked that few female students attended their engineering classes. Student C was the only Black engineering student, and Student S was the only female Asian student. Student C remarked that male students could be condescending, especially in workshop settings where they perceived female students as being in their ways. Student S commented that when she offered an answer to a calculation, the male students always checked to ensure she was correct. Students J and S entered college as computer science majors, and both have already switched majors. Both indicated that they could not visualize themselves in computer science careers. The curriculum became harder without providing examples of how the program could be used in the workplace. Student R commented that she planned to declare a computer science major but hoped to study the more creative aspects of technology, such as app design.

Quantitative results. Six female participants and one male participant replied to the online survey (see Appendix B). The small survey sample did not provide sufficient data for the results to be generalizable. The survey results indicated the following qualitative findings:

1. The researcher queried students about their interests in future careers. The analysis of the descriptive statistics concerning students' interests in computer science jobs indicated a low interest in programming and math fields (see Appendix G). The researcher evaluated this statistic in conjunction with the qualitative finding that two students exited a computer science major in their freshman years.
2. The frequency reports on interest in math and science advanced courses indicated that 57.1% of the seven students were very interested in taking a calculus course. This finding was in alignment with the qualitative finding that the female students wanted access to more math and science course offerings.
3. Over half of the students indicated that they were very interested in physics courses. This finding aligned with the qualitative data indicating that girls wanted more science course offerings.

4. The HSI students showed little interest in computer science careers or majors; however, more than half indicated that they were very interested in taking a course in this subject.
5. The HSI students indicated moderate math anxiety on an upcoming math test. This finding corresponded with the students' qualitative feedback regarding upcoming tests.
6. Four of the seven students strongly agreed that both parent partners should share equally in career and childcare. This finding was in alignment with the qualitative interview feedback.
7. One section of the survey queried students' attitudes toward computer self-efficacy. Most respondents agreed that knowledge of computers enhanced one's career opportunities. This finding was echoed by Student J, who indicated that even though she dropped computer science as a major and declared an economics major, the skills that she learned in programming class would help her succeed in any field.
8. Two of the six HSI female survey participants indicated that males were better than females in computer science, revealing a residual cultural bias or stereotype threat toward males as better in computer science. All other participants, including the one male participant, responded that females and males had an equal chance of succeeding in this field.
9. The researcher asked the students to rate their math, science, and computer science teachers. One student indicated that computer science was not offered at HSI. Five students selected the option that computer science was offered, but they were not taking the course. One student selected that their computer science teacher was very

good. J indicated that technology courses outside of computer science majors were easy, such as creative computing and society. S expressed a similar viewpoint—in her computers, technology and trends class, the curriculum covered pioneers of the technology field without mentioning one female leader.

Conclusions and Future Research

The researcher performed the initial needs assessment to answer the research questions that the researcher developed to guide the qualitative and quantitative measures. The findings indicated that students wanted more applicable coursework, which could be used as a tool to analyze new situations. Math anxiety was more related to the lack of applicability of math examples and to students' fear of poor grades, rather than their lack of self-efficacy to succeed in math courses.

The participants reported that STEM subject teachers could be fast-paced. Participants also mentioned teachers would have accents that were difficult to understand, especially in college math. High school teachers instructed according to a curriculum that was not geared to preparing students for the rigorous math and science courses required in the field of engineering.

The participants reported an admiration for the maternal role, especially when their mother sustained a full-time job, while maintaining effective parenting practices. Maternal influence manifested in subtle ways. For instance, Lindiwe Matali of South Africa created Knit2Code that teaches girls programming concepts through knitting, which is taught by grandmothers and mothers, who serve as role models in computational thinking without the use of a computer (Matali, 2018). Future motherhood and partnerships were held on equal ground by both high school and college students. Both groups expected their partners to take an equal share in employment and childcare.

The question regarding computer science and programming self-efficacy yielded surprising results; two college students already dropped technology majors because they could not envision how this field would apply to the future. One high school student was planning a computer engineering major but indicated that she would like to add creative computing aspects to her future career goals. This finding was in line with the findings in the body of literature (Doube & Lang, 2012), indicating an emphasis on the creative aspects of technology to attract more females to the field.

The needs assessment yielded two actionable factors: ineffective teaching strategies and stereotype threat. During the qualitative interview stage of the needs assessment, the students used the phrase "applicable math" regarding STEM classroom settings. This observation referred to both math and computer science classes where subject teachers could not deviate from scripted textbook examples to apply skills to unique problems. The students also shared that there was a chilly climate in STEM classrooms toward women, who were often questioned by male classmates regarding their presence in math and computer science classes. Thoman, Arizaga, Smith, Story, and Soncuya (2014) posited that females were pushed from STEM classes due to a chilly climate, which indicated a balancing pull toward completing their feminine social identities in non-STEM courses that fostered warmer climates, even if this meant changing majors. Two of the students in the needs assessment study shared experiences of changing computer programming majors—one to non-STEM and another to join a friend in a mechanical engineering major.

Chapter 3: Intervention Literature Review

Brief Overview of Actionable Factors

The needs assessment (Mistretta, 2017a) indicated three actionable factors of the problem of practice regarding the underrepresentation of women in STEM courses, majors, and careers. Females exhibit a sustained lack of enrollment in male-dominated, rigorous courses, including computer programming, engineering, and physics (Cheryan et al., 2017). Females have achieved some equity in the social and life science fields; however, these rigorous electives remain under-enrolled by female students (Beyer, 2014; Nugent et al., 2015; Riegle-Crumb et al., 2012; Spitzer & Aronson, 2015; Wang, 2013). The National Science Foundation (2017) reported that White men held 49% of all science and engineering (S&E) occupations, followed by 18% of White women. Asian females achieved only 7% of S&E occupations, followed by 2% of Black women, and 2% of Hispanic women (National Science Foundation, 2017).

The three actionable factors of this study included (a) the unmet need for computer programming course offerings, (b) stereotype threat, and (c) the opportunity to apply math skills in authentic contexts. These three actionable factors also aligned with the existing literature, in which researchers identified these factors as unresolved barriers to women in STEM fields (Mistretta, 2017b). In the next three sections, the researcher delineates the supporting literature for each factor.

Unmet Need for Computer Programming Course Offerings

The first factor to emerge from the needs assessment was the desire of female students to gain access to programming electives. Each student interviewed during the needs assessment indicated that they wanted to take more computer courses, but their school administration did not offer classes in the curriculum. Specifically, students mentioned a variety of programming languages that communicated with a computer's architecture, such as PHP and Assembly. School administration did not have enough course offerings to develop and sustain females' skills in computational thinking through the study of programming (see Guzey et al., 2016; Knezek et al., 2015; Peters-Burton et al., 2015).

Stereotype Threat

The second factor to emerge from the needs assessment was the chilly climate of STEM classes and a perceived lack of a sense of belonging by females in male-dominated courses. Female students participating in the needs assessment interviews (Mistretta, 2017a) shared that their male classmates exhibited a mistrust of females' answers in class or an imbalance of male and female equity in team assignments. "S" (see Table 2) shared that male students consistently checked her answers during engineering team projects, and "C" indicated that male students frequently implied that she was in the way while using shop equipment. This stereotype threat could contribute to low enrollment in rigorous, math-intensive courses by females, as well as reduced numbers of women completing coursework or moving on to STEM careers (see Barth et al., 2015; Brown & Leaper, 2010; Cheryan et al., 2017; Liben, 2016; Sekaquaptewa, 2011; Steele, 1997).

Apply Math Skills in Authentic Contexts

During the needs assessment, the researcher explored the concept of math anxiety by asking students whether they were nervous about math and their abilities to understand mathematical concepts. The literature was prevalent with the notion that males were better at math compared to females (Bian et al., 2017; Danaher & Crandall, 2008; Gunderson et al., 2012; Halpern & LaMay, 2000); however, the students participating in the needs assessment shared that they were anxious about the math grade, not the math itself. The phrase "applicable math" surfaced during the qualitative interview portion of the needs assessment (Mistretta, 2017a). The students claimed that they felt confident about their math skills; however, the examples in class and on assessments did not give them opportunities to figure out a solution because the problems did not apply to authentic, real-world examples. The students wanted to move away from convergent thinking that invoked prior knowledge—for instance, formulas—and move toward divergent thinking that discarded recipes to develop solutions to open-ended problems (see McKeown, 2014). The participants in the needs assessment (Mistretta, 2017a) reported a need to create innovations through ill-structured problems (Kirkley, 2003) without a single solution (Daly, Mosyjowski, & Seifert, 2014).

Intervention Theoretical Framework

The overarching theoretical framework that guided the intervention was critical theory. Rothe and Ronge (2016) referred to a constellation of philosophical thinkers and disciplines that formed the multi-disciplinary approach to the critical theory. Beginning in 1924, the Frankfurt School brought together theorists, such as Horkheimer (1972), who examined the work of Karl Marx during the era of World War II. The Frankfurt School considered political and economic circumstances that suppressed humanity regarding the injustices of capitalism and worker disempowerment (Kellner, 1989; Marx et al., 2013).

The core concept of critical theory is immanent critique (Antonio, 1981). This type of critical approach is derived by seeking the contradictions of a social reality from within, rather than a transcendent approach that is evoked from the outside of circumstances (Fornas, 2013). The word *critical*, used in combination with the word *theory*, does not have a connotation of fault-finding. Rather, the critique is evaluative in nature to question the norms from within a social construct (Fornas, 2013; Sarkela, 2017).

Educational Philosopher John Dewey employed the tenets of critical theory when he highlighted the need to critique a social system from within (Laitinen, 2017). Dewey described habits as patterns of individual behavior that could be regarded as customs by humans in social settings, thereby becoming a tradition if absorbed into a system (Wang, 2012). Looking through the lens of Dewey's viewpoint on behaviors, customs, and traditions, the math-intensive STEM fields of physics, engineering, and computer science are traditionally male dominated (Cheryan et al., 2017). Women exhibit patterns of behavior in bypassing upper-level math and science high school electives that provide foundational knowledge in STEM college majors (Nugent et al., 2015; Riegle-Crumb et al., 2012; Spitzer & Aronson, 2015; Wang, 2013).

Three decades of empirical evidence showed the behavior of systematic avoidance of math electives by females (Berryman, 1983; Ellis et al., 2016). A pervasive STEM cultural norm depicted males as being better at math and science than females (Albano & Rodriguez, 2013; Danaher & Crandall, 2008; Enderson & Ritz, 2016). Researchers indicated females began to believe such traditional gender biases as early as 6-years-old (Bian et al., 2017; Eccles, 1994). This cultural depiction of males as better in math and science is pervasive through college (Grunspan et al., 2016) and similarly influences career choices (Blickenstaff, 2005; Deemer et al., 2014; Eccles, 2011; Steele, 1997). Subtractive processes exist in the culture of STEM classrooms, where males dominate projects or assign the role of note-taker to females (Brickhouse et al., 2000).

Kellner (2003) noted a contemporary call for a critical theory of education and suggested the work of Dewey as a foundation to meet the challenges of the ever-evolving, multicultural, technological, and global models of modern educational settings. Benade (2017) suggested that the traditional classroom was rendered obsolete by the globalized, knowledge-based economy that necessitated collaboration and teamwork in settings that changed brick-and-mortar schools. Cormier (2008) emphasized *rhizomatic* education, which addressed the dispersed packets of knowledge found by students on the Internet—rather than the static, teacher-centered environments of modern instruction. Multicultural education can embrace humanistic approaches to innovation, such as encouraging students in STEM environments to produce technology for individuals with diverse needs (Moller & Kettley, 2017).

Supporting Literature for a Proposed Intervention

Beginning with critical theory's core concept of immanent critique (Antonio, 1981), an intervention could address the norms of social contexts from within educational settings. Kellner (2003) delineated a call for a critical theory of education by drawing on the work of John Dewey, whose pragmatic approach to education was centered on everyday practice of skills, thereby improving society. A close examination of the three factors that emerged from the needs assessment (Mistretta, 2017a) indicated that the linchpin of the factors was math. Drawing from the world of engineering, a STEM component discipline, a linchpin referred to something that was necessary to an entity. By focusing on math as a pivotal skill, one might develop an intervention to address math skills and improve students' outcomes in programming courses in both online and social environments.

The Math Component of Each Factor

Math is vital to computer programming through the understanding of algorithms that are essential to problem solving (Beilock et al., 2010). Boolean logic, a system of evaluating a variable in one of two conditions—true or false—is crucial to the successful flow of program looping operations (Grover, Pea, & Cooper, 2015; Kurbanoglu, Akkoyunlu, & Umay, 2006). Computational thinking is an important skill to identify problems and develop solutions in many fields (Aguar et al., 2016; Peters-Burton et al., 2015; Yadav, Stephenson, & Hong, 2017). Perceptions of males being better at math than females permeated the literature regarding women's avoidance of agentic, math intensive courses and fields (Berryman, 1983; Ceci et al., 2014; Eagly, 2013; Ellis et al., 2016).

Opportunity to Learn

The opportunity to apply math in authentic contexts was prevalent in the literature regarding real-world problem solving (Breiner et al., 2012; Bruce-Davis et al., 2014; Yadav et al., 2017). Gee (2008) defined the opportunity to learn as affordances and effectivities. Affordances are individuals' perceptions of the feasibility of acting on something in their environments. An effectivity is an opportunity contained in an environment that individuals perceive they can put into action. Google and Gallop (2016) reported that 39% of K-12 principals indicated that their schools did not offer any computer sciences courses, 42% indicated that their schools offered one to two courses, and 4% reported that their schools offered more than five courses.

In the context of this intervention, neighboring districts enrolled their students in the HSI STEM Academy to provide programming courses in the absence of a computer science curriculum (A. Servello, personal communication, February 6, 2017). Students in HSI and ASP contexts of the problem of practice did not have opportunities to take advanced programming courses to learn how to develop algorithms and Boolean logic to apply math in authentic, real-world applications. At the time of this study, the current researcher was a member of the High School of Education and Training (SET) in the ASP district.

The pre-kindergarten through eighth grade curriculum did not offer any technology courses or electives (Paterson Public Schools, 2018). Based on conversations with advisory board members, the curriculum should be modified to provide updated applications, such as Google classroom, to teach students how to create and edit documents, spreadsheets, and presentation slides. Two student government representatives attending the May 2018 SET advisory board meeting requested more technology course offerings (School of Education and Training, 2018).

Rationale of the Proposed Intervention

This intervention to address this problem of practice was an opportunity for students to learn beginner, intermediate, and advanced programming skills using a small, open, online course (SOOC). The students could collaborate in a face-to-face Hack-A-Thon to solve authentic STEM problems by working together on an original application. This intervention provided a solution to the unmet need of advanced electives for programming students. The SOOC provided students with an opportunity to access an accumulation of flipped video lessons that covered necessary skills to complete an Android application using MIT App Inventor. The videos were posted before the face-to-face Hack-A-Thon to increase students' programming skills before participating in a face-to-face team environment.

The researcher defined the Hack-A-Thon portion of the intervention to ameliorate stereotype threat in a coed STEM setting that provided students with an opportunity to collaborate with more capable peers (see Vygotsky, 1978). In Bandura's (1986) social cognitive theory, this researcher posited that a learner's personal, behavioral, and environmental influences interplayed with one another to impact how learners behaved. Therefore, the Hack-A-Thon was an opportunity to assemble all participants in a social setting to form heterogeneous teams of males and females who possessed a variety of programming skill-levels. The recruitment process was purposeful to recruit female students to consider participation in the SOOC and Hack-A-

Thon intervention. The intervention was not limited to females; the researcher aimed for the Hack-A-Thon to immerse heterogeneous students in mixed gender and programming skill levels in a STEM team environment.

The heterogeneous groups served a twofold purpose. First, the researcher implemented Vygotsky's (1978) ZPD to place learners among more capable peers to bridge current levels of programming skills from what they could accomplish unaided, what they could do with guidance, and the new levels they wished to achieve. Second, STEM female role models were scarce and important for girls to sustain STEM fields (see Herrmann et al., 2016). Collins et al. (1989) described cognitive apprenticeships where novices learned at the side of experts. Maltby, Brooks, Horton, and Morgan (2016) suggested the concept of a living-learning community that provided a support structure for up-and-coming women in STEM.

As a role model in STEM, the female researcher's presence created a living-learning community in a warm and welcoming, after-school environment. Students could be apprentices in programming. Female students' identities-as-a-programmer could be enhanced, which Farland-Smith (2012) evidenced in their study of middle-school girls improving their science identities by working with scientists in a summer camp setting. Grover et al. (2015) confirmed that a blended learning environment using a MOOC and brick-and-mortar classes improved students' grasp of programming concepts.

After-school Program

The context of the intervention was an after-school program in a poverty demographic. The school district did not have a computer programming curriculum, and instructional technology curriculum centered on Microsoft Office Word, Excel, and PowerPoint (Paterson School District, 2018). Barton, Tan, and Rivet (2008) suggested the creation of a hybrid space for girls, especially in urban environments, where participants could discuss terms and phrases unique to STEM in social settings. Master et al. (2016) concluded that a warm and welcoming classroom, rather than an equipment-filled room, was inviting to female students and improves their attitudes toward STEM. Hargrave (2015) posited that after-school programs were *counter spaces* that provided students, especially African Americans, with an opportunity to become successful in a setting other than school, where they might be labeled as disinterested or not motivated in education. Mouza, Marzocchi, Pan, and Pollock (2016) posited that educators could enhance equity by conducting computer programming instruction during after-school programs. Informal learning environments, such as after-school computer programming courses, could enhance the engagement levels of Black and Latina girls, as well as interests of their teacher-facilitators in further coursework (Koch & Gorges, 2016).

As a member of the High School of Education and Training Advisory Board in the same school district as the after-school program, the researcher observed old classrooms and armed police officers in each hallway. The school had more of a prison environment than a school. While the district has antiquated schools with few resources, the organization in which the after-school program takes place is an affirming oasis for women and their children. The organization provides a food pantry, free breakfast, free lunch, clothing, GED classes, ESL courses for adults, and many other services to a multicultural group of women and their children. Women are already the focus of this organization; therefore, enhancing this environment through teaching programming may increase children's interest in STEM, possibly providing an avenue to lift the family out of poverty.

STEM Connections to Computer Programming

The “T” in STEM refers to the overarching concept of technology, which prepares students to compete within the present Fourth Industrial Revolution in a global knowledge economy (Gray, 2016). One may characterize the first three Industrial Revolutions by the power needed to enact production, namely steam, electricity, and computer electronics (Gray, 2016). The present Fourth Industrial Revolution resulted from the fusion of physical devices, digital technology, and biological innovation to power products and services (Schwab, 2016). Deloitte (2018) defined knowledge workers as full-time employees, aged 21- to 64-years-old, who relied on technology to conduct core responsibilities of their jobs.

Computational thinking is a knowledge skill that does not rest solely in the discipline of technology. Rather, Denning (2017) defined computational thinking as a design process that directed any object using an algorithm to enact an intended model to produce a desired effect. For example, Lindiwe Matali (2018) of South Africa used knitting to teach programming and computational thinking. Children’s games, such as battleship, use computational thinking to find opponents ships (Computer Science Education Group, 2018). Seymour Papert (1980) was perhaps the first to use the term *computational thinking* regarding children using the Logo educational programming language. To compete in the knowledge economy, students must have opportunities to design algorithms to direct objects and enact models to achieve a desired effect, using computational thinking.

A STEM environment integrates an approach to the component disciplines of science, technology, engineering, and math. This environment offers students the opportunity to collaborate iteratively in a project-based classroom to solve ill-defined problems, which do not have one correct answer. The MIT App Inventor is an intervention tool to integrate STEM component disciplines by allowing students to develop applications to display STEM concepts in the form of mobile applications.

Science Concepts

The current researcher's definition of programming was the following: "Writing instructions to cause an object made of plastic, glass, and electricity to solve logical and mathematical statements repetitively." The SOOC small-skill videos contained micro-lessons on the chemical components of the devices that students programmed to expand their knowledge regarding aspects of chemistry in computer devices. Students developed geology applications, such as "The 10 Most Dangerous Volcanoes," by programming the device's user interface components using buttons, sliders, and file storage to reinforce science concepts. Students create applications to accept user input to create silly sentences, known by students as *MadLibs*, to learn about simple and compound machines.

Technology Concepts

A small-skill video began with the concept of a color additive display to learn how a computer interpreted color that differed from the results of color mixing in art classes. Students were familiar with the user interface components of *touch, drag,* and *click*. They would program the device to respond to the selection of colors, line thickness, and erase capabilities to become familiar with how a computer translates user input to the display features of the device. Color additive display was also mathematical because the computer interpreted color through the hexadecimal numbering system.

Engineering Concepts

The micro-lesson contained in the SOOC small-skill video began with an explanation of the Global Positioning System (GPS), which worked through a constellation of 24 satellites and

Earth ground stations powered the mapping applications of the investigation's mobile devices. Students programmed maps that used the MIT App Inventor GPS components by entering a longitude and latitude in a user interface field.

Math

Programming a computer game is inherently mathematical. Popular games, such as Mole Masher, 2048, and dice, required extensive planning, computational thinking, and revision until the program worked as planned. Students maintained their player scores in the devices' memories using variables and employed Boolean logic to keep track of game sequences. MIT App Inventor conducted a monthly challenge for *young inventors* (12 years and under), *teen inventors* (13 to 19 years), and *adult inventors* (older than 20 years; Massachusetts Institute of Technology, 2018).

Inclusive Environment

Students could develop a sense of belonging by practicing programming skills using the SOOC, connecting with teammates at the Hack-A-Thon in a social setting, and forming their programmer identities through creating an MIT app-of-the-month in the larger Android community. Although the setting of the intervention was a poverty demographic, most students had a personal Android device, even if they did not have a warm coat to wear on a cold winter day. As students developed their applications, they paired their personal devices to the MIT App Inventor website to run their programs. Students achieved a level of parity by aligning their work with the greater Android community as mobile app developers.

The rationale of critical theory in the problem of practice was to address the individual behaviors, cultural norms, and traditions from within the context of a blended online and face-to-face intervention. Providing students with an opportunity to complete a programming course that exercised math algorithms, Boolean logic, and a chance to collaborate in a social, coed setting could improve the representation of females in STEM courses, majors, and careers.

Literature in Support of a Blended Intervention

Given the paucity of advanced computer programming course offerings and a need to improve a sense of belonging in STEM settings, a blended approach of online and face-to-face opportunities to learn could provide students with a foundation of skills to inform an immanent critique of the current problem of practice.

Self-paced Learning

Students appreciate the opportunity to learn to program at their own pace (Dang, Zhang, Ravindran, & Osmonbekov, 2016). Researchers have revealed higher completion rates of online courses when self-pacing is an integral component (Evans, Baker, & Dee, 2015). This theoretical perspective supports that through blended intervention, students of beginner, intermediate, and advanced levels can develop programming skills in a personal learning environment before participating in a face-to-face programming event in a social setting.

Personal Learning Environments

Informal learning environments provide students with opportunities to expand instruction beyond teacher-centered school venues to student-centered instruction (Dabbagh & Kitsantas, 2012). Online courses in the form of small-skill videos can improve the convenience of learning; students can repeat a video through self-regulated learning (Dabbagh & Kitsantas, 2012).

Self-regulation

The ability to set a pace and momentum in online learning requires a positive emotional response to the small-skill lessons. Bloom (1956) identified three domains of learning: affective, cognitive, and psychomotor. As lesson planners, teachers often dwell in the most familiar cognitive domain, but self-regulation is associated with the affective, emotional domain (Bloom, 1956). Interest is one of the five objectives of the affective domain (Richey, Klein, & Tracey, 2011), and self-regulation refers to the capability to sustain interest in learning (Bandura, 2006). In online environments, teachers must remind students of Internet safety (Reich, 2017) and civility, which Forni (2002) defined as self-regulation in any in-person, written, or online interactions.

Motivation and Volition

Motivation and volition take on a different dynamic in an online learning environment compared to in face-to-face learning. Teachers have a collection of unique humans in every section during the school year. Each student mediates his or her own learning through affective, motivational, and volitional factors (Richey et al., 2011). Affective factors include the attitudes and emotional responses present in social settings. Motivation describes students' desires to choose to pursue a task or goal (Reiser & Dempsey, 2018). One may examine student motivation through the lens of a behaviorist approach as extrinsic using online guides, feedback from instructors or rewards, such as earned badges or certificates (Bonk & Khoo, 2014). Intrinsic motivation aligns with the self-determination theory as a student's enjoyment or interest in a learning task (Bonk & Khoo, 2014). Intrinsic learners align with the cognitivism learning theory where motivation align with students' expectations, beliefs, and goals (Reiser & Dempsey, 2018). Kizilcec, Piech, and Schneider (2013) analyzed three computer science courses offered through a massive, open, online course. The results revealed that students' reasons for enrollment was that they considered the online course to be challenging and fun.

Volition moves beyond motivation and involves a student's perceptions of hindrances and obstacles to overcome in the learning process (Reiser & Dempsey, 2018). Learners struggle with two conflicting goals that garner their attention: the completion of an assignment and the pull of another, distracting, social goal (Kizilcec et al., 2013; Reiser & Dempsey, 2018). Online users encounter an increased opportunity to have their attention pulled to social media, especially when learning platforms utilize blogs, Twitter, and YouTube (Dabbagh & Kitsantas, 2012).

The literature indicated that learning could improve through familiar social media platforms (Ghislandi, Ierardi, Leo, & Spalazzi, 2013). Reich (2017) posited that students could overcome obstacles, such as shyness, through online platforms that gave introverted students the time to collect their thoughts before participating. Yagci (2016) described an introvert as a person who preferred to work alone, was self-sufficient, and was less social. Educators' awareness of thinking styles could promote life-long learning using online courses. Students who registered for online courses were categorized into registrants, starters, active users, persisters, and completers (Perna et al., 2013).

Types of Online Learners

Registrants. Klobas (2014) found that registrants of online courses were either information seekers, who wished to gain access to materials that were only available through formal registration; window shoppers, who wanted to view the syllabus and evaluate the assignment schedule; or samplers, who tried an introductory video but did not receive adequate extrinsic motivation to continue with the course.

Starters. Starters who did not persist to the end of the course revealed that the coursework was too difficult or they did not allocate enough time to complete assessments (Klobas, 2014). Kizilcec et al. (2013) recommended that online instructors should allow starters, also referred to as auditors, access to course assessments to facilitate learning.

Active users and persisters. The number of active online learners was a small percentage of the total of those who registered in MOOCs (Evans et al., 2015; Perna et al., 2013). Up to 80% of MOOC registrants did not persist to the end of the course (Evans et al., 2015; Kizilcec et al., 2013; Perna et al., 2013). Persistence requires prolonged engagement in a course, and instructors who are aware of intrinsic and extrinsic motivation can address this goal-directed behavior to help learners feed engaged and finish the course (Evans et al., 2015; Reiser & Dempsey, 2018).

Completers. Evans et al. (2015) explored persistence patterns in MOOCs, discovering that the completion of a pre-course survey that sparked interest in the course was a predictor of course completion. The objectives of the affective domain (Richey et al., 2011) could be applied to the success of the pre-course survey in order to align students' interests, attitudes, values, emotions, and biases to persist to course completion.

Cognitive Load and Online Learners

The ARCS model of instructional design considers learners' attention, relevance, confidence, and satisfaction in online learning (Keller, 1987). This model posits that it is not enough to gain learners' attention, but teachers must sustain learners' attention by considering cognitive load and the human capacity of thinking (van Merrienboer, Jeroen, Kirschner, & Kester, 2003). Just as student motivation categories are intrinsic or extrinsic, cognitive load is delineated into intrinsic and extrinsic categories (Chen, Woolcott, & Sweller, 2017).

Intrinsic cognitive load. An instructional designer can reduce students' cognitive load by varying the expertise of the learners into beginner, intermediate, and advanced levels (Chen et al., 2017). Learners experience a high cognitive load when they do not have the schema, which are packets of information organized in long-term memory, to structure a current learning task (Reiser & Dempsey, 2018).

Extrinsic cognitive load. Learners can form cognitive organizations and memory structures better when instructors sequence the instructional materials (Schunk, 2012). An extrinsic cognitive load is regulated by how the instructor presents the learning materials to the students (Chen et al., 2017). Schmidt, Loyens, Van Gog, and Paas (2007) defined element interactivity as the load levied by the number of elements that a learner must consider simultaneously. Programming instructors must consider the sequence of elements, especially in computational thinking, when the order of code is imperative to a working program (Grover et al., 2015).

Problem Solving in Online Learning Environments

Kirkley (2003) defined problem-solving categories as well-structured problems that utilized the same step-by-step solution, moderately structured problems that have more than one acceptable solution, and ill-structured problems that were open-ended with many solutions. Richey et al. (2011) defined problem-based learning as learner-centered, allowing students to set strategies for organization and educational goals. Teachers could use instructional strategies, such as worked examples, to guide students in solving problems, which they could then extrapolate to new problems (Chen et al., 2017). Teachers could achieve deeper learning by providing students with a problem to complete, such as a program debugging exercises that would require students to correct and retest their solutions (Grover et al., 2015).

The constructivist instructional theory embraces problem solving; students use prior knowledge to explore and reflect on potential solutions (Bonk & Khoo, 2014). In an online environment, problem solving requires special consideration to effective instructional design and attention to the learner, task, and context (Richey et al., 2011). Feedback from instructors to students during problem-solving is more difficult in online environments due to the asynchronous nature of content delivery (Bonk & Khoo, 2014). Online environments remove the immediate social cues that would otherwise provide instructors with timely opportunities to offer critiques of present work (Yuan & Kim, 2015). The challenges and strategies to provide timely, substantive feedback to learners are the topics of discussion in the next section.

Feedback in Online Environments

Hardiman and Whitman (2014) stressed the importance of continual feedback regarding the learning brain. Information, actively retrieved at strategically spaced intervals, is associated with long-term learning (Roediger & Pyc, 2012). Lack of quality and timely feedback causes high attrition rates in online courses, while efficient feedback improves student-teacher relationships (Thomas, West, & Borup, 2017), as well as students' motivation, self-regulation, and confidence (Gikandi & Morrow, 2016; Yuan & Kim, 2015).

A paucity of face-to-face, instructor-to-student communication in online classes makes it difficult for students to feel the instructor's social presence (Thomas et al., 2017). Teachers can establish a social presence and facilitate feedback through one-to-one meetings via Google Hangout, email threads, or in virtual platforms (e.g., blogs; Yuan & Kim, 2015). Any delivery of feedback should include information regarding, "Where am I going?" called "feed up," "How am I going?" referred to as "feedback," and "Where to next?" termed "feed forward" (Hattie & Timperley, 2007, p. 81).

Instructors can also design online formative feedback by providing opportunities for peer-to-peer feedback. This student-centered feedback stimulates learners to take active roles in critiquing others' work; they can foster collaborative learning and reflection (Gikandi &

Morrow, 2016). Feedback is more powerful when provided through multiple sources, such as instructors, classmates, and students' self-discovery of ways that they can improve their learning (Yuan & Kim, 2015). This reflection and self-discovery activity leads to an important aspect of metacognition—the process of thinking about thinking.

Metacognition

Continuing the analysis of feedback and linking this concept to metacognition, Yuan and Kim (2015) indicated that the timing and perhaps delay of feedback was crucial, especially regarding challenging tasks. Difficult concepts with greater amounts of information to be synthesized require time for students to process the information and create schemas for future retrieval (Richey et al., 2011). Drawing students' attentions to metacognitive activities, such as acting on feedback, helps learners to discover what they know, identify what they do not know, and set goals to achieve understanding (Dunn & Lo, 2015).

Open Online Courses in Blended Settings

The history of online learning models began in the late 1990s (Hill, 2012), shortly after the inception of the World Wide Web in 1989 by Sir Tim Berners-Lee (Savage, 2017). Particularly interesting about the inception of online courses was the phrase *educational delivery models*, which Hill (2012) employed to emphasize the method of delivery of learning conducted by an instructor present in a brick-and-mortar classroom situated with learners using physical course materials. Between the terms *online* and *learning*, there was a bridge that must be built to deliver content to students who were not physically present.

Ad-hoc online courses. The faculty of U.S. postsecondary institutions in the late 1990s perceived the Internet as a way to augment the delivery of content to tuition-paying students enrolled in their classes (Hill, 2012). Instructors who were early adopters of online content experimented in hypertext markup language (HTML) to deliver and archive course content during the first decade of the World Wide Web; at the time, this process was conducted through local area networks (Leiner et al., 1997) or through an ever-expanding Internet backbone, which was acquired by Verizon in 2006 (Lee, 2014).

The framework of critical theory and the core concept of immanent critique (Antonio, 1981) were evident in the actions of professors who created ad hoc online courses using the new capabilities of their computer network. These instructors aimed to engage students through an intriguing tool that could create an area of collaboration and information sharing that extended beyond the classroom walls. This change questioned the norms within the social construct of the university and made modifications from within the organization (Fornas, 2013; Sarkela, 2017).

Fully online programs. The for-profit business sector and nonprofit institutions began offering online instruction called a *master course* in standardized format. These courses could be created by instructional designers and replicated to multiple instructors in a turnkey format (Hill, 2012). This course delivery method created a dichotomy between content and instructors' who did not have a say in materials, assessments, and discussion board writing prompts.

School-as-a-service and educational partnerships. Some organization leaders outsourced online content and curriculum through for-profit companies, such as Pearson. In addition, leaders of Cisco offered work-related certifications (Hill, 2012).

Flipped learning. Educators have adopted the concept of flipped learning that transitions lectures and examples to videos assigned for homework. This process increases class time to collaborate in a blended environment to problem solve together and to differentiate instruction to learners in the same class (Love, Hodge, Corritore, & Ernst, 2015; Sams et al., 2015).

MOOCs. David Wiley of Utah State University and Alex Couros of the University of Regina in Canada offered an online course in 2008 to an unlimited number of students (Hill, 2012). David Cormier (2008) first coined the acronym MOOC; he referred to the course as an event that would redefine the role of an educator.

Cormier (2008) used a botanical metaphor of a rhizome to compare a MOOC with a plant whose root system spread without boundaries except for the limitations of its habitat. This author described information in the digital age, framed by the new learning of theory of connectivism, as *rhizomatic* because it addressed the extensive depth and breadth of information on the Internet (Cormier, 2008). The tenets of connectivism indicate that the need to know more and the ability to synthesize information are crucial core skills required to learn in the digital age (Siemens, 2005).

The pursuit of knowledge changed traditional, face-to-face educational settings in 2011, when an *xMOOC* in Artificial Intelligence enrolled 160,000 learners residing in 190 countries (Bozkurt, Akgun-Ozbek, & Zawacki-Richter, 2017). The xMOOC category fostered prerecorded material without learner communities. This finding was in contrast to the *cMOOC*, which was associated with connectivism and a socially networked environment for learning (Bozkurt et al., 2017).

Literature regarding pedagogical practices in MOOCs indicated the xMOOC was video-based, and instructors transitioned their teacher-centered lectures to video without deference to how students learned (Bali, 2014). Expanded learning time of online learning is a benefit for educators who utilize MOOC platforms to deliver online content and create opportunities for increased social collaborations in a blended environment (Bali, 2014). Administrators of universities, such as Stanford, have provided courses in *xMOOC,* a video-based format employed by middle school educators to augment their computer science curriculums in blended environments (Grover et al., 2015). The researcher analyzes blending in middle school settings in the following section.

Middle school applications of university MOOC platforms. Grover et al. (2015) published an article regarding a study to determine if middle school students, aged 11- to 14-years-old, would increase transferability of programming skills by taking a Foundations of Computational Thinking course in MOOC format through Stanford University's OpenEdX platform. Face-to-face instruction in Scratch, a block-based programming language, occurred in a classroom setting; students exercised skills that they learned in the MOOC (Grover et al., 2015). This study context complemented this intervention of a SOOC blended with a face-to-face Hack-A-Thon in MIT App Inventor, a block-based programming language. The results of this mixed method study indicated three outcomes that aligned with the intervention research questions (IRQ) of the problem of practice, including male to female ratios in study samples of 21:5 and 20:8 (see Table 5).

Table 5

Comparison of Intervention Research Questions to Grover et al. (2015)

Intervention Research Question	Study Results
IRQ1 –Students Interest in Advanced Programming Electives What are students' attitudes toward increasingly advanced SOOC offerings? In what way does gender influence persistence in achieving higher programming skill levels?	Students were able to transfer skills from block-based programming to advanced text-based programming.
IRQ2 –Students' Perceptions of Stereotype Threat What are students' perceptions regarding a sense of belonging in a coed STEM environment? In what way does gender influence perceptions of belonging?	Students exhibited a significant growth toward a more mature understanding of the discipline of computer programming.
IRQ3 – Applicable Math What are students' experiences regarding applicable math during the SOOC and Hack-A-Thon? In what way does gender explain differences in willingness to apply math in real-world applications?	Students exhibited significant learning gains in algorithmic thinking skills.

The most meaningful result of the Grover et al. (2015) study to this problem of practice was the outcome of math where students exhibited a significant growth in algorithmic thinking. The metaphor of math as the linchpin of the problem of practice at hand was evident in students using a MOOC to refine skills in computational thinking could gain substantial ground in math to transition from block-based to advanced text-based programming skills.

SOOCs. The *New York Times* deemed the year 2012 as the year of the MOOCs (Pappano, 2012). The present intervention literature review was part of coursework in December of 2017, only 5 years since 2012 and 9 years since the first MOOC. The literature was prevalent with researchers who concluded that MOOCs had uncertain pedagogical potential (Bali, 2014; Bonk & Lee, 2017; Kizilcec et al., 2013; Núñez, Caro, & González, 2017; Steffens, 2015; Wang, Anderson, Chen, & Barbera, 2017; Yin, Adams, Goble, & Madriz, 2015). The researcher reviewed articles from peer-reviewed journals where others attempted to define and apply classification taxonomies of MOOCs (see Evans et al., 2015; Major & Blackmon, 2016).

Few peer-reviewed articles with the quality of work found in the Major and Blackmon (2016) study were present in the literature regarding SOOCs as more manageable forms of open, online course offerings. Researchers cited the scalable nature of MOOCs and proposed using these in professional development (Salmon, Gregory, Lokuge Dona, & Ross, 2015). Klobas (2014) explored the success of scalable, open, and online courses by delineating criterion for SOOC instructional design and organizational measures. The table of criterion that Klobas (2014) provided was helpful in during the development of the SOOC instructional design project and presentation.

Conclusions

The underlying theory of treatment regarding the intervention addressed three outcome timeframes (see Appendix Z). In the short term, within 3 months, the treatment sought to change students' attitudes toward math by providing an advanced programming course using real-world, applicable math examples. Students indicated that school math contexts were devoid of cases that exercised their abilities to apply concepts in realistic settings (Mistretta, 2017a). In the medium term, within 4 to 9 months, the underlying goal was to change the enrollment ratio of male to female students in programming course offerings by improving female students' sense of belonging in STEM environments. Historic course enrollment in the context of a Hispanic Serving Institution (HSI) was predominantly male with past male to female ratios of 9:3, 10:4, 12:1, and 11:4. Rigorous technology electives remained under-enrolled by female students (Beyer, 2014; Nugent et al., 2015). In the long term, through prerequisite courses (see Appendix

J), the treatment sought to reduce females' attitudes of avoidance toward agentic, math-intensive STEM careers (Cheryan et al., 2017).

The independent variables that influenced variations in the intervention were participation in the SOOC and participation in the Hack-A-Thon. The dependent variables were knowledge of MIT App inventor skills, improved attitudes toward applicable math through real-world examples, STEM attitudes, a sense of belonging in STEM environments, and enrollment in future advanced programming course offerings.

By participating in the intervention, students learned an advanced programming platform, which could improve their willingness to apply math in real-world settings through the practice of creating and solving algorithms (see Beilock et al., 2010; Ramirez et al., 2013). The students' interests in STEM careers could be influenced by participation in STEM environments (Ceci et al., 2014; Cheryan et al., 2017). Students' interests in STEM careers could form in middle school (Aguar et al., 2016; Bian et al., 2017; Guzey et al., 2016; Knezek et al., 2015). A chilly climate was prevalent in the literature as being a strong negative influence on females in STEM environments (Barth et al., 2015; Danaher & Crandall, 2008; Deemer et al., 2014). Bandura (1986) created the triadic-reciprocal model of causality to posit that the behavior observed in social settings had a potential for self-regulation. This model could be applied to an improvement of the climate in STEM settings to foster acceptance. Students' perceptions of success in the SOOC and the Hack-A-Thon could influence their enrollment in future advanced programming course offerings (Aguar et al., 2016).

Regarding math-intensive classes, Gottlieb (2018) indicated that students had positive perceptions of the social and time costs of selecting courses that increased the likelihood of planning a career that required a bachelor's degree. The SOOC and Hack-A-Thon could increase subjective task value, a key aspect of expectancy-value theory (Eccles, 2009), as a task that students find valuable on interest, utility, attainment, and cost levels (Eccles, 2009; Gottlieb, 2018). Students would pursue a task if they found that the activity was enjoyable and interesting. A perceived utility of a task to help achieve short-term and long-term goals was appealing to students to learn mobile applications that could build their personal résumés for acceptance into STEM high school or college programs. The attainment value of a task indicated one's perceived self- and social-image as a person who could code mobile applications. The cost in time and engagement in a social task, such as the Hack-A-Thon, could contribute to a student's collective identity in a team environment.

The program defined students' STEM attitudes as a union between their self-efficacy and expectancy-value beliefs. A researcher defined self-efficacy as the extent to which students would plan and implement behaviors related to goal achievement (Bandura, 1986). Expectancy-value beliefs described students' assessments of the likelihood of attaining a goal and the perceived gain or loss of value from the attainment of the goal (Eccles & Wigfield, 2002). Unfried, Faber, Stanhope, and Wiebe (2015) defined attitude as a composite of self-efficacy and expectancy-value beliefs. The program queried students' STEM attitudes pre and post intervention through the S-STEM surveys (Friday Institute for Educational Innovation, 2012a; 2012b). The researcher performed individual interviews following the Hack-A-Thon to probe students' attitudes toward STEM. The researcher transcribed the interview discourse in the Otter.ai application. The causal model (see Appendix J) depicted self-efficacy in the Mediating Variables column. The program covariated the moderating variables depicted in the causal model (see Appendix J) with surveyed students' STEM attitudes to discover the effects of the intervention on subgroups of the targeted population.

Chapter 4: Intervention Procedure and Program Evaluation Methodology

The intervention addressed the need to provide a programming course for an extended timeframe to a diverse population of coed students in fourth through 12th grades in an after-school program in the Northeast United States. The SOOC provided male and female students with an opportunity to learn MIT App Inventor in an online, self-paced learning environment before convening in a face-to-face, coed, collaborative, Hack-A-Thon event to develop an authentic STEM mobile application.

Intervention Research Questions

The researcher developed the following intervention research questions to provide a foundation for the exploration of gender-based attitudes in STEM environments. The research questions queried students' STEM attitudes regarding the three factors that emerged in the needs assessment (see Mistretta, 2017a). Each research question also probed for differences in STEM attitudes along gender groupings.

Intervention Research Question 1 (IRQ1): Interest in Programming Electives

What are students' attitudes toward increasingly advanced SOOC offerings? In what way does gender influence persistence in achieving higher programming skill levels?

Intervention Research Question 2 (IRQ2): Students' Perceptions of Stereotype Threat

What are students' perceptions regarding a sense of belonging in a coed STEM environment? In what way does gender influence perceptions of belonging?

Intervention Research Question 3 (IRQ3): Applicable Math

What are students' experiences regarding applicable math during the SOOC and Hack-A-Thon? In what way does gender explain differences in willingness to apply math in real-world applications?

The research questions address the social reality or norms regarding the perception of males as better at math, non-applicable math instruction in traditional course settings, and females' perceptions of a chilly climate in STEM environments. Drawing upon Kellner's (2003) contemporary call for a critical theory of education, the researcher seeks to explore students' gender-based attitudes by addressing the contradictions of social reality from within an advanced programming course offering, rather than a transcendent approach evoked from outside circumstances (Fornas, 2013).

Research Design

The design of the intervention was a convergent, mixed method approach that involved recruiting one group of student-participants without a randomized experimental or nonrandomized, quasi-experimental control group. The potential sample size of this setting was small; therefore, the advisory committee suggested that the intervention concentrated on the recruitment of as many students to one sample as possible. In a convergent, mixed method approach, data were equal in priority, collected concurrently, analyzed separately, and merged for final analysis (Creswell & Plano Clark, 2011). Both qualitative and quantitative evidence of students' attitudes was valuable because employing both methods provided a fuller picture of participants' perspectives.

Process Evaluation

The process evaluation question regarding the intervention, depicted in the logic model (see Appendix I), was the following: Did the small-skill video lessons posted on the scalable, open, online course provide students with *sufficient* instruction to complete worked-example assignments?

Implementation of program component. Linnan and Steckler (2002) indicated that the implementation component of a process evaluation revealed the degree to which the targeted participants applied and utilized the program. The SOOC instructional design provided a 28-day, self-paced timeframe to the targeted population of students in fifth through 12th grades, with three entry points of small-skill, video-based programming instruction. The students completed a star-rated survey after each video and received consecutively numbered digital badges to monitor their lesson completion.

The program expected the students to make progress through 33% of the 30 available videos, which was equivalent to one of the three levels of the SOOC. The quantitative *progress indicator* was measured using the extent of completion of video star ratings and number of student-achieved badges. The researcher collected qualitative data from instructor/student interview sessions and a focus group at the culmination of the Hack-A-Thon. The implementation of the program component aligned with the inputs, activities, and outputs columns of the logic model (see Appendix I).

Context component. The context of an intervention is the macrosystem (Bronfenbrenner, 1977) or the overarching political and social environments that influence the program (Baranowski & Stables, 2000; Linnan & Steckler, 2002). The SES of participants' families might moderate the effects of the intervention. The parent demographic survey administered at the beginning of the program included questions regarding SES and the family's available devices to access the Internet. Inconsistent network access or availability of devices could limit students' abilities to transition through the three SOOC levels.

The program expected the context of the school district to moderate the effects of the intervention, as aligned with the SES of 100% of students receiving free breakfast and lunch

(Evans, 2017). The quantitative *device indicator* covariate SES with surveyed student devices. The qualitative data collected through email correspondences documented the devices employed by students to complete assignments. The context component aligned with the moderating variables of the causal model (see Appendix J).

Participant responsiveness component. The component of responsiveness refers to how participants' engagement and viewpoints indicated their levels of satisfaction with the program (see Dusenbury, Brannigan, Falco, & Hansen, 2003). The S-STEM surveys (Friday Institute for Educational Innovation, 2012a; 2012b) provided quantitative data regarding students' STEM attitudes through pre and post intervention measurements. The qualitative data collected during student interviews after the Hack-A-Thon event enriched the analysis of the data. The program expected at least 10% attrition of participants from the intervention, which was typical of online courses (see Bonk & Lee, 2017). The participant responsiveness component aligned with the mediating and dependent variables depicted in the causal model (see Appendix J).

Contamination component. The contamination component refers to the extent to which participants engage in instruction outside of this program (Baranowski & Stables, 2000). External contamination could occur through other online offerings, such as the video tutorials provided on the MIT App Inventor website. The program expected less than 25% of students to have prior experiences with online programming classes. Internal contamination occurred when friends or parents assisted students in completing assignments. The researcher coded qualitative instructor/student interviews to detect internal contaminant influence. The contamination component aligned with the moderating variables of the causal model (see Appendix J).

Process evaluation indicators. The process evaluation indicators of progress, device, student attitudes regarding STEM, and influence were central in answering the process evaluation question posed in this plan (see Appendix L for Process Evaluation Data Collection Matrix).

Progress indicator. The program defined the progress indicator as the extent to which a student watched small-skill video lessons beginning at the pre-assessed entry point, completed a subsequent transition to the next SOOC levels of advanced achievement, and participated in the Hack-A-Thon. Each of the three levels in the SOOC was a collection of 10 small-skill videos, for a total of 30 lessons. The maximum dosage of the program was 30 videos completed by a student who pre-assessed into the beginner level, completed all subsequent videos, and attended the Hack-A-Thon (see Dusenbury et al., 2003). The minimum dosage of the program was watching one or no small-skill videos at any entry point level or participation of only the Hack-A-Thon (Dusenbury et al., 2003).

The program collected progress data at the completion of star-rated surveys following each small-skill video that triggered the award of a consecutively numbered digital badge placed into the student's Google folder. The Independent Variables column of the causal model (see Appendix J) and the Outputs column of the logic model (see Appendix I) showed students' progress as attending only the SOOC, attending the SOOC and Hack-A-Thon. Students' SOOC attendance was self-paced and mediated by their self-efficacy and confidence in 21st century learning constructs queried during the pre and post intervention S-STEM surveys (Friday Institute for Educational Innovation, 2012a; 2012b). All participants were invited to attend the Hack-A-Thon, even if their progress indicator was less than one viewed lesson. The researcher posed focus group interview questions (see Appendix K) after the Hack-A-Thon to probe for the level of participation and progress in the program.

Device indicator. The program defined the *device indicator* as a covariate between the family's self-declared SES and available devices with Internet access to complete programming assignments. Lack of Internet-connected computers and testing devices could impede instruction. The device indicator was important to answering the process evaluation question at hand. SES factors and available devices could explain a student's lack of progress, rather than the student's self-efficacy or confidence in 21st century learning constructs. The program considered the assumptions depicted at the bottom of the logic model (see Appendix I) through the device indicator. Simpson et al. (2015) suggested testing the logic model as a key task of the process evaluation. By incorporating the logic model assumptions into the device indicator, the program applied the underlying critical theory of the intervention. Immanent critique (Antonio, 1981) was the core concept of critical theory that sought contradictions of social reality from within rather than any approach outside of circumstances (Fornas, 2013). The researcher collected the device data during the parent demographic survey at the beginning of the program.

Student STEM attitudes. The program defined students' STEM attitudes as a union between students' self-efficacy and expectancy-value beliefs. Bandura (1986) defined self-efficacy as the extent to which students planned and implemented behaviors related to goal achievement. Eccles and Wigfield (2002) defined expectancy-value beliefs as students' assessments of the likelihood of attaining a goal and the perceived gain or loss of value from the attainment of the goal. Unfried et al. (2015) defined attitude as a composite of self-efficacy and expectancy-value beliefs.

The program queried students' pre and post intervention STEM attitudes through the S-STEM surveys (Friday Institute for Educational Innovation, 2012a, 2012b). The researcher asked interview questions (see Appendix K) used during individual interviews following the Hack-A-

Thon to probe students' attitudes toward STEM. The researcher recorded the interview discourse using the Otter.ai application. The causal model (see Appendix J) depicted self-efficacy in the Mediating Variables column. The program covariates moderating variables depicted in the causal model (see Appendix J) with surveyed students' STEM attitudes to discover the effects of the intervention on subgroups of the targeted population.

Influence. The program defined influence as a combination of internal assistance by students' parents to complete lessons, as well as external assistance regarding other sources of programming experience. The causal model (see Appendix J) depicted other sources of programming experience in the moderating variables column of the diagram. Examples of external influence are Khan Academy or MIT App Inventor website tutorials viewed independently by the student. The researcher included questions in the student/instructor interviews (see Appendix K) to detect the level of independent use of Internet videos.

Outcome Evaluation

The outcome evaluation question regarding the intervention depicted in the logic model (see Appendix I) was the following: How do females and males compare in attitudes toward science, technology, engineering, and math (STEM) environments before and after participation in an advanced STEM program? The objective of the current study was to better understand students' gender-based attitudes in STEM environments.

Effect size. The expected effect size of this intervention was 0.5, which aligned with a sample size of 18 students, given the context of an after-school program that was chartered to enroll up to 100 students in fourth through 12th grades. The researcher performed two a priori power analyses using the G*Power tool (Buschner, Erdfelder, Faul, & Lang, 2018), which revealed total sample sizes of 18 by setting the power at 0.5 (see Appendix M) and 34 by setting the power at 0.8 (see Appendix N). The smaller sample size of 18 participants and an effect size of 0.5 were realistic due to the limited enrollment of the intervention setting. The researcher implemented a convergent, mixed methods approach to enrich the quantitative survey data with qualitative interviews of each student. The researcher's committee suggested a purposeful recruitment of participants to include as many girls as possible, given the focus of the study on the underrepresentation of women in STEM courses, majors, and careers. The recruitment collected signed informed consents and assents from 15 girls and 8 boys for a total of 23 participants. Of the 23 participants, 17 attended the Android Inventor program. Of the 17 students, 11 were girls and 7 were boys, which achieved the purposeful recruitment of female participants.

Hill, Bloom, Black, and Lipsey (2008) suggested that researchers should observe the effect size for similar interventions that could be attainable in the present study. Yerdelen, Kahraman, and Tas (2016) employed the same S-STEM surveys (Friday Institute for Educational Innovation, 2012a; 2012b) as planned in this intervention. Using G*Power for a post hoc calculation of achieved power with the sample size of 263 participants in the Yerdelen et al. (2016) study, with a two-tailed test, and a 0.5 effect size, results in a calculated power was 1.0 (see Appendix O).

Yerdelen et al. (2016) did not reveal the null hypothesis regarding their study; however, they did offer a research question regarding gender, grade, and socioeconomic status: Is there a gender and grade level difference in low socioeconomic status students' STEM career interest? These researchers recognized that fewer women selected STEM careers; however, the results indicated positive attitudes toward STEM careers, without significant interaction moderated by gender or grade level.

Based on their literature review, Yerdelen et al. (2016) concluded that gender does not moderate attitudes toward STEM. The results of this study, however, revealed that 48% of the students chose a non-STEM career (e.g., soccer player, singer, police) for future employment, and none of the students chose an agentic, male-dominated technology career (Diekman & Eagly, 2000). Yerdelen et al. (2016) revealed that 52% of the STEM careers that the participants chose were in the life sciences. Careers in life science aligned with the types of communal work that females often select (Eagly, 2013). Based on a literature review regarding agentic and communal career choices made by males and females (Mistretta, 2017b), the post hoc power analysis that Yerdelen et al. (2016) conducted could support alignment with the present intervention's hypothesis that gender did moderate STEM attitudes.

Evaluation design. The design of this intervention was a convergent, mixed method approach that recruited one group of student-participants without a randomized experimental or non-randomized quasi-experimental control group. The potential sample size of this setting was small; therefore, the advisory committee suggested that the researcher concentrated on the recruitment of as many students to one sample as possible. In a convergent, mixed method approach, data were equal in priority, collected concurrently, analyzed separately, and then merged for final analysis (Creswell & Plano Clark, 2011). Collecting evidence of students' attitudes using both quantitative and qualitative approaches was valuable; employing both methods provided a fuller picture of participants' perspectives.

The program defined students' STEM attitudes as a union between student self-efficacy and expectancy-value beliefs. Researchers defined self-efficacy as the extent to which students would plan and implement behaviors related to goal achievement (Bandura, 1986). Expectancy-value beliefs are a student's assessment of the likelihood of attaining a goal and the perceived gain or loss of value from the attainment of the goal (Eccles & Wigfield, 2002). Unfried et al. (2015) defined attitude as a composite of self-efficacy and expectancy-value beliefs.

The S-STEM surveys (Friday Institute for Educational Innovation, 2012a; 2012b) provides quantitative data regarding student STEM attitudes, 21st century learning constructs pertaining to working well with others, and interests in STEM careers through measurements at pre and post intervention points. The S-STEM surveys grouped STEM constructs according to outcome indicators of math, science, engineering, and technology attitudes (see Appendix P for data collection matrix). This process provided the researcher with the ability to analyze students' attitudes and viewpoints in subgroupings of the STEM acronym. Questions regarding working well with other students and future careers aligned with data queried in the qualitative participant interviews (see Appendix K for interview questions) to enrich the analysis of data collected in the quantitative surveys.

The evaluation design considered gender, socio-economic status, race, ethnicity, and grade as moderating variables (see Appendix J for causal model). The plan to evaluate the outcomes of the intervention included blocking the sample according to similar groups of participants to perform a Chi-Square analysis of covariance statistical tests (Lipsey & Hurley, 2009). An Chi-Square test conducted with blocks of all males and all females could reveal gender-based differences in attitudes toward STEM environments after taking part in an advanced STEM program. This measurement aligned with the research question that asked the following: What are students' perceptions regarding a sense of belonging in a coed STEM environment, and in what way does gender influence perceptions of belonging?

The evaluation design considered prior knowledge as a control variable (see Appendix P for Outcome Evaluation Data Collection Matrix). Salkind (2010) defined a control variable as a variable that was not of primary interest, but whose influence merited consideration. Students might have prior knowledge of the advanced programming topics covered in this intervention through outside influences, such as other online instruction websites or school course offerings. Plausible alternatives to explain the influence on STEM attitudes must be considered to accurately determine the correlation of the changes to the present intervention (Wholey, Hatry, & Newcomer, 2010).

Strengths and limitations of the evaluation design. Using the Wholey et al. (2010) evaluation pyramid of strength as a guide (see Appendix Q), this evaluation plan began with a strong base through measurement reliability and validity. Researchers considered a measure to be reliable when it produced similar results after repetitive observations under similar conditions (Wholey et al., 2010). The constructs of the S-STEM survey revealed high Cronbach's Alpha reliability levels (see Appendix H). A review of the literature and collaboration with subject matter experts provided evidence of the content validity of the S-STEM surveys (Unfried et al., 2015). Exploratory factor analysis, which examined correlations among variables to identify interrelated variables (Leedy & Ormrod, 2010), confirmed the construct validity of the survey instruments (see Unfried et al., 2015).

The researcher achieved triangulation by comparing students' attitudes during interviews to the analysis of the S-STEM survey data. Member checking occurred through follow-up interviews with selected participants to confirm the research findings. Moving up the design evaluation pyramid of strength (see Appendix Q), internal validity referred to the inferences that a researcher made regarding the causal relationship between two variables (see Shadish, Cook, & Campbell, 2002). This intervention was a non-experimental design, which did not employ a control group due to the limited participant pool in this setting. The current research design controlled for a prior knowledge variable to mitigate alternative explanations (see Appendix L for data collection matrix).

Attrition of an already small sample size was a threat to internal validity. A small sample size might result in the lack of significant results due to low statistical power (Salkind, 2010). The researcher performed non-probabilistic sampling, involving participants who were available to study (see Creswell & Plano Clark, 2011) from an after-school program where a subset of the 100 enrolled children participate. This issue represented a threat to validity because the participants were not necessarily representative of the population of all students served in this context. Therefore, the small sample size might not yield conclusions of causality regarding changes in students' STEM attitudes. Rather, the researcher might identify a correlation between students' attitudes regarding STEM environments and gender based on the quantitative and qualitative data gathered.

There was a threat to external validity; causal inferences might not extend to new participants and settings (Shadish et al., 2002). Children who attended the after-school program during this intervention resided in poverty (Shafer & Peron, 2018). They must overcome many difficulties—including lack of food and dangerous living conditions—before they could attempt to succeed in their educational settings. Causal inferences based on a population with low SES might not be applicable to populations in higher SES settings.

Shadish et al. (2002) defined statistical conclusion validity as whether independent and dependent variables covary using appropriate statistical analysis. In this intervention, the independent variables (see Appendix J for causal model) included (a) participation in a small, open, online course and (b) participation in a face-to-face Hack-A-Thon; together, these comprised the advanced STEM program referenced in the evaluation question. The dependent variables addressed in this evaluation plan included STEM attitudes and a sense of belonging in STEM environments (see Appendix J for causal model). Controlling for prior knowledge from other STEM programs and conducting Chi-Square statistical analysis blocked by gender as a moderating variable, this plan sought to reject the null hypothesis that gender did *not* moderate attitudes toward STEM. Analysis of the combined quantitative and qualitative databases revealed a change in students' attitudes toward a sense of belonging in STEM environments. A moderating effect of gender influences answered the research question regarding change of attitudes in STEM environments along gender blocking groups.

Method

Participants

The context of this intervention was an after-school program for children living in poverty in an urban setting in Northern New Jersey. The charter of the after-school program limited the enrollment to 100 students; from this population, recruitment of participants took place. The students were males and females in fourth through 12th grades, and this context was part of the situated problem of practice depicted as a Venn diagram (see Appendix A) where the original needs assessment occurred. All students in the after-school program were eligible to participate in the intervention. There were no planned exclusions of participants in this intervention.

Recruitment. The researcher attended two parent events held at the after-school facility in August 2018 to meet with interested parents to distribute parent demographic surveys (see Appendix R) and parental informed consents (see Appendix S) in English and Spanish. There were no adult participants aged 18 years or older who came forward to complete an adult informed consent form (see Appendix U). All minor students completed an assent form provided in English and Spanish (see Appendix W).

The recruitment of participants involved purposeful sampling technique to help enrollment of a sufficient number of female students to provide maximal variation sampling to reflect differing viewpoints regarding STEM environments between females and males. Past male-to-female ratios of the researcher's programming classes were 9:3, 10:4, 12:1, and 11:4. The intent was to recruit a diverse population of male and female students in as much of an equal proportion as possible to reveal the central concept of gender viewpoints explored in this study.

All parents with children currently enrolled in the after-school program and after-school faculty received an email that contained a link to a VoiceThread recruitment video in English and Spanish (see Appendix T for VoiceThread script) describing the research and inviting parents to enroll their students. The education department had a supply of the forms to distribute to interested parents who did not attend the parent event or who did not have email addresses. Jessica Egger, the director of the education initiatives at the After-School Program, was a member of the study team and facilitates the distribution and collection of informed consents and parent surveys on behalf of the researcher.

The researcher hired Demi Matos to serve as a STEM intern to help facilitate the Android Inventor program, especially to communicate in Spanish with the parent group. Matos signed an Investigator Agreement (see Appendix BB) with the Homewood IRB and was a study team member. The study team posted flyers (see Appendix V) in English and Spanish at Oasis with QR codes that the parents could scan with their mobile devices to access a form to contact the researcher (see Appendix W). The flyer and link to the contact form were emailed to parents to advertise the program and recruit participants.

The study enrolled 23 students in fourth through ninth grades during the two parent events in August 2018. The enrollment achieved the purposeful recruitment of female participants with 15 girls and 8 boys. Of the 23 students, 17 attended the 25-day program consistently with 11 girls and 7 boys that maintained the purposeful recruitment ratio targeting female participants. The study team maintained a password-protected master attendance list. The 17 consistent students averaged a 79% rate of attendance. Females attended the program at a rate of 76% and males at 83%.

Measures

The quantitative and qualitative measures comprised a *convergent, mixed methods research design* where data were collected simultaneously, analyzed separately, and merged into one database for further analysis at the culmination of the intervention. Appendix Y contains a summary of indicators, alignment of research questions, the operationalization of indicators, data sources, data collection tools, and frequency of collection of data. The measures began with a parent survey available in English and Spanish (see Appendix R) at the start of the intervention that provided demographic data. The parents completed the SurveyMonkey instrument when the researcher received the signed informed consent (see Appendix S and U for parental informed consents) at the parent event in August 2018.

The researcher placed all participants in the beginner level of the SOOC. The small-skill videos centered on developing a dice game application using MIT App Inventor. The beginner, intermediate, and advanced programming levels contained all necessary steps to complete a working application. A password-protected Google Classroom housed the small-skill videos in three separate classes named *beginner, intermediate,* and *advanced*. Students who demonstrated working applications to the researcher progressed to the next level by receiving the "join code" for the next section.

The S-STEM surveys (Friday Institute for Educational Innovation, 2012a, 2012b) provided quantitative student STEM attitudes data through measurements at pre and post intervention points. Within the S-STEM survey questions, the researcher asked the students to indicate their first name and last initials, which the researcher could use to identify participant data.

A measure was considered reliable when it produced similar results after repetitive observations under like conditions (Wholey et al., 2010). The constructs of the S-STEM survey revealed high Cronbach's Alpha reliability levels (see Appendix H). A review of the literature and collaboration with subject matter experts provided evidence of S-STEM surveys' content validity (Unfried et al., 2015). Exploratory factor analysis, which examined correlations among variables to identify interrelated variables (Leedy & Ormrod, 2010), confirmed the construct validity of the survey instruments (Unfried et al., 2015).

Throughout the SOOC, students completed small-skill videos and received up to 28 consecutively-numbered digital badges to keep track of their progress through the lessons. The researcher awarded the digital badge after the students demonstrated a working program. The researcher asked each student to complete a star-rating SOOC Lesson Interval Survey (see Appendix X). The consecutively numbered digital badges and star-rated surveys comprised the progress indicator (see Appendix Y). Each participant could view their collections of digital badges on the online Padlet virtual bulletin board application created by the researcher for every student.

At the culmination of the intervention, the researcher conducted the same S-STEM survey to discover potential shifts in students' attitudes toward STEM environments. The researcher conducted student interviews (see Appendix K for questions) during the last two days of the 25-day program to record student reflections regarding STEM subjects, programming, college, and career plans. In the following sections, the researcher examines the trustworthiness of naturalistic inquiries.

Trustworthiness of Naturalistic Inquiries

Guba (1981) offered researchers four criteria of trustworthiness of naturalistic inquiries. The requirements include truth value, applicability, consistency, and neutrality. In the following sections, the researcher discusses the rigor of the qualitative measure of this study.

Truth Value

A researcher assesses the truth value of quantitative data by how well the study manages threats to internal validity supported by changes in the independent variable, the intervention, accounting for changes in the dependent variable, students' attitudes toward STEM environments (Krefting, 1991). To manage threats to internal validity, the researcher must account for confounding variables in the data through the influence indicator (see Appendix Y).

The researcher assessed the truth value of qualitative data through credibility (see Guba, 1981) that maintained a prolonged field experience during the SOOC through the researcher's presence at the after-school computer room, and presence at the Hack-A-Thon. The researcher performed persistent observation attempts to sample all students' interactions. The researcher and STEM Intern were a part of the research and not separate; therefore, a field journal was particularly important to keep a daily schedule, logistics, and methods log that provided an audit trail and annotations of the researcher's and STEM intern's ideas, thoughts, and feelings (see

Krefting, 1991). Triangulation increases credibility through the convergence of multiple perspectives of data methods; surveys, interviews, email, correspondence, and journaling. Member checking is the ability of informants to recognize their experiences as recorded by the researcher (Krefting, 1991). Peer examination of results by the after-school education department could increase the credibility of findings and resolve inconsistencies. The authority of the researcher could gain credibility through four characteristics developed by Miles and Huberman (1984). The first was the researcher's degree of familiarity with the setting under study (Krefting, 1991). This characteristic was true because, during the past 2 years, the researcher coached a robotics team in this setting and participated in a policy change to improve after-school education initiatives by replacing inexperienced high-school tutors with student-teachers from the High School for Education and Training.

Applicability

A researcher assesses applicability as the degree to which another researcher could utilize the findings in other contexts and settings (Krefting, 1991). In the quantitative world, external validity describes the ability to generalize to a larger population to support causal inferences (Wholey et al., 2010). Krefting (1991) posited that generalizability was irrelevant in qualitative research because the strength of this approach was in naturalistic settings with limited controlling variables. Guba (1981) encouraged using the word transferability to describe a goodness of fit in two contexts that were the responsibility of the next researcher to reenact the study, rather than the duty of the original researcher. The dense description provides a database that permits transferability judgments by the future researcher to reenact the study (Krefting, 1991).

Consistency

The researcher assessed consistency as the degree to which the methods revealed consistent findings upon replication. The quantitative approach bases reality as a single view and uses the term reliability to determine if repeated administration of measures provides the same data (Krefting, 1991). In a qualitative approach, the researcher and the informants are instruments within the study and greatly vary from context to context. Guba (1981) recommended using the term dependability, which rested on the trackable, expected variability within data sources. Quantitative measures identified outliers and used these to determine boundaries. Qualitative measures sought a range of experience; if an informant was not representative of the group under study, his or her viewpoint remained essential. The current researcher established dependability through a code-recode procedure during the analysis phase to reexamine emerging themes.

Neutrality

A researcher assesses neutrality, defined as freedom from bias, by Guba's (1981) shift of neutrality from the researcher, who maintains contact with informants, to the data through confirmability. Krefting (1991) offered strategies to increase confirmability through an audit of the field notes, data reduction through condensed notes, thematic categories. Reflexivity is an assessment of evidence of the researcher's background and perceptions in the research process (Ruby, 1980).

STEM Subscales

Quantitative data analysis of the 21st Century Learning section of the S-STEM Surveys (see Appendix AA) triangulates with student interviews (see Appendix K) to contribute to the researcher's understanding of a sense of belonging in STEM environments. Questions in the 21st

Century Learning section touched on having leadership, helping others, respecting differences, and setting goals.

The analysis of STEM subscales considers preparing students for the global economy and connections to 21st-century skills (Partnership for 21st Century Learning [P21], 2007). P21 (2007) was a collection of skills to succeed in the present millennium culled by teachers, education experts, and leaders in the business sector. The collection began with a list of disciplines that Banks (2015) referred to as *school knowledge*, which consisted of textbook content that was rarely examined by students regarding underlying assumptions. The 21st Century Framework for Learning began with a list of subject disciplines, including technology proficiency, life, career, and innovation skills (Partnership for 21st Century Learning, 2007); however, one skill that appeared on the World Economic Forum list (Schwab, 2016) that the P21 framework lacked: emotional intelligence.

Salovey and Mayer (1990) defined *emotional intelligence* (EI) as the ability to monitor one's own and others' feelings, to differentiate among emotions, and to act upon these to guide thinking or actions (Labby, Lunenburg, & Slate, 2012). Gray (2016) offered a comparison of the World Economic Forum list from 2015 to the list of skills needed to compete in the global economy of 2020. EI was not on the 2015 World Economic Forum list. Banks (2015) suggested that empathy for others required higher-order thinking skills that moved beyond textbook knowledge to consider the plight of marginalized people.

The S-STEM surveys included questions regarding the effect on others during decision-making (see Appendix AA), and the researcher believed that this attribute was crucial in the Fourth Industrial Revolution STEM environments. This researcher believed that the STEM constructs queried by the S-STEM 21st Century Learning survey (see Appendix AA) addressed

EI as a crucial skill to engage in the Fourth Industrial Revolution workplace. EI should be the focus of attention by educators to provide situated sociocultural contexts for students to improve threats to what Gee (2008) referred to as affective or emotional threats to social, cultural, and emotional perceptions.

Resnick (1987) emphasized that schools fostered individual cognition, whereas the workplace centered on the social construction of knowledge. In his situated sociocultural perspective, Gee (2008) listed three aspects of a person's environment that influenced learning: embodiment, distributed cognition, and social practices. Embodiment links learning to experience where students do not just understand skills but also make connections through the application of learning (e.g., mobile programming applications in MIT App Inventor). Distributed cognition used tools that Vygotsky (1978) called mediating devices. Cultural sense of self and perceived threats could prohibit learners to engage in the social practices of learning in situated sociocultural learning, such as the Hack-A-Thon (see Gee, 2008).

Regarding sense-of-belonging, the feedback from informants triangulated with the quantitative S-STEM survey 21st Century Skills and the interview/focus group to examine rich data regarding students' viewpoints of the self and others. Labby et al. (2012) cited empathy among the five domains of emotional intelligence. Consideration of others' opinions, viewpoints, and feelings provided students with the necessary skills to foster belonging in STEM environments.

Procedure

The timeline of the intervention (see Appendix Z) commenced in June 2018 with the submission of all study documents to the Johns Hopkins University Homewood Institutional Review Board (IRB). Once IRB approved the study, the recruitment of participants began in

August 2018 by posting flyers at the After-School building in Paterson, New Jersey. Through the systematic process at two parent events in August 2018 of replying to parents' inquiries, collecting completed informed consents, student assents, and parent surveys, the study team focused on recruiting one sample of students. This study was a mixed-method convergent design that did not employ an experimental-randomized or a non-randomized quasi-experimental control group.

The advisory committee suggested that the researcher concentrated on recruiting as many participants to the study as possible, given the low number of 100 students in the after-school program setting. Twenty-three families signed parental informed consents and student assent forms. Of the 23 students enrolled in the study, 17 consistently participated in the 25-school-day program. The purposeful recruitment of female participants resulted in 10 girls and seven boys actively attending the SOOC. The overall rate of attendance was 79%, with girls attending at a rate of 76% and boys at 83%.

During October 2018, participants completed one of two S-STEM surveys, according to their grade levels (see Appendix AA). The researcher provided students with login credentials to the Google Classroom website. The same Google login credentials established an MIT App Inventor account for each participant. All students used the MIT App Inventor Android emulator software downloaded to the After-School program's 18 desktop computers to test their developing programs. As students completed the beginner, intermediate, and advanced level videos, they tested their developing programs at the three intervals on Chromebooks paired to two of the researcher's Android phone devices.

The official "kick-off" of the SOOC was on Monday, October 1, 2018, when participants gathered in the after-school computer room to receive a set of ear buds to plug into the audio port of the computer to facilitate listening to the small-skill video. The researcher worked with the students to login to the Google Classroom and MIT App Inventor websites. Throughout October 2018, the students met in the computer room and progressed through the programming skill levels. Students could access up to 28 small-skill videos from the computers at Oasis. The researcher attended the after-school program each of the 25-day program from October 1 through November 3 to answer questions.

As the students completed videos and filled out the star-rating survey (see Appendix X), they received one of 28 consecutively numbered digital badges to mark their progress. Students who completed a level received a paper certificate to award their achievements. Each student had access to a virtual bulletin board on the Padlet website that archived their awarded digital badges and an electronic copy of beginner, intermediate, and advanced level certificates (see Appendix CC).

On November 3, 2018, students convened at the after-school building to participate in a Hack-A-Thon to practice their MIT App Inventor skills. The researcher encouraged team formation of heterogeneous groups based on beginner through advanced levels of programming skills. The researcher provided two challenges to the students to complete an Android application in teams of two during the Hack-A-Thon. The first challenge was a painting application that allowed the user to draw on the screen in red, green, black, or blue using two line widths. The finger painting application exercised the x/y axis points of the screen and provided the users with the ability to erase their drawings to begin again. The second challenge was a "mole masher" game-like arcade device that displayed a mole at varying points on the screen using a random-number generator. The user gained and loses points that the programmer must calculate and display on the screen. At the end of the day, students gathered together for a focus group (see

Appendix K) to reflect on STEM environments, programming, college, and career plans. During November, the researcher organized the data for analysis. The researcher contacted selected participants to interview for member checking to confirm findings.

Intervention. The objective of this study was to better understand students' gender-based attitudes in STEM environments. The current researcher's focus was not on the acquisition of programming knowledge. Instead, the focus was on students' attitudes in STEM environments. The SOOC and Hack-A-Thon were advanced programming, agentic, math-intensive STEM environments that were typically avoided by female students (see Nugent et al., 2015; Riegle-Crumb et al., 2012; Spitzer & Aronson, 2015; Wang, 2013). Students' attitudes before the intervention began (see Appendix AA) were compared to the same students' perceptions at the end of the SOOC, which indicated a change in attitudes regarding STEM environments. Focus group and individual interviews conducted after the Hack-A-Thon could enrich the quantitative data and reveal the impact of an advanced programming course on attitudes toward STEM. The researcher hypothesized that females would continue to choose communal careers that helped others (see Eagly, 2013), while males would continue to select agentic, rigorous careers that were math-intensive (Diekman & Eagly, 2000).

Data collection. The data collection depicted in the Summary Matrix (see Appendix Y) provided data to establish opportunities to covary STEM attitudes with the moderating variables of gender, SES, race, ethnicity, and grade. Controlling for prior knowledge, analysis of the data could reveal that the intervention had a positive, negative, or no effect on students' attitudes. The effect size (see Appendix M), given the expected small sample, was not robust enough to claim causality. The researcher expected a moderate effect of .5 as per Cohen (Cohen, 1988), rather than a small (.20) or large (.80) impact (see Appendix N).

In the short term, within three months, the intervention sought to change students' attitudes toward math by providing an advanced programming course using real-world, applicable math examples. Students indicated that school math contexts were devoid of cases that exercised their abilities to apply concepts in realistic settings (see Mistretta, 2017a). In the medium term, within 4 to 9 months, the proximal outcome could change the enrollment ratio of male to female students in advanced programming course offerings by improving female students' sense of belonging in STEM environments. In this context, historic course enrollment was predominantly male, with past male-to-female ratios of 9:3, 10:4, 12:1, and 11:4. Rigorous technology electives remain under-enrolled by female students (Beyer, 2014; Nugent et al., 2015). In the long term, through prerequisite courses, the intervention sought to reduce females' attitudes of avoidance toward agentic, math-intensive STEM careers (Cheryan et al., 2017).

Summary matrix. The summary matrix table (see Appendix Y) presents all quantitative and qualitative data collected pre and post intervention. The table is organized in columns by indicator, intervention research question, operationalization of indicator, data sources, data collection tool, and frequency. The categories of indicators include Process (P), Outcome (O), Moderating (M), and Control (C). The categories of intervention research questions refer to IRQ1 as students' interest in advanced programming (prog) electives; IRQ 2 as students' perceptions of stereotype threat; and IRQ3 as students' interests in applicable math in real-world contexts.

Progress indicator. Linnan and Steckler (2002) indicated that the implementation component of a process evaluation revealed the degree to which the program was applied and utilized by the targeted participants. The first of three process indicators collected in quantitative and qualitative measures was the progress indicator. The program defined the progress indicator as the extent to which a student completed small-skill video lessons. The study measured students' progress through the SOOC using quantitative star rating surveys at the end of each small-skill lesson and consecutively numbered earned digital badges. Qualitative measures archive and code email correspondence with the researcher and focus group/interview data. The research questions addressed by the progress indicator included IRQ1, students' interests in advanced programming electives by their levels of achievement regarding the number of lessons completed and IRQ3, students' willingness to apply math in real-world applications, as evidenced in applications working without error.

***Device indicator*.** The second of three process indicators collected in quantitative and qualitative measures was the device indicator. The context of an intervention is the macrosystem (Bronfenbrenner, 1977) of overarching political and social environments that influence the program (Baranowski & Stables, 2000; Linnan & Steckler, 2002). The SES of participants' families could moderate the effects of the intervention. A parent demographic survey conducted at the beginning of the program includes questions regarding SES and the family's available devices to access the Internet. Inconsistent network access or availability of devices could limit students' ability to transition through the three SOOC levels. The program expected the context of the after-school program to moderate the effects of the intervention as aligned with the SES of 92% of living in poverty (Shafer & Peron, 2018). The quantitative device indicator covariates SES with surveyed student devices. The qualitative data collected through email correspondence documented the devices employed by students to complete assignments. The research question addressed by the device indicator was IRQ2, students' perceptions of stereotype threat. If students perceived exclusion regarding their SES levels or access to home computers and testing devices outside of the after-school computer room, then this aspect could impact their sense of belonging in STEM environments.

Influence indicator. The third of three process indicators collected in quantitative and qualitative measures was the influence indicator. The program defined influence as a combination of internal assistance by students' parents to complete lessons, as well as external assistance regarding other sources of programming experience. The skill pre-assessment queried students' external influences. The program archived instructor/student email correspondence to detect and code instances of internal assistance to complete assignments. The research question addressed by the influence indicator was IRQ2, students' perceptions of stereotype threat. If students perceived that their parents or siblings interfered with their progress in the SOOC by either not allowing them to attend the after-school program (family conflicts, homelessness) or interfering with their assignments on home computers, then this aspect could impact their sense of belonging in STEM environments. External influences could include other online programming platforms or school programs that impact their attitudes toward STEM environments.

Outcome indicators. There were seven outcome indicators that categorize student attitudes toward STEM, including 21st century learning attitudes and interest in STEM careers (see Appendix AA). The S-STEM survey placed math, science, engineering, technology, 21st century learning, and interest in STEM career data into separate sections, thus allowing the researcher to analyze outcomes by STEM category. The researcher administered the same S-STEM survey pre and post intervention. The values of the questions were from 1 to 5 on a scale of *strongly disagree* to *strongly agree* (see Appendix AA for survey questions).

Each section had a separate aggregate value that the researcher analyzed. The first six categories were then averaged into the students' attitudes toward STEM indicator to detect change from pre to post intervention measurements. The data collected after the Hack-A-Thon during focus group/interviews of students regarding their attitudes toward STEM environments enriched the quantitative S-STEM outcome indicators. Depending on the number of students recruited for this intervention, the researcher intended to conduct one-to-one interviews (see Appendix K) of each student to enrich the quantitative data.

Moderating indicators. There were five indicators that served as moderating, defined as variables that influenced the strength between two variables in a particular context (Leedy & Ormrod, 2010). Gender was a moderating variable collected in the pre- and post-S-STEM survey and in the student pre-assessment of programming skills. Gender engaged each of the three intervention research questions regarding programming, stereotype threat, and math. The parent survey collected race, ethnicity, and SES at the beginning of the intervention. The S-STEM surveys contained questions regarding race and ethnicity. The researcher chose to use the S-STEM surveys in their original format to maintain the established reliability and validity of the measure. The parent survey queried race, ethnicity, and SES, and these sought to answer IRQ2 regarding stereotype threat to examine the influence of STEM environments in the context of the poverty demographic (see Alexander, 2016) of the after-school setting. Grade level was the final moderating variable queried during the pre-assessment, pre and post intervention S-STEM measures, and noted in the focus group/interview processes. A sleeper-effect, defined as a change in attitude manifested after a time delay (Shadish et al., 2002), could be present regarding a change in STEM attitudes through participation in this intervention. According to Gee (2008), a student's environment contains affordances defined as a person's perception of the feasibility of acting upon something in their environment (Gee, 2008; Greeno, 1994). An effectivity is something contained in a student's environment that he or she perceives can be acted on (Gee, 2008). Students change in attitude can be distal rather than proximal when electing to take more STEM electives or pursue STEM college majors or careers.

Control indicator. The final indicator was the control variable of prior knowledge, which the researcher queried during the pre-assessment regarding other courses that might account for a change in STEM attitudes. This variable was considered during data analysis to determine if the researcher should consider other alternative explanations other than the intervention regarding the change in students' STEM attitudes.

Summary

The intervention addressed the unmet need of advanced programming courses in an underserved population of coed students in fourth through seventh grades in an after-school program in the Northeast United States. The course provided male and female students with an opportunity to learn MIT App Inventor in a self-paced scalable, open online course, before convening at a one-day Hack-A-Thon to develop an authentic STEM mobile application in a team event. This intervention sought to understand better gender-based attitudes in STEM environments.

The research design was a convergent, mixed methods approach that included recruiting a purposeful, gender-balanced sample of students without employing a randomized experimental or nonrandomized, quasi-experimental control group. The setting of the intervention was a small after-school program, and all participants in the sample received the treatment of up to 28 small-skill, worked-example videos at pre-assessed skill levels, and a 1-day team Hack-A-Thon event. The evaluation design considered gender as a moderating variable (see Appendix Y). Lipsey and

Hurley (2009) provided a multiplier of effect size on an ANOVA test associated with moderating variables that could reveal an increased effect size regarding gender attitudes toward STEM environments.

Quantitative measures included an S-STEM (Unfried et al. 2015) pre and post survey that queried student attitudes toward each subject area of the STEM acronym, as well as viewpoints regarding 21st century skills and future career aspirations (see Appendix AA). The research included a parent survey (see Appendix R) at the beginning of the intervention, and SOOC lesson interval surveys (see Appendix X) of students' progress through the video lessons. The program awarded up to 30 consecutively numbered digital badges that served to quantify students' progress through the intervention.

Qualitative measures included archived instructor/student email correspondences and focus group/interviews after the Hack-A-Thon. The researcher and STEM intern conducted member checking to clarify students' viewpoints recorded during the focus group/interview process. The convergent mixed methods approach prioritizes the quantitative and qualitative data equally, analyzes findings separately, and then combines data into one database to triangulate and enrich analysis.

Chapter 5: Process of Implementation

Process of Implementation

The Education Department of ASP and the researcher agreed on the program name "Android Inventor" to provide enrolled students with an opportunity to learn to program using the MIT App Inventor online development environment. The recruitment of participants aligned with a 2-day Back to School Boutique during August 2018 where ASP invited students and their parents to receive school supplies and backpacks for the upcoming school year. The researcher attended the 2-day event to meet the families and explain the Android Inventor program. During this time, 25 students in fourth through ninth grades completed assent forms, students' parents filled out informed consents (see Appendix S), and parents completed a demographic survey in English or Spanish (see Appendix R). Purposeful recruitment sought female students to provide data to inform the focus of the study regarding the underrepresentation of women in STEM courses, majors, and careers. The Back to School Boutique recruitment resulted in 15 girls and 8 boys for a total of 23 students that provided a 2:1 ratio of girls to boys thus fulfilling the intended purposeful recruitment.

To assist in the implementation of the Android Inventor program at ASP, the researcher received IRB approval to add an intern to the study team (see Appendix BB). The intern, a female college Freshman majoring in computer science, assisted in maintaining a password-protected master list of students, communicating with parents in Spanish, and organizing the study participants during the 23 days that the Android Inventor sessions occurred. The intern contributed to the researcher's Evernote journal to record qualitative data regarding the participants of the study in their day-to-day program activities. The researcher and intern met with the principal investigator each Thursday during the intervention via Zoom to discuss the progress of the study.

The researcher established a Google classroom platform to link small-skill videos in beginner, intermediate, and advanced class levels. Because the students and parents did not maintain personal Gmail accounts, the researcher established 25 email addresses to facilitate participants' login to the Google classroom and the MIT App Inventor development environment. ASP did not subscribe to the Google G Suite classroom product; therefore, students did not have an organizational email assigned to them by ASP that could facilitate login to the online platforms. All students started the program at the beginner class level to progress through the development of a dice game on MIT App Inventor.

When the students first arrived at the Android Inventor program held in the second-floor computer room of ASP, they selected a desktop device to sit next to friends. Once the students selected a device, the researcher and intern placed nametags on the back of each desktop screen (see Appendix CC) to learn the names of the students and to facilitate attendance in the password-protected master list. The ASP Education Department asked the researcher and intern to assist all students with the completion of homework assignments first. Then, each student could progress to the Android Inventor Google Classroom after they completed their schoolwork. During the first week of the Android Inventor program, the students used the computer room desktops to complete the S-STEM pre-survey on the researcher's password-protected SurveyMonkey account to query students' attitudes regarding science, technology, engineering, math, 21st century skills, and STEM careers.

The researcher and intern wrote a schedule on the classroom whiteboard to indicate timeframes for homework, Android Inventor work, and a plan for bathroom or water breaks.

ASP required that teachers or their assistants accompanied all students to the bathroom, water breaks, or dismissal to the cafeteria on the ground floor of the building. The schedule helped the researcher and intern maintain effective classroom management of students from the time they arrived at the computer room at approximately 3:45 pm until dismissal at 6:00 pm.

The researcher developed 1 prototype of a dice game on MIT App Inventor and recorded 9 beginner, 12 intermediate, and 7 advanced small skill videos to facilitate instruction of students in programming the dice application. The skill level groupings resided in three classes on the Google Classroom website, and students used their assigned Gmail to log into both the Google classroom and the MIT App Inventor development environment. The researcher provided earbuds to each student to connect to the desktop audio port to facilitate watching and privately listening to the small-skill programming explanations (see Appendix FF). The class programmed and tested their developing dice game on a software emulator downloaded to each desktop by the ASP technology coordinator prior to the start of the Android Inventor program (see Appendix EE). The emulator software that simulated an Android phone became problematic on some desktop devices. Students who opened another browser tab to play a video game, instead of making progress on their applications take up random access memory (RAM) needed by the MIT App Inventor emulator. The study team remedied this situation by clearing the Chrome browser cache and restarting the emulator. Students who stayed on task without opening new tabs with video games had no problems with the emulator to test their developing programs.

The students received one of 28 digital badges posted to their individual, online, Padlet.com bulletin board each time they completed a small-skill video (see Appendix DD). As students completed one of the three skill levels, the researcher tested the application on an Android device paired with a Chromebook laptop and awarded the student with a paper certificate commemorating their accomplishments. The desktops in the computer lab connected to the Internet through a network that was unavailable to mobile devices. Therefore, students logged into their MIT App Inventor account using the Chromebook laptop that could connect to the same ASP wireless network as the researcher's Android test device. The researcher chose to use desktop stations to facilitate homework and the Android Inventor programming because there were 18 desktop devices and only nine working Chromebooks in the ASP computer lab.

The first student to complete the beginner level dice game was a seventh-grade female student. She exhibited her working program on a Chromebook device, tested her application on an Android mobile phone, received the nine beginner-level digital badges on her Padlet.com virtual bulletin board as she completed the videos, and received a paper beginner STEM certificate to take home to show her family (see Appendix GG). By the end of Week 1 of the Android program, 19 students earned 51 badges with an average of 3 badges per student. Two female students were consistently absent during the remaining three weeks of the program and were subsequently removed from the data analysis. Therefore, the final sample size was 17 participants including 10 girls and seven boys with a 1.5:1 ratio of girls to boys.

During the 4-week program, 12 students completed the beginner level and started the intermediate class. Two male students completed the intermediate level, received a paper intermediate certificate, 12 intermediate digital badges, and moved to the advanced level. One male student completed all 28 video lessons to receive every digital badge and an Advanced STEM certificate.

During the last 2 days of the Android Inventor program, the researcher conducted interviews in an office down the hall from the computer room with the 17 participants in small groups. The intern remained with the class to monitor the remaining students. The researcher used the “otter.ai” recording and transcription application on a password-protected iPhone to capture and transcribe the interview discourse. To provide a backup of all interviews, the researcher also typed the students’ replies to interview question (see Appendix K) in the password-protected Evernote study journal to verify the “otter.ai” transcriptions. All 17 students completed a post S-STEM survey recorded on the researcher’s password-protected SurveyMonkey account using the computer room desktops.

On the last day of the Android Inventor program, 14 of the 17 participants convened in the ASP third floor activity room for a 3-hour Hack-A-Thon to collaborate on two new Android applications. Of the 14 students present, nine were girls, and five were boys. The researcher and intern permitted the students to choose a partner and receive suggested screen layouts for a mole masher game and finger paint Android applications. The student pairs worked together on a shared laptop to collaborate to employ the skills that they learned during the Android Inventor lessons to complete programmed solutions.

There were two male/female teams and five same-gender teams. The teams chose which of the two applications to work on first. The researcher and intern walked around the activity room to observe collaborations and answer questions. The atmosphere was collegial and happy. Teams that completed an application tested the program on the laptop paired with an Android device on the same wireless network. If the team encountered errors in their program, they were asked to examine their programs, make corrections, and retest their applications. Most teams completed two applications during the 3-hour Hack-A-Thon.

The researcher received prior IRB approval to provide the students with an empanada lunch prearranged through ASP by a local business. The teams took a break for lunch, and some returned to their laptops while still consuming empanadas to continue to program. Toward the end of the session, the researcher repeated the same interview questions with the assembled group. The intern used the "otter.ai" application on the researcher's password-protected iPhone to record the participants' answers. Subsequently, the intern listened to the recording again and corrected a copy of the transcript in the researcher's Evernote journal as needed.

Quantitative Data

The researcher exported the pre- and post- S-STEM surveys into two datasets in SPSS format. The survey queried the students' name, and the intern examined the dataset to verify that all 17 participants of the Android Inventor program were present in the data. The S-STEM survey contained five sections regarding attitudes toward math, science, engineering/technology, 21st century learning, and STEM careers. One science and three math questions in the S-STEM survey were negatively worded (Friday Institute for Educational Innovation, 2012c). The researcher used the transform-recode into different variables feature of SPSS to create positively-coded variables. A mean calculation of each section of the S-STEM survey using all the positively-coded variables resulted in five pre- and five post-variables. The researcher created the STEM Agentic Careers Attitudes variable regarding students' attitudes toward agentic, math-centered, male-dominated careers by calculating the mean of students' pre- and post-attitudes toward physics, mathematics, computer science, chemistry, energy/electricity, and engineering. The researcher created a variable for each of the five sections to reflect the differences between the post-S-STEM and pre-S-STEM attitudes. Participants' STEM pre- and post-attitudes variables contain an average of students' math, science, engineering and technology, and 21st century learning attitudes to provide the study with an overall reading of participants' STEM Attitudes (see Table 6).

Table 6

Pre- and Post-S-STEM Variables

Variable	Pre-S-STEM	Post-S-STEM	Difference
Math Attitudes	PreMeanMath	MeanMath	DifMath
Science Attitudes	PreMeanScience	MeanScience	DifScience
Engineering and Technology Attitudes	PreMeanET	MeanET	DifET
21st Century Learning Attitudes	PreMean21st	Mean21st	Dif21
STEM Agentic Careers Attitudes	PreAgenticCareers	AgenticCareers	DifAgentic
STEM Attitudes	PreSTEMAttitudes	STEMAttitudes	DifSTEM

Qualitative Data

The qualitative data were comprised of an Evernote study journal, transcripts of student interviews and the Hack-A-Thon focus group, and notes keyed into the Evernote study journal by the researcher during participant interviews. The researcher could not interview three students because two female students and one male student were absent during the interview dates. Those students also did not attend the Hack-A-Thon.

The researcher and intern met once a week through Zoom in the November 2018 to January 2019 timeframe to code the qualitative data sources (see Appendix Y). To establish intercoder reliability (Creswell & Plano Clark, 2011), the researcher created a copy of the Evernote interview journals to provide the intern with the opportunity to code independently before comparing notes of emerging themes by highlighting keywords. After they completed an independent review of the interview data, the intern and researcher convened online in Zoom sessions to compare emerging themes. The researcher and intern used the Evernote study journal to review notations of students' progress and persistence through the small-skill videos.

During these analysis sessions, three iterations of coding (Saldana, 2016) ensued to discover recurring themes in the categories of science, technology, engineering, math, and careers (see Appendix HH). The first iteration of coding yielded themes in science which reveal that the students equated science experiments with engineering. Both genders thought that the labs conducted in science class were examples of experience in building. Students offered the phrases “experiments,” “building,” “health,” “musical instruments,” “helps other people,” and “projects.” The second iteration of coding summarized the science category as “experiments” and “engineering.” The final code attributed to the science category was “equates experiments with engineering” (EEE).

The researcher and intern conducted the same process with the technology category. The first iteration in the technology category yielded the phrases “games,” “typing,” “Google Classroom,” “play,” “Google accounts,” “activity,” and “few computers.” The second iteration of coding in the technology category summarized the themes as “games” and “online learning systems.” The researcher and intern named the final code as “limited exposure to technology” (LET).

The engineering category produced few codes since the students equate science with building. The first iteration of codes yielded the themes “science,” “experiments,” and “don’t know.” The second iteration produced the code “science” and the final code regarding engineering was “equates engineering with science” (EES).

The math category yielded student-produced labels of “hard,” “easy,” “teacher,” and “problems.” The second iteration centered on the code “problems” and the final code produced “teacher-centered well-structured problems” (WSP).

The careers category produced the first iteration of codes naming careers or a lack of ideas of future jobs. Several students indicated that they "don't know" what career they want to pursue. Some indicated that they want to "help other people," whereas others indicated "model," "programmer," "engineer," "policeman," "doctor," "baker," and "marine biologist." The second iteration established codes as "help others" or "math-intensive field." The final code in the career category resulted in "communal" for careers that help people and "agentic" for math-intensive.

The last category was STEM to code the transcripts for knowledge of STEM as an integrated field of study. The first iteration of codes yielded "a part of a plant," "unaware" or "survey." One student revealed that she learned the meaning of the STEM acronym from the researcher's survey. The second and final codes (Creswell & Plano Clark, 2011) yielded "STEM-Blinders" (SB).

Empirical Findings

The empirical findings of this study aligned with the summary matrix of research questions, indicators, and data sources (see Appendix Y). The researcher presents these findings organized by research question and substantiates findings with indicators and data sources.

IRQ1 - Students' Interest and Persistence in Advanced Programming Electives

The first research question asked, "What are students' attitudes toward increasingly advanced SOOC offerings? In what way does gender influence persistence in achieving higher programming skill levels?" The 17 students of this study completed up to 28 small-skill videos in the computer lab during the 23 school-day timeframe of the Android Inventor program. The device indicator (see Appendix Y) documented during the parent demographic survey (see Appendix R) revealed that all families categorize themselves at the poverty income level (Federal Register, 2018) without consistent computer or Internet access at home. Therefore, the students completed the Android Inventor small-skill videos on ASP devices during the week while present at the program. The intervention did not exercise the remote access aspects of a SOOC. Instead, the individual progress of students through small-skill videos on a Google Classroom platform provided participants with the opportunities to complete self-paced, online instruction to program an Android application in increasingly advanced programming techniques while present in the ASP computer room.

Of the 10 female participants, six progressed to the intermediate level. Of the seven male participants, six progressed to the intermediate level. Two males started the advanced level videos and one male completed all 28 videos (see Table 7).

Table 7

Increasingly Advanced Levels by Gender – Google Classroom Login Data

Gender	Beginner	Intermediate	Advanced
Female	10 of 10 achieved 100%	6 of 10 achieved 60%	0 of 10 persisted 0%
Male	7 of 7 achieved 100%	6 of 7 achieved 86%	2 of 7 persisted 29%

The intern verified each student's number of completed videos by logging into each MIT App Inventor account and viewing the steps accomplished in their program to quantify digital badges earned by student and gender. The researcher analyzed the level of persistence by examining the number of digital badges achieved by each student to answer Research Question 1 regarding persistence to advanced levels of programming by gender (see Table 8). A mean calculation of percentage of completed videos by gender reveals that males persisted at a 54% completion rate while females completed 36%. The females achieved an average of 10 badges while the males collected an average of 15 badges.

Table 8

Number of Digital Badges Achieved per Study Participant

Android Inventor ID	Gender 1 = Female 2 = Male	Total Number of Digital Badges	Percentage of 28 Possible Badges
Inventor1	1	9	32.14%
Inventor2	2	15	53.57%
Inventor3	1	16	57.14%
Inventor4	2	9	32.14%
Inventor5	1	12	42.86%
Inventor6	1	9	32.14%
Inventor8	1	10	35.71%
Inventor10	2	28	100.00%
Inventor11	1	3	10.71%
Inventor12	2	12	42.86%
Inventor14	1	9	32.14%
Inventor15	2	1	3.57%
Inventor16	2	19	67.86%
Inventor17	1	19	67.86%
Inventor20	1	4	14.29%
Inventor21	1	10	35.71%
Inventor25	2	22	78.57%
Totals	10 Females 7 Males	Female Average 10 Male Average 15	Female Avg. 36% Male Avg. 54%

The researcher and intern administrated the pre- and post-S-STEM Survey to all 17 study participants. The S-STEM Likert scale measures students' attitudes as 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, and 5 = *strongly agree*. During this phase of the quantitative analysis, the researcher looks for scores 4 and above to show positive attitudes toward the five sections of the survey; math, science, engineering and technology, 21st century skills, and attitudes toward agentic careers. The programming of a dice game exercised math and technology skills. The application represented the type of program understood by workers in agentic careers in STEM environments. Therefore, math, engineering and technology, and overall STEM attitudes assisted the researcher in answering Research Question 1, regarding advanced SOOC offerings and persistence through advanced course offerings by gender. The following math, engineering and technology, and STEM attitudes sections present the empirical findings that contribute to answering research question one.

Quantitative Considerations of RQ1 - S-STEM Survey Results – Math Attitudes

The pre-S-STEM survey revealed that 8 of the 10 females' attitudes were in the 1 to 3 = range to *disagree* or *remain neutral* regarding having math abilities. Two of the 10 girls indicated confidence in math by indicating the 4 = *agree* response. Of the 7 boys, 5 revealed attitudes in the 1 to 3 range to *disagree* or *remain neutral* regarding math abilities. Two of the boys indicated confidence in the Pre-S-STEM survey regarding confidence in math (see Table 9).

Table 9

Preintervention Mean Math Attitudes by Gender

	S-STEM Survey Likert Score													
Gender	1.88	2.25	2.50	2.63	3.13	3.50	3.63	3.75	3.88	4.13	4.25	4.38	4.50	Total
Female	1	1	1	0	0	1	2	2	0	1	1	0	0	10
Male	0	0	0	1	1	0	0	1	1	0	1	1	1	7
Totals n = 17	1	1	1	1	1	1	2	3	1	1	2	1	1	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

During the post-S-STEM survey, the females did not indicate any 1 = *strongly disagree* or 2 = *disagree regarding* math abilities. However, only 1 girl indicated a 4 = *agree confidence* in the post-S-STEM survey regarding math abilities. The 9 other females were neutral in the 3 = *neither agree nor disagree* range. Of the 7 boys, 3 were neutral in math abilities with a 3 = *neither agree nor disagree* response. The remaining 4 boys indicated a 4 = *agree* in math abilities in the post-S-STEM survey (see Table 10).

Table 10

Post intervention Mean Math Attitudes by Gender

	S-STEM Survey Likert Score								
Gender	3.00	3.25	3.38	3.50	3.63	3.75	4.00	4.50	4.75	Total
Female	1	1	2	1	1	3	1	0	0	10
Male	0	0	0	1	1	2	1	1	1	7
Totals n = 17										
	1	1	2	2	2	5	2	1	1	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

Regarding the difference between the pre-STEM and post-STEM survey of math abilities, the DifMath variable (see Table 6) represented the post-STEM math mean attitudes minus the pre-STEM math attitudes. The results of this calculation revealed that four girls had a change in math attitudes from pre-to post intervention indicated by a negative number in the DifMath variable (see Table 6). The remaining six girls showed small increases in up to 1.50 Likert score in math attitudes. Three of the seven boys also showed a reduction in math attitudes pre-and post intervention with an up-to-1-point increase for the remaining four boys (see Table 11).

Table 11

Difference of Post-Math and Pre-Math Attitudes by Gender

	S-STEM Survey Likert Score														
Gender	-.75	-.63	-.50	-.38	-.13	.00	.13	.38	.63	.75	.88	1.00	1.25	1.50	Total
Female	1	0	0	3	0	1	1	1	0	1	0	0	1	1	10
Male	0	1	1	0	1	0	1	0	1	0	1	1	0	0	7
Totals n = 17	1	1	1	3	1	1	2	1	1	1	1	1	1	1	17

Note. Likert Score Categories: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree.

Qualitative Considerations of IRQ1 – Math Attitudes

The qualitative student interview transcripts, intervention journal entries, and Hack-A-Thon focus group transcripts reveal an overall lack of math ability in the study participants. The researcher and intern coded the qualitative data independently to arrive at inter-rater reliability regarding participants' overall struggle with math except for one female participant, Inventor 17 (see Appendix GG), who was the first to receive a Beginner Android Inventor Certificate. During the interview, Inventor 17 indicated that she wants more math classes in school. When the researcher asked the remaining Inventors about math class, some students admit that they find the subject difficult while others reveal that they like math and receive good grades. The students mention math-skills tests during school but do not appear to know how and when to apply math in-context.

Inventor5 showed a strong interest in post intervention engineering and technology attitude with a Likert score of 4.56 and an interest in agentic careers at 4.00. However, this female student shared, "Math is hard. I don't understand rounding."

Quantitative S-STEM Survey Results – Engineering & Technology Attitudes

Eight of the ten females indicated disagreement or neither agree nor disagree regarding attitudes toward engineering and technology (ET) skills on their pre-intervention survey. Two of the 10 females indicated positive attitudes toward ET pre-intervention (see Table 12).

Table 12

Preintervention Mean Engineering and Technology Attitudes by Gender

	S-STEM Survey Likert Score												
Gender	2.89	3.00	3.11	3.33	3.44	3.56	3.67	3.78	4.00	4.22	4.33	4.78	Total
Female	1	1	1	1	0	1	1	2	0	0	1	1	10
Male	0	0	1	0	1	0	0	2	1	1	0	1	7
Totals $n = 17$	1	1	2	1	1	1	1	4	1	1	1	2	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

During the post intervention survey, 6 females remained in either the disagree or neither agree nor disagree in ET attitudes. Four females indicated agreement by scoring in the 4.00 to 4.67 range regarding positive attitudes in ET, which increased by two students pre-to post intervention. Three of the seven boys indicated positive attitudes toward ET pre-intervention, and the remaining four boys indicated neither agree nor disagree (see Table 13).

Table 13

Post intervention Mean Engineering and Technology Attitudes by Gender

	S-STEM Survey Likert Score													
Gender	2.22	2.33	2.89	3.11	3.22	3.33	3.56	3.78	3.89	4.00	4.56	4.67	5.00	Total
Female	1	1	1	0	0	2	0	1	0	2	1	1	0	10
Male	0	0	0	1	1	0	2	0	1	1	0	0	1	7
Totals *n* = 17	1	1	1	1	1	2	2	1	1	3	1	1	1	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

The difference between pre-and post-intervention attitudes toward ET revealed a change in seven of the 10 females' Likert scores. Of the 7 boys, 2 indicated an increase in attitude toward ET, 2 remained the same, and 3 showed a change in attitude toward ET (see Table 14).

Table 14

Difference of Post-Mean E & T and Pre-Mean E & T Attitudes by Gender

	S-STEM Survey Likert Score												
Gender	-1.00	-.89	-.78	-.67	-.56	-.44	-.22	.00	.11	.22	.78	.89	Total
Female	1	1	1	1	0	1	1	0	0	1	0	3	10
Male	0	1	0	0	1	0	1	2	1	0	1	0	7
Totals *n* = 17	1	2	1	1	1	1	2	2	1	1	1	3	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

Qualitative Results – Engineering and Technology Attitudes

The participants possessed the general technology knowledge to log into the desktop computer, complete homework assignments that included browsing for information, attaching the earbuds to the desktop's audio ports, and accessing the small-skill videos. During the interviews, the students shared that they had little experience with programming prior to Android Inventor. Some students indicated that their school accessed code.org during Hour of Code events at school (Hour of Code, 2019). Regarding the influence indicator (see Appendix Y), the researcher could not detect any outside programming influences, such as technology classes or Internet websites, that contributed to the students' attitudes toward technology. When asked about engineering, the students mentioned experiments in science class as their opportunities to engineer or build something. For instance, they mentioned using a balloon to move a toy car, placing a rock in vinegar, perhaps using a carbonate stone to release carbon dioxide, and the properties of magnets.

When the researcher asked the students about their thoughts regarding technology, they responded with words, such as “amazing,” “fun,” and the opportunity for more programs. One research question probed for the reason the students attended the Android Inventor program. Some mentioned that their parents encouraged them to attend. Most students, both male and female indicated that they wanted an opportunity to learn how to program.

Findings - IRQ1 - Students’ Interest and Persistence in Advanced Programming Electives

Based on the data, the findings indicated that gender *did* influence persistence in students’ attitudes toward increasingly advanced programming electives. Achievement of digital badges revealed that boys persisted at a 54% completion rate of small-skill videos to the girls’ 36% (see Table 8). The researcher looked for Likert scores of 4 = *agree* or 5 = *strongly agree* in the post-STEM survey regarding math. After exposure to a math-intensive, advanced programming course, only 1 of 10 females indicated 4 = *agree* with her math abilities (see Table 10) with 4 females showing a change in math attitudes pre-to post intervention (see Table DifMath). Three of seven boys indicated agreement with math abilities, while four males remained in the *neither agree nor disagree* category (see Table 10).

The researcher looked for Likert scores of 4 = *agree* or 5 = *strongly agree* in the post-S-STEM survey regarding ET. Regarding post intervention ET Likert scores, six females revealed a change in ET attitudes after participating in an advanced programming experience (see Table 14). All males remained in a neither agree nor disagree range or in agreement of ET abilities, with one male scoring a 5 = *strongly agree* (see Table 13).

To further elucidate the findings of persistence in advanced programming electives, the triangulation of quantitative and qualitative data reveals that Inventor21, a target-female student of this study shows positive, post-intervention attitudes in math, engineering & technology, and overall positive STEM attitude of 4.11. Inventor21 reveals that she wants to go to college to take engineering courses to learn how to build cars. However, she did not persist in the small-skill increasingly math-intensive videos to achieve 10 of the 28 possible badges (36%) (see Table 15). To provide a contrast of STEM attitudes and completed badges, Inventor2, a male student of this study reveals neutral*, neither agree nor disagree*, STEM attitudes with an overall attitude of 3.38. He is not sure about college or career, admits that he is good at math but sometimes finds it hard. Inventor2 was frequently off-task during the intervention to run a video game in a browser tab that impacted the random-access-memory (RAM) of the computer. The diminished RAM resulted in the researcher or STEM intern restarting his MIT App Inventor emulator to test his developing program. Even with his off-task behavior, Inventor 2 achieve 15 out of the 28 possible badges (54%) that outpaced the 36% of badges achieved by the target-female, Inventor21.

Table 15

Target Female Participants Compared to Male Participants

Android Inventor ID (STEM Attitude)	Math Attitude	E&T Attitude	Career?
Male Inventor2 (3.38)	3.63	3.56	not sure
Female Inventor5 (3.21)	3.75	4.00	programmer
Female Inventor6 (3.94)	3.38	4.56	modeling
Male Inventor10 (3.61)	4.00	3.11	fix computers
Female Inventor17 (4.20)	4.00	4.00	scientist or engineer
Female Inventor21 (4.11)	3.38	4.67	not sure

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

IRQ2 – Students' Sense of Belonging in STEM Environments

The second research question asked, "What are students' perceptions regarding a sense of belonging in a coed STEM environment? In what way does gender influence perceptions of belonging?" The S-STEM survey contained a section regarding 21st century skills that queried the students' attitudes toward working well with others, including those different from themselves. The researcher used the pre- and post-21st century skills as one of the ways to gauge students' sense of belonging in STEM environments. The quantitative S-STEM 21st century skills data triangulated with the qualitative interview and focus group transcripts to determine students' sense of belonging in STEM environments.

Quantitative S-STEM Survey Results – 21st Century Skills and Overall STEM Attitudes

Six of the 10 females indicated agreement regarding working well with others with one female scoring a *strongly agree*. The remaining four females scored in the 3.18 to 3.82 range of *neither agree nor disagree*. Four boys indicated agreement with working well with others, and the remaining three places in the *neither agree nor disagree* range of 3.27 to 3.91 (see Table 15).

Table 16

Pre-intervention Mean 21st Century Skills Attitudes by Gender

	S-STEM Survey Likert Score												
Gender	3.18	3.27	3.55	3.73	3.82	3.91	4.00	4.36	4.45	4.55	4.82	5.00	Total
Female	1	0	1	1	1	0	3	1	0	1	0	1	10
Male	0	1	0	0	1	1	1	1	1	0	1	0	7
Totals $n = 17$	1	1	1	1	2	1	4	2	1	1	1	1	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

The post-21st century skills data indicated that the girls remained the same, with six females indicating that they worked well with others, and four stayed as *neither agree nor disagree*. The boys showed an increase in positive 21st century skills with six of the seven indicating agreement and one as *strongly agree*. One male remained in the *neither agree nor disagree* range at 3.55 (see Table 16).

Table 17

Post intervention Mean 21st Century Skills Attitudes by Gender

	S-STEM Survey Likert Score										
Gender	3.00	3.27	3.36	3.55	3.82	4.00	4.09	4.45	4.55	4.73	5.00	Total
Female	1	1	1	0	1	2	1	1	0	1	1	10
Male	0	0	0	1	0	2	2	0	1	0	1	7
Totals *n* = 17	1	1	1	1	1	4	3	1	1	1	2	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

Regarding a change between pre- and post-attitudes, despite positive indicators in pre-and post-21st century skills, 5 females showed a change in attitudes with negative differences, 2 remained unchanged, and 3 showed an increase with 1 at a full point. For males, 2 showed a decrease in 21st century skills attitudes, 1 remained unchanged, and 4 showed a slight increase (see Table 17).

Table 18

*Difference of Post-Mean 21*st *Century Skills and Pre-Mean 21st Century Skills Attitudes by Gender*

	S-STEM Survey Likert Score									
Gender	-73	-.45	-.36	-.27	.00	.18	.45	.73	1.00	Total
Female	1	1	1	2	2	1	1	0	1	10
Male	0	0	1	1	1	3	0	1	0	7
Totals *n* = 17	1	1	2	3	3	4	1	1	1	17

The researcher created a variable pre- and post- that contained the mean of the four S-STEM survey categories: math, science, engineering and technology, and 21st century skills. The pre and post variables represented students' overall attitudes toward STEM. During the preintervention measurement, 15 students scored in the 2.91 to 3.97 range that indicated neither *agree nor disagree*. One female scored in the *agree* category at 4.27 and one male a 4.14 (see Table 18).

Table 19

Preintervention Mean of Math, Science, Engineering & Technology, and 21st Century Skills Attitudes by Gender

	S-STEM Survey Likert Score											
	2.91	2.98	3.20	3.30	3.38	3.44	3.54	3.66	3.72	3.80	3.85	3.92
Gender												
Female	1	1	1	1	0	1	0	0	1	2	0	1
Male	0	0	0	0	1	0	1	1	0	0	1	0
Totals n = 17	1	1	1	1	1	1	1	1	1	2	1	1

	S-STEM Survey Likert Score				
Gender	3.97	4.14	4.27	4.66	Total
Female	0	0	1	0	10
Male	1	1	0	1	7
Totals n = 17	1	1	1	1	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

During the post intervention measurement, two girls' scores decreased to the disagree range at 2.75 to 2.79. Seven girls scored in the *neither agree nor disagree* range regarding overall STEM attitudes. Two females recorded a 4.11 and 4.20 to indicate *overall agreement* in STEM attitudes. Five boys scored in the *neither agree nor disagree* range of 3.51 to 3.99. Two males indicated *overall agreement* with 4.54 and 4.66 scores, and two females revealed positive STEM Attitudes with a 4.11 and 4.20 score (see Tables 19 and 20).

Table 20

Post intervention Mean of Math, Science, Engineering & Technology, and 21st Century Skills Attitudes by Gender A

	S-STEM Survey Likert Score											
Gender	2.75	2.79	3.08	3.21	3.38	3.42	3.46	3.51	3.58	3.61	3.79	3.94
Female	1	1	1	1	0	1	1	0	1	0	0	1
Male	0	0	0	0	1	0	0	1	0	1	1	0
Totals *n* = 17	1	1	1	1	1	1	1	1	1	0	1	1

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

Table 21

Post intervention Mean of Math, Science, Engineering & Technology, and 21st Century Skills Attitudes by Gender B

	S-STEM Survey Likert Score					
Gender	3.99	4.11	4.20	4.54	4.66	Total
Female	0	1	1	0	0	10
Male	1	0	0	1	1	7
Totals *n* = 17	1	1	1	1	1	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

Regarding differences between pre- and post-STEM attitudes, 6 of the girls reported a reduction in STEM attitudes, while 4 females reported an increase in the range of .14 to .52 points (see Tables 21 and 22). Overall, 13 students reported a *neither agree nor disagree* regarding overall STEM attitudes that supported qualitative findings, as discussed in the next section.

Table 22

Difference of Post-STEM and Pre-STEM Attitudes by Gender A

	S-STEM Survey Likert Score											
Gender	-.85	-.71	-.28	-.25	-.19	-.18	-.16	-.14	-.12	.14	.16	.32
Female	1	1	0	0	1	0	1	1	1	0	1	1
Male	0	0	1	1	0	1	0	0	1	1	0	0
Totals *n* = 17	1	1	1	1	1	1	1	1	2	0	1	1

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

Table 23

Difference of Post-STEM and Pre-STEM Attitudes by Gender B

	S-STEM Survey Likert Score				
Gender	.41	.45	.50	.52	Total
Female	1	0	1	0	10
Male	0	1	0	1	7
Totals *n* = 17	1	1	1	1	17

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

Qualitative Results – Sense of Belonging in STEM Environments

During the 23 days of the intervention, the researcher and intern referred to the program as Android Inventor and to the students as participants in a study. The study team *did not mention* the meaning of the acronym STEM or that males were typically associated with technology and programming. The students were familiar with the researcher as a programming and robotics teacher at ASP and identified the intern as a tutor in the ASP program. The interviews conducted during the last 2 days of the program revealed that only one of the 17 students knew the meaning of the acronym STEM. The researcher asked the one fourth-grade female who knew the names of the four component subjects how she learned this information. She indicated that she learned it during the pre-S-STEM survey. All other participants indicated either that STEM was a part of a plant, or they did not know.

Regarding the Android Inventor program, the participants indicated that they liked the class. The students remained in friend groupings at neighboring desktop computers chosen at the beginning of the intervention. A problem occurred when one male learned the password of another boy's MIT App Inventor account. The boy used the password to erase portions of the student's program. The intern had to restore the program and change all Gmail passwords. During the Hack-A-Thon, the researcher repeated the interview questions (see Appendix K) to the group, and three boys and two girls answered most of the focus group questions at the Hack-A-Thon. The one girl who knew the definition of the STEM acronym shared her answer with the assembled participants. Overall, the atmosphere of the culminating Hack-A-Thon event was happy and collegial. Students asked when the next program would begin.

The students in this program did not have any preconceived ideas about STEM environments. They did not know the definition of STEM, so any expressed attitudes result from the atmosphere of the 23-day program conducted at the ASP. During the interview process, students remarked that liked programming a dice game and used the words "fun," "amazing," and "cool" to describe their experiences.

Findings – IRQ2 - Students' Sense of Belonging in STEM Environments

Based on the data, the findings indicated that students based their perceptions of belonging in a STEM environment on the Android Inventor and Hack-A-Thon events. The participants had no prior knowledge of the STEM acronym. Overall, STEM attitudes for both genders remain in the neutral, 3 = *neither agree nor disagree* range that reflected the lack of prior knowledge of advanced programming attitudes. The interview data showed that students enjoyed the Android Inventor program with the opportunity to collaborate in the Hack-A-Thon event. Keywords "amazing," "cool," and "fun" reflected participants' responses to their first exposure to an advanced programming course. Most students requested more opportunities to join future programming courses at ASP.

Inventor5 is a target-female student who informed the researcher that she learned of the meaning of the STEM acronym from the S-STEM survey. She achieved 12 of the 28 digital badges (43%), wants to go to college to pursue a career in programming. Her post-intervention math and overall STEM attitudes are in a neutral in the *neither agree nor disagree* range, however her post-intervention E&T and agentic career scores reveal interest (see Table 15). Inventor5 shared that she finds math hard.

Inventor6 is also a target-female who achieved 9 of the 28 digital badges (32%), wants to go to college, and would like to pursue a modeling career where she can use the Internet to model clothing. Inventor6 reveals a neutral post-intervention attitude toward math in the *neither agree nor disagree* range and a STEM mean attitude of 3.94 that approaches the agree range. Her post-intervention attitude toward E&T is at a robust 4.56 (see Table 15). Inventor6 is a good example of a female whose interest in STEM develops in middle school (Guzey et al., 2016; Knezek et al., 2015) where educators can sustain and foster interest (Nugent et al., 2015).

IRQ3 – Applicable Math

The third research question asked, "What are students' experiences regarding applicable math during the SOOC and Hack-A-Thon? In what way does gender explain differences in willingness to apply math in real-world applications?" The researcher used the progress indicator, S-STEM math, and S-STEM engineering and technology, and the S-STEM Agentic Careers attitude variables to answer the third research question. The Attitude Toward Agentic Careers variable was a mean of students' attitudes toward physics, mathematics, computer science, chemistry, energy/electricity, and engineering. The agentic careers were math-intensive and aided the researcher in answering gender differences in willingness to apply math in real-world applications. The Likert scores for the career section of the S-STEM survey were 1 = *not at all interested*, 2 = *not so interested*, 3 = *interested*, and 4 = *very interested*. For purposes of analysis, the researcher looked for 3s and 4s in students' survey results pre- and post intervention, and then a difference between pre- and post agentic careers data. The results were 3 of the 10 girls indicated interest in agentic careers pre-intervention, 5 females indicated not so interested, and 2 replied not at all interested. Six of the seven boys indicated interest, with one boy indicating a 2.67, which was in the not so interested range (see Table 23).

Table 24

Pre-intervention Mean Agentic Careers Interest by Gender

	S-STEM Survey Career Likert Score											
Gender	1.67	1.83	2.00	2.33	2.50	2.67	2.83	3.00	3.33	3.50	3.67	Total
Female	1	1	1	1	1	1	1	1	1	0	1	10
Male	0	0	0	0	0	1	0	3	0	2	1	7
Totals $n = 17$	1	1	1	1	1	2	1	4	1	2	2	17

Note. Likert Score Categories: 1 = *not at all interested*, 2 = *not so interested*, 3 = *interested*, 4 = *very interested*.

During the post intervention survey, all seven boys indicated interest in agentic careers. For girls, 2 indicated not at all interested, 3 indicated not so interested, 4 replied interested, and 1 responded very interested (see Table 24).

Table 25

Post intervention Mean Agentic Careers Interest by Gender

	S-STEM Survey Career Likert Score											
Gender	1.17	1.83	2.00	2.17	2.50	3.17	3.33	3.50	3.67	3.83	4.00	Total
Female	1	1	1	1	1	2	1	0	1	0	1	10
Male	0	0	0	0	0	0	3	1	2	1	0	7
Totals $n = 17$	1	1	1	1	1	2	4	1	3	1	1	17

Note. Likert Score Categories: 1 = *not at all interested*, 2 = *not so interested*, 3 = *interested*, 4 = *very interested*.

Regarding the difference between pre-and post intervention interest in agentic careers, 4 girls showed a change in interest and 6 increased in a range between .33 and .83 (see Table 25).

Table 26

Difference of Post Intervention Mean Agentic Careers Interest and Pre-Intervention Mean Agentic Careers Interest by Gender

	S-STEM Survey Career Likert Score								
Gender	-.83	-.50	.00	.17	.33	.50	.67	.83	Total
Female	1	3	0	0	2	0	3	1	10
Male	0	0	1	1	3	1	1	0	7
Totals *n* = 17	1	3	1	1	5	1	4	1	17

Note. Likert Score Categories: 1 = *not at all interested*, 2 = *not so interested*, 3 = *interested*, 4 = *very interested*.

Overall, five of the 10 girls and all the boys showed a post intervention interest in agentic, math-intensive careers (see Table 24). After exposure to a math-intensive, advanced programming course, only 1 of 10 females indicated 4 = *agree* with her math abilities (see Table 10), with 4 females showing a change in math attitudes pre- to post intervention (see Table 11). Three of seven boys indicated agreement with math abilities, while four males remained in the *neither agree nor disagree* category (see Table 10).

Qualitative Results – Applicable Math

Regarding math class, one boy shared that his teacher told them the math problem, they wrote it down, studied it, and then took a test. Another male indicated that he frequently helped his friends in math class because he was good at math. A girl indicated that she received 100% on her math tests but struggled during ASP with all math homework. Another young man indicated that it was hard to concentrate in math class, and he could not see the board. A girl who wanted to open a bakery someday said that math would help her keep track of the money that she made in her business.

The researcher queried the students' future college and career plans (see Table Careers). All students present for the interviews indicated that they wanted to go to college. Of the students who had an idea of a future career, two girls and two boys named STEM, agentic careers in computers, programming, science, or engineering (see Table 26). Female participant Inventor 17 who was the first to receive a Beginner Android Inventor certificate (see Appendix GG) indicated that she wanted to go to college and take more math courses.

Table 27

Student IDs (STEM Attitudes), Genders, College, and Careers

Android Inventor ID (STEM Attitude)	Gender 1 = Female 2 = Male	College?	Career?
Inventor1 (2.79)	1	absent for interview	absent for interview
Inventor2 (3.38)	2	not sure	not sure
Inventor3 (3.08)	1	yes	own a bakery
Inventor4 (3.99)	2	yes	not sure
Inventor5 (3.21)	1	yes	programmer
Inventor6 (3.94)	1	yes	modeling
Inventor8 (3.42)	1	yes	doctor
Inventor10 (3.61)	2	yes	fix computers
Inventor11 (3.58)	1	yes	actress
Inventor12 (3.79)	2	yes	policeman
Inventor14 (2.75)	1	not sure	not sure
Inventor15 (4.54)	2	absent for interview	absent for interview
Inventor16 (3.51)	2	yes	scientist or engineer
Inventor17 (4.20)	1	yes	not sure
Inventor20 (3.46)	1	absent for interview	absent for interview
Inventor21 (4.11)	1	yes	scientist or engineer
Inventor25 (4.66)	2	yes	marine biologist
Totals	10 Females 7 Males		Female STEM = 2 Male STEM = 2

Note. Likert Score Categories: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

Overall, the students in this study did not appear to receive math instruction that gave them the opportunity to solve ill-structured problems. Instead, the students struggled to apply math in authentic applications. The Android Inventor program could be one of the few times that students received instruction through small-skill videos regarding advanced mathematic techniques, such as random-number generation and indexing into an array of data. Those students who persisted into the intermediate and advanced levels of the Android Inventor program received instruction regarding increasingly advanced math concepts. Boys persisted at a rate of 54% to the girls 36% in math levels of difficulty in a real-world application (see Table 8).

Findings – IRQ3 – Applicable Math

Based on the data, the findings indicated that the SOOC and Hack-A-Thon were students' introductory experiences to a real-world, applicable math example to produce a game application on a mobile device. Students' attitudes toward math reflect a school system that used well-structured problems with one right answer, rather than ill-defined problems that students must applied math skills to arrive at solutions. Taking the results of the math section of the post-S-STEM survey into consideration, nine females are neutral in the 3 = *neither agree nor disagree* range of math abilities (see Table 10). Of the seven boys, three were neutral in math abilities with a 3 = *neither agree nor disagree* response. The remaining four boys indicated a 4 = *agree* in math abilities in the post-S-STEM survey (see Table 10). Taking the boys' post intervention math results (see Table 10) plus males' persistence in achieving increasingly advanced programming levels (see Table 8) and the girls' neutrality regarding math indicated that boys were more willing to take on math challenges.

Interview data indicated that the participants in this study struggled with math homework in the presence of the researcher and intern during the homework sessions of the Android Inventor program. The one exception was Inventor 17, a female who completed homework without asking for help and progressed seamlessly to the programming sessions each day of the study. When asked about future careers, only 2 of the 10 girls and 2 of the 7 boys indicated future STEM careers. Lack of interest in agentic careers aligned with the participants' lack of knowledge of the STEM acronym. Apart from a brief explanation of each career in the S-STEM survey, this program was the first exposure to information regarding STEM careers in the workforce.

Inventor17 is a target-female participant who was the first to receive a Beginner Android Inventor Certificate. She revealed during interviews that she intends to go to college, wants more math classes in school but is not sure of a future career. Inventor17 achieved 19 of the 28 digital badges (68%) and reveals positive E&T (4.67) and STEM attitudes (4.20) post-intervention. Male Inventor10 is the only student to achieve all 28 digital badges (100%) and all three paper certificates; beginner, intermediate, and advanced. Inventor 10 reveals that he likes math classes and wants to fix computers as a career that includes knowledge of computer operating systems. His persistence through all 28 small-skill videos represents a positive attitude toward increasingly difficult math. His post-intervention math attitudes are positive at 4.00 but his E&T attitude is in the *neither agree nor disagree* range (see Table 15). Inventor10 aligns with the literature regarding the stereotype that considers males as better at math than females (Barth et al., 2015; Danaher & Crandall, 2008; Enderson & Ritz, 2016)

Study Conclusions

This study examined the problem of the underrepresentation of women in STEM courses, majors, and careers with the intention of improving enrollment of females in programming classes through an opportunity to participate in an advanced course offering at an after-school program in a poverty demographic. Three research questions guided the examination of gender influences on increasingly advanced programming course offerings, the sense of belonging in STEM environments, and a willingness to apply math in real-world applications. The following sections summarize conclusions by research question.

Intervention Research Question 1 (IRQ1): Interest in Programming Electives

What are students' attitudes toward increasingly advanced SOOC offerings? In what way does gender influence persistence in achieving higher programming skill levels?

IRQ1 conclusion. Based on the data, the findings indicated that gender *did* influence persistence in students' attitudes toward increasingly advanced programming electives. Males exhibited a 54% achievement of digital badges that reflected increasingly difficult math concepts to females 36%. One of 10 females (10%) revealed positive attitudes toward her math abilities post intervention, while 42% of males expressed math confidence. Males expressed positive attitudes in ET, while females initially expressed confidence in ET pre-intervention, but 60% recorded a change in ET attitudes post intervention.

Intervention Research Question 2 (IRQ2): Students' Perceptions of Stereotype Threat

What are students' perceptions regarding a sense of belonging in a coed STEM environment? In what way does gender influence perceptions of belonging?

IRQ2 conclusion. Based on the data, the findings indicated that students did not have prior knowledge of the STEM acronym. They did not possess a preconceived notion of attitudes regarding STEM environments or established gender roles. Overall, STEM attitudes for both genders remained in the neutral, 3 = *neither agree nor disagree* range that reflected the lack of prior knowledge of the acronym as an integrated field of study. Students either indicated that STEM was a part of a plant, or they did not know. One female student offered an accurate description of the component subjects but reported that she learned of the meaning of STEM during the pre-survey. The post intervention STEMAttitudes variable that was an average of students' MeanMath, MeanScience, MeanET, and Mean21st variables (see Table 6) reflected participants' interview responses regarding no prior knowledge of STEM with 13 of the 17 students reporting in the neutral, 3 = *neither agree nor disagree range*.

Intervention Research Question 3 (IRQ3): Applicable Math

What are students' experiences regarding applicable math during the SOOC and Hack-A-Thon? In what way does gender explain differences in willingness to apply math in real-world applications?

IRQ3 conclusion. Based on the data, the findings indicated that boys were more willing to apply math in real-world contexts. The SOOC and Hack-A-Thon were students' introductory experiences to a real-world, applicable math example to produce a game application on a mobile device. Both genders reported positive attitudes in interview discussions regarding enjoyment of both the SOOC and Hack-A-Thon. Most students made a request for more programs, such as Android Inventor. Post intervention survey data indicated that females were neutral in their attitudes toward math abilities, whereas 57% of the boys reported positive attitudes toward math. All male participants indicated positive attitudes toward agentic, math-intensive careers during the post intervention survey. Half of the 10 girls revealed interest in agentic careers with one responding 4 = *very interested*.

Discussion

Students in the United States who live in high poverty settings never academically outperform their higher SES peers in any subject area or grade level (Dotson, & Foley, 2016). The academic impact of a child living in poverty is greater than gestational exposure to cocaine (Pawloski, 2014). Children who attended this study's after school program (ASP) resided in poverty and must overcome lack of food and dangerous living conditions before they could attempt to succeed in school. The students in this program continued to fall well below Level 4, meeting or exceeding expectations, on PARCC standardized tests results (Shafer & Peron, 2018). Within this poverty demographic, the study took place during the October 2018 through November 2018 timeframe. The logic model (see Appendix I) served to frame the recommendations and limitations of this study regarding the underrepresentation of women in STEM courses, majors, and careers.

Inputs to the Android Inventor Program

The inputs to the Android Inventor Program included digital and personnel resources. The digital Google classroom provided an effective way to organize small-skill videos in beginner, intermediate, and advanced levels. As students completed programming levels and demonstrated working applications, the researcher provided them with the password to the next level of programming skills. The ASP did not subscribe to a Google G-Suite that could provide organizational Gmail accounts to students. Therefore, the researcher created 25 Gmail accounts to facilitate participants' logins to the Google Classroom and MIT App Inventor integrated development environment. Using a set of email accounts with the researcher listed as owner caused periodic security checks to verify the identity of the user. This process resulted in a periodic interruption of the flow of students' work but was not a major deterrent to progress in small-skill videos.

One student did discover another participant's password, logged in as that user, and deleted some programming blocks. The researcher and intern had to revise all participants' passwords and restore the student's work. This interruption did not deter the participant whose password was compromised. He was one of the two male participants who achieved the advanced programming level.

Students enjoyed receiving individual digital badges as they completed small-skill videos. The researcher created a Padet.com digital bulletin board with each participant. The student chose the background and icon images. As the students completed videos, the researcher added a digital badge to the board. Paper certificates awarded to the students were also depicted on the Padlets to document achievements (see Appendix CC).

The researcher developed star-rated surveys to document students' impressions and progress of each small skill video. The star-ratings did not serve as an effective means to record attitudes or persistence because the researcher did not require the survey before presenting the next small-skill video. The students did not complete the star-rated surveys on a consistent basis. The researcher did not include these surveys as a measure of students' progress. Future iterations of this program could place a completion requirement before progressing to the next lesson. However, digital badges and paper certificates served as a motivator for students to progress to complete additional videos.

The personnel inputs included the researcher who acted as the course creator, developer, and reviser of the all small-skill videos. The researcher maintained the Google Classroom and

Gmail accounts. The researcher performed ongoing updates of the digital badge Padlets, and paper certificate awards.

The intern, a female college freshman majoring in computer science, acted as an assistant to the researcher in all aspects of the intervention. Among the intern's tasks were communicating with Spanish-speaking parents on an as-needed basis, providing classroom management among the 17 participants in the ASP computer room. The intern worked among the students to help them with homework and transition them to the Android Inventor tasks. Students periodically asked the intern questions regarding the software emulator, and she resolved any difficulties in a timely manner. The intern contributed to the Evernote research journal to take attendance and make notes regarding students' progress. At the culmination of the intervention, the intern worked with the researcher to provide intercoder reliability (Creswell & Plano Clark, 2011) to coding interview data and triangulating themes to quantitative survey results.

The researcher shared insights with the STEM intern regarding research methodologies and practices throughout the intervention. The process of analyzing the journal for symbolic words or phrases to denote recurring themes becomes apparent in iterations of coding (Saldana, 2016). The study team used two identical copies of the research journal to perform independent annotations of rising themes in the document. The researcher and STEM Intern met once a week with the Principal Investigator to discuss findings and once a week throughout first quarter of 2019 to discuss findings. The categories of codes aligned with the interview questions (see Appendix K) to reveal students' attitudes toward the component STEM disciplines, agentic careers, and overall knowledge of the STEM acronym. Three iterations of coding resulted in 6 final codes used to analyze and triangulate the data (see Appendix HH).

The participants in this study included 17 students in fourth through seventh grades who consistently participated in the Android Inventor program during the October 2018 to November 2019 timeframe. The study setting consisted of the ASP computer and community rooms throughout the intervention. This cohort of learners consisted of 10 girls and seven boys to fulfill a purposeful recruitment of females to the study to query females' attitudes regarding STEM.

Activities and Outputs of the Android Inventor Program

To facilitate the research questions regarding students' attitudes toward increasingly advanced programming opportunities, STEM environments, and willingness to apply math in real-world contexts, the researcher chose to develop a dice game. Games provide an innovative way to engage students in authentic learning environments (Devers & Gurung, 2015). A dice game is inherently mathematical to exercise increasingly advanced programming such as random-number generation, indexing into an array of data, and scoring rolls of dice as indicated by the user of the program.

The researcher maintained nine beginner, 12 Intermediate, and seven advanced videos on a Google Classroom. The transitions to the next level represented programming the dice to roll, to lock dice to reflect a user's choice of what they want to retain in three rolls, and to use a database to archive two player's scores.

The literature supported the benefits to students regarding the opportunity to learn at their own pace (see Dang et al., 2016). Participants progressed through the small-skill videos in an informal learning environment that exercises student-centered instruction through self-regulated learning (see Dabbagh & Kitsantas, 2012). Students exhibited extrinsic motivation to earn digital badges and paper certificates (see Bonk & Khoo, 2014). Digital badges encouraged positive, on-task behavior in students (see Homer, Hew, & Tan, 2018).

The Hack-A-Thon provided the students with an opportunity to develop two applications in a team environment during a culminated event in November 2018. The researcher provided the students with two suggested applications involving a mole-masher game and a finger paint game. The students worked in pairs, developed the programs, and tested their resulting applications on the researcher's Android mobile device. The students used the skills that they developed during the Android Inventor program to write the two programs without much assistance from the researcher or the intern. Sometimes, a team tested a program, and it did not work properly. They worked together to resolve the problem and were proud of their efforts.

Implications for Practice

Researchers who wish to replicate this study in their setting would benefit from the following notations regarding the implementation of an integrated development environment such as the MIT App Inventor Android to program mobile applications. Chen et al. (2017) recommend that instructional designers develop coursework to reduce students' cognitive load by varying the expertise of the learners into beginner, intermediate, and advanced levels. Make sure that you create all the small-skill videos, badges, and certificate templates prior to the start of a study and assign these components based on skill-levels. Use a readily available online learning system such as Google Classroom that does not have firewall restrictions. Provide each student with a join code at each of the three skill-level classes. An integrated development environment such as MIT App Inventor requires a Google login that does not have to be an email address. Establish login accounts before the start of the intervention and archive passwords in a researcher's online password-protected journal.

Give each student join codes so that they can work at their own pace. The digital badges align with the number of videos accomplished by the participants and gives the program coordinator a benchmark as to the progress of the student. As students demonstrate error-free beginner applications, they can earn digital badges on an online bulletin board such a Padlet, a paper certificate commemorating their achievement, and the next join code for the intermediate and ultimately advanced classes. Evans et al. (2015) indicate higher completion rates of online courses when self-pacing is an integral component of instruction. The students could start, rewind, and repeat videos as needed to complete a prototype in their integrated development environment account. The students can use headphones or ear buds to listen privately to small-skill videos.

MIT App Inventor Emulator Software

An integrated development environment such as MIT App Inventor software requires an initial download to a computer device to run a virtual emulator (Connect – Emulator in the drop-down menu of an MIT App Inventor account) to test applications. It is recommended that the study team invoke an application such as the MIT App Inventor's aiStarter program before a student selects the emulator software to test their program. The emulator will not run if the aiStarter program is not running beforehand. The program coordinator could use desktop computers or laptops to facilitate accessing the online learning system that contains the small-skill videos.

Pairing MIT App Inventor to a Mobile Device

A mobile device and the computer running an integrated development environment such as MIT App Inventor account must be on the same WiFi network to "pair" the devices. Android phones must contain the free MIT AI2 Companion application downloaded from the Google Play store to test programs. The student can tap the MIT AI2 Companion application and pair the phone to their program by reading a QR code in the Connect – AI Companion dropdown menu in the MIT App Inventor program.

Hack-A-Thon Configurations

The students can form self-selected teams to work on new MIT App Inventor programs. The program coordinator could reserve a large community room with tables, chairs, and computer devices accessing the Internet using the same WiFi network as Android phones to facilitate the design and development of programs. Teams can share a laptop device and collaborate on their application. Vygotsky's (1978) Zone of Proximal Development can become evident as students share what already know to reach new levels of expertise in the company of more capable peers.

Outcomes of the Android Inventor Program

The researcher depicted the outcomes of the Android Inventor Program in three time segments: short, medium, and long as depicted in the Logic Model (see Appendix I). The short-term outcomes forecasted a 3-month outcome, the medium-term conjectured a 4- to 9-month outcome, and the long-term represented distal outcomes that could echo in the future from participation in the Android Inventor program.

Short-term outcomes. The short-term outcomes included knowledge of MIT app inventor skills and improved attitudes toward applicable math through real-world examples. During the Hack-A-Thon, the students did not need to be reminded of the process to begin, write, save, and test their programs. While their applications contained some errors, they returned to their programs and resolved the issues.

Most teams completed the two applications during the three-hour Hack-A-Thon. The atmosphere of the Hack-A-Thon was happy and collegial. Students would see the researcher in the hallways of ASP after the completion of the program and ask when the next program would occur. Overall, the students enjoyed the program. Because this program was their first foray into the world of programming, the Android Inventor program could prove a good foundation for future interest in STEM courses and environments.

The short-term outcomes reflect the participants' attitudes toward STEM in an environment that practiced authentic, real-world programming applications. The authors of the S-STEM survey operationalized *attitudes* as the melding of self-efficacy and expectancy-value beliefs (Unfried et al, 2015). Bandura (1977) assigns a central role to self-efficacy in overcoming fears and a change in behavior. This study observes females as less persistent than males to perform increasingly difficult applications of math through the trajectory of beginner, intermediate, and advanced small-skill videos to complete an Android mobile application. During the Hack-A-Thon, the researcher observed the females push aside any reluctance to apply math by developing two new mobile applications in a STEM team environment. The female students exhibited MARC self-perceptions to adopt an expectancy value to participate in an event to use their MIT App-Inventor skills in a collaborative team environment.

Gee (2008) lists three aspects in a learner's environment that influence learning; embodiment, distributed cognition, and social practices. Embodiment links experience to learning where the participants of this study not only understand their programming skills but also make connections through the application of learning in MIT App Inventor. Distributed cognition uses tools that Vygotsky (1978) describes as *mediating devices*. In this intervention, the mediating devices were programs that run on laptops and Android devices to make learning tangible through technology. The participants of this study exhibited a sense of self that allowed the learners to engage in the situated sociocultural learning environment of the Hack-A-Thon.

Medium-term outcomes. The medium-term outcomes included a sense of belonging in STEM environments and enrollment in future advanced programming course offerings. Based on students' feedback during the interview process, students were not aware of the definition of the STEM or the acronym as an integrated field of study. The participants did not have any preconceived ideas of traditional gender roles of males dominating STEM course, majors, and careers. The researcher and intern agree that the Android Inventor program provided the participants with a foundation of confidence to continue to pursue STEM programs in the medium-term and long-term timeframes.

The participants in this study are fourth through seventh graders. Early exposure to computer science education in underserved populations at the K-12 level can result in an increase in participation of students in subsequent programming classes (Aguar et al., 2016). Experiences in programming in K-12 grade levels can dispel the idea that information technology is just for boys (Master et al., 2016). Regarding confidence in programming abilities, females should take advantage of STEM affordances in middle school to sustain their self-efficacy as they transition to high school (Dare & Roehrig, 2016; Lofgran et al., 2015); Yeager et al., 2016).

Long-term outcomes. The long-term outcomes of the Android Inventor program were distal. There was a sustained lack of female STEM role models (see Beyer, 2014; Diekman et al., 2016; Farland-Smith, 2012). The researcher and intern, who are both females in STEM fields, may act as role models to female participants who may consider enrolling in STEM – focused high schools or careers in the future. The ASP school district did offer a STEM-focused high school to allow participants to continue to pursue STEM courses. During their high-school years, the participants could enroll in pre-requisite courses, such as calculus, to prepare themselves for math-intensive, agentic careers.

Regarding role models, it is crucial for females to witness successful women in the field of technology (Fuesting & Diekman, 2017). Women who occupy technology positions help students push past doubt in STEM courses (Herrmann et al., 2016). It is especially important for women of color to observe females in STEM positions to improve retention in engineering and technology (Rice & Alfred, 2014). The participants of this study collaborated with two female role models that anchor a learning community to provide the support structure for rising women in STEM (Malby et al., 2016).

External factors and assumptions. The researcher listed the external factor of a poverty demographic as important to consider in this intervention. All parents reported income at or below poverty level during the demographic survey conducted at the beginning of the program (see Appendix R). The students attending schools in this poverty demographic did not have access to technology classes. The pressure on districts in lower-SES demographics to exhibit improved learning during high-stakes testing narrows the focus on any technology or engineering curriculum (Belfanz, 2012).

According to Coleman et al. (1966), "The school appears unable to exert independent influences to make achievement levels less dependent on the child's background - and this is true within each ethnic group, just as it is between groups" (p. 297). In a 2016 study marking the 50th anniversary of the publication of the *Coleman Report*, Morgan and Jung (2016) concluded that family background, rather than any additional resource inputs, remained the most significant determinant of educational attainment and achievement.

The ASP provides parents and children with many resources including food, clothing, social assistance, and educational opportunities. Bryk (2010) listed strong parent-community-school ties as one of five essential supports for school improvement. Hargrave (2015) wrote about the benefits of "counterspaces" in the form of after-school programs that would provide students with opportunities to take classes not offered in their school settings. The Android Inventor program provided students with opportunities to learn that were not present in district schools or that parents could not provide given their poverty income level.

Limitations of recruitment. The researcher conducted the recruitment of participants during a two-day back-to-school boutique attended by parents and children to receive free school supplies. The attendance of this subset of parents and children of the ASP community could represent a self-selection bias of parents who choose to participate of their volition rather than a randomized sample of the approximately 100 families that attend ASP.

Of the parents who agreed to enroll their student in the intervention by completing an informed consent, the researcher observed some parents encouraging their students to enroll whereas other students implored their parent to sign them up for the program. In her seminal work *Unequal Childhoods,* Lareau (2011) describes lower-SES parents as espousing the *natural growth* of their children by allowing schools to direct the education of the family. This is the opposite of the higher SES echelon of parents who practice the *concerted cultivation* of their children's education by augmenting education through additional programs (Lareau, 2011). The poverty-level families that opted to participate in the Android Inventor program represent an intersection of the natural growth and concerted cultivation practices when parents recognize an affordance and encourage their child to enroll in a programming course in the after-school program. The families who said no to the Android inventor program were either influenced by students who expressed disinterest to the parent or do not practice the intersection of natural growth and concerted cultivation.

The parents who were not aware of the Android Inventor program either did not attend the back-to-school boutique, did not follow through to enroll their student in the days leading up to the intervention in October 2018 or who were members of the general public who do not enroll their students in ASP. Parents in Hispanic communities provide their daughters with a pre-education called *ways of knowing* to help them defend against prejudice or adverse reactions to their pronunciations of words with a Spanish accent (Kayumova et al., 2015). Despite the English and Spanish options in the informed consents and the parental demographic survey, it is possible that parents were reluctant to inquire about the program because of their lack of fluency in the English language. Some children translated what the English-speaking researcher said to their parent at the Back-to-School Boutique, but the impact of the dual lack of fluency perhaps influenced the number of enrolled participants.

Relationships to Theoretical Frameworks

The overarching theoretical framework that guided the intervention was critical theory. The core concept of critical theory is immanent critique (Antonio, 1981) that seeks contradictions of a social reality from within rather than a transcendent approach that is evoked from the outside (Fornas, 2013). Studying the participants in the setting of an after-school program in a poverty demographic revealed the social reality of students whose parents relied on an ineffective school district and a community center to provide their children with the means to advance their educational attainment.

Bronfenbrenner's (1977) and Bronfenbrenner and Morris' (2006) ecological systems theory (EST) framed the problem of practice regarding the underrepresentation of women in STEM courses, majors, and careers. Students in this demographic experienced a complete lack of exposure to STEM opportunities in the proximal processes of their microsystems. The processes that together made up a mesosystem included the girl, her family living in a poverty demographic, peers in like circumstances, teachers teaching to high-stakes tests, a school district struggling to provide effective instruction, and a community center that dedicates itself to a family's basic needs. This study found a complete lack of available opportunities to learn STEM disciplines.

Gee's (2008) sociocultural perspective describes affordances as the perception of the feasibility of acting upon something in their environment, and effectivities as opportunities contained in an environment that students perceive that they could put into action. The affordance and effectivity in this study commenced during the Back to School Boutique recruitment event. The Android Inventor program was the first time that students had an opportunity to take part in a STEM course.

This study examined Eccles' (1994) model of achievement-related choices that centers on the complex underlying factors of what shaped females' choices pertaining to their expectations for success. The mosaic of race and ethnicity of this demographic was predominantly Black and Hispanic. Kayumova et al. (2015) conducted a study of Latina girls and mothers regarding the private lessons taught by Hispanic mothers to their daughters called *ways of knowing*. This instruction gave Latinas the tools they needed to prepare themselves for the EST macrosystem of cultural norms of prejudicial treatment by society. If the girl or her mother spoke with Hispanic accents, they were frequently deemed ignorant because of her pronunciations resulting in a curtailed verbal participation in school and work settings (Kayumova et al., 2015). Before a Latina girl could develop a sense of belonging in a STEM environment, she must shield herself with strategies to achieve acceptance in a chilly climate regarding her race and ethnicity.

The causal model (see Appendix J) served as a framework to culminate the discussion of the findings regarding this study of an intervention to address the underrepresentation of women in STEM courses, majors, and careers. The study did not claim causality in the improvement of short-, medium-, and long-term goals as depicted in the logic model (see Appendix I). However, certain findings of this study could inform STEM educators to augment course offerings to females in poverty demographics to provide more achievement-related choices (Eccles, 1994) to create a STEM trajectory for Black and Latina females living in a poverty demographic.

Moderating Variables

The moderating variables depicted in the causal model (see Appendix J) included gender, race, ethnicity, current grade, socioeconomic status, and other sources of programming experience. Based on the data, this study showed that gender did moderate regarding males' persistence in students' attitudes toward increasingly advanced programming electives, and willingness to apply math in real-world contexts over their female classmates. Race and ethnicity combined with the socioeconomic status of students living in a poverty demographic echo Coleman et al. (1966) findings that family background, rather than any additional resource inputs, remained the most significant determinant of educational attainment and achievement. The current grade and other sources of programming experience did not moderate students' achievements in this study.

The independent variables identified in the causal model (see Appendix J) are participation in the SOOC and Hack-A-Thon interventions. Seventeen students, 10 girls, and seven boys, participated in the SOOC accessed exclusively at ASP. The intervention did not exercise the remote access features because of the lack of students' personal computers. Fourteen students, eight girls, and six boys attended the 1-day Hack-A-Thon culminating event.

The mediating variables depicted in the causal model (see Appendix J) are self-efficacy, confidence in 21st learning constructs, students' perceptions of the SOOC and Hack-A-Thon, and degrees of participation. This study defined STEM attitudes as a union between their self-efficacy and expectancy value beliefs. Bandura (1986) defined self-efficacy as the extent to which students will plan and implement behaviors related to goal achievement. Expectancy value beliefs described students' assessments of the likelihood of attaining a goal and the perceive gain or loss of value from the attainment of the goal (Eccles & Wigfield, 2002). Unfried et al. (2015), authors of the S-STEM survey employed during this intervention, defined attitude as a composite of self-efficacy and expectancy-value beliefs. The aggregate variable, STEMAttitudes with a mean of students' math, science, engineering and technology, and 21st century learning attitudes indicated that 14 of the 17 participants were neutral by neither agreeing nor disagreeing with their STEM abilities. This finding aligned with students' interview responses that showed a complete lack of knowledge of the component subjects of the STEM acronym or of the integration of subjects as a field of study. Students shared positive feedback during the interviews and focus group regarding their perceptions of the SOOC and Hack-A-Thon and request future programs.

The dependent variables identified in the causal model (see Appendix J) align with the outcomes of the logic model (see Appendix I). The variables listed as dependent that aligned with short-term outcomes were knowledge of MIT App Inventor skills, and improved attitudes toward applicable math through real-world examples. Participants exhibited a solid knowledge of MIT App Inventor skills at the Hack-A-Thon to develop, test, and complete two applications at this culminating event. The intervention served as the students' first foray in an advanced programming course and expressed interest in future courses.

This study of the underrepresentation of women in STEM courses, majors, and careers continued to reveal females' lack of persistence in increasingly advanced applications of math in real-world examples. The results indicated females, especially Black and Hispanic girls who resided in poverty, did not have any opportunities to take courses that could prepare them for STEM college majors that could lead to careers in STEM careers. The field should explore avenues to provide substantive STEM courses in poverty demographics.

Discussion Conclusions

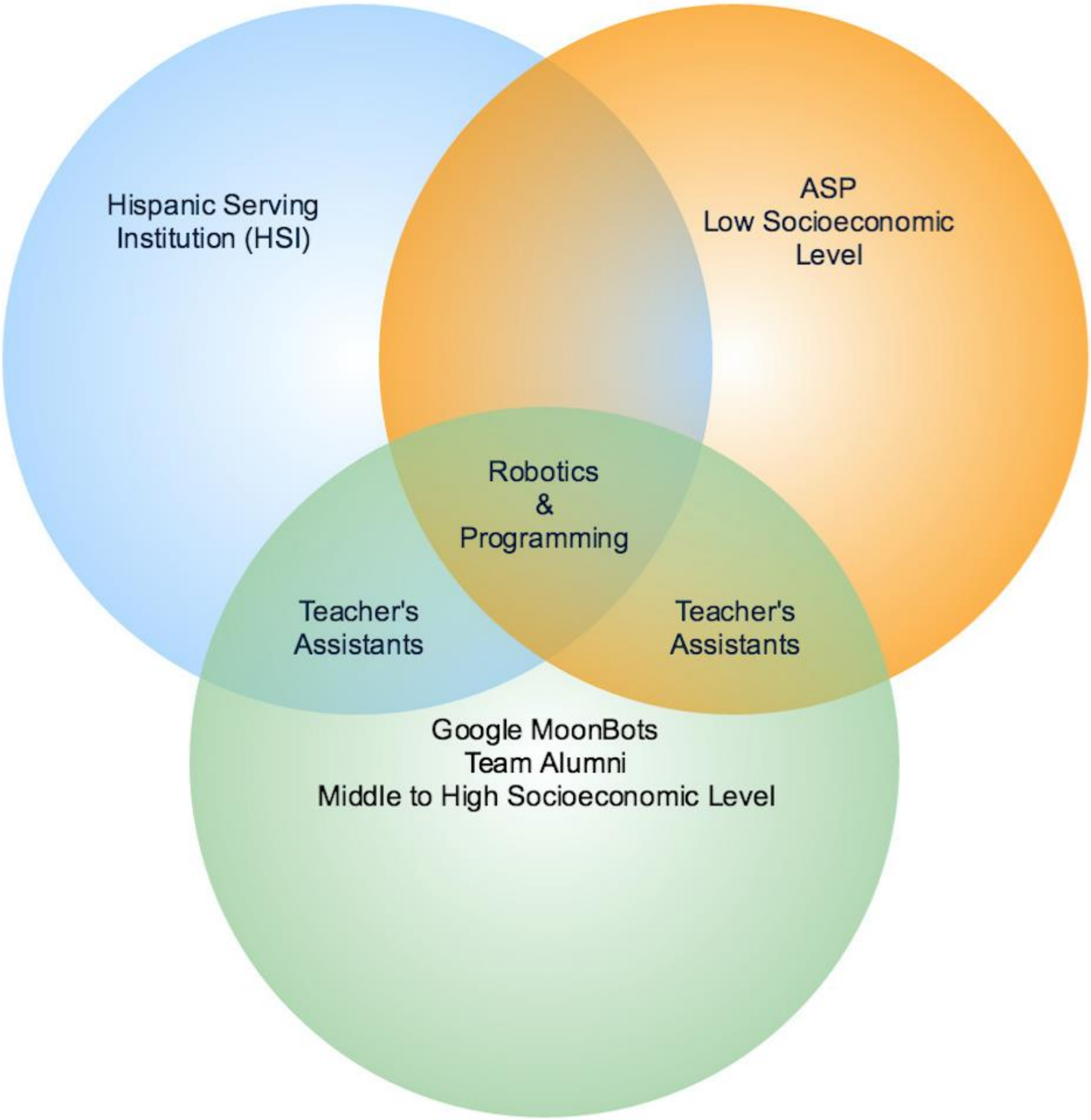
The researcher concludes that girls are reluctant to persist in higher levels of mathematics. Based on the participants' feedback during the post-intervention interviews and the researcher's observations during the students' completion of homework, the children in this poverty demographic have math classes that utilize well-structured problems with one correct answer. They do not know how to use their math skills to perform calculations to solve new, ill-structured problems. These present math abilities converge on my central finding that Gee's (2008) opportunity to learn identifies a missing link in my students' learning. They do not have the affordances, identified by Gee as students' perception of the feasibility of acting upon something in their environment. The children do not have the opportunity to solve new math problems in their school environment. The Android Inventor intervention was the first time that students had the affordance to solve new problems with math skills. Those students and parents that chose to participate in the intervention crossed a new bridge to Gee's (2008) effectivities that is something in their environment that they choose to act upon. The 17 participants acted upon an affordance and effectivity pair in our after-school program. The boys' persistence over the girls aligns with Eagly's (2013) discussion of males' preference for agentic, math-intensive careers with a trajectory to a good job. Girls, according to Eagly (2013) prefer communal careers that help people or animals. The communal STEM careers, such as life sciences, are not math-intensive.

The most surprising finding of this study is that all the participants in this poverty demographic did not know the meaning of the STEM acronym or the aggregate disciplines as an integrated field of learning. Their responses to, "What does STEM mean?" elicited either a part of a plant, or no prior knowledge of the STEM acronym. One little fourth grade girl gave the researcher a correct response of science, technology, engineering, and math as the definition of STEM. When the researcher asked her where she learned about the acronym, she replied that she learned it from the pre- and post intervention survey. The code STEM-Blinders (see Appendix HH) aptly describes the lack of awareness of this acronym that represents a hidden curriculum to students in poverty demographics.

Future research regarding the underrepresentation of STEM course, majors, and careers could examine the medium-term outcomes of the logic model (see Appendix I) through reenrollment of students in future course offerings at ASP. The same S-STEM survey (Unfried et al., 2015) could show a shift in students' overall attitudes toward STEM. Regarding distal, long-term outcomes, the researcher could interview the participants to determine if the elementary and middle school students enroll in STEM courses when they transition to high school. A future follow-up study of the participants' high school courses, first-year college majors that sustain to graduation, and the selection of STEM careers could bring this study to a full-circle of conclusions regarding the impact of the Android Inventor program on students' attitudes in future STEM environments.

Appendix A

Situated Problem of Practice Venn Diagram



Appendix B

Survey Conducted With HSI College Students

Student Course and Career Goals Survey
Informed Consent

The purpose of this research study is to ask you about your goals for the courses that you take in school and the future careers that you are considering. This survey research will highlight potential areas for ways to help students achieve their goals. By completing this survey, you are consenting to be in this research study. Your participation is voluntary and you can stop at any time. Kindly read the following informed consent and proceed to the first question. An electronic signature is not required.

INFORMED CONSENT FORM

Title: Student Course and Career Goals
Principal Investigator: Dr. Amanda Gunning, Mercy College, Dr. Christine Eith, Johns Hopkins University
Date: March 15, 2017

PURPOSE OF RESEARCH STUDY
The purpose of this research study is to ask you about your goals for the courses that you take in school and the future careers that you are considering. This survey research will highlight potential areas for ways to help students achieve their goals. By completing this survey, you are consenting to be in this research study. Your participation is voluntary and you can stop at any time.

For this preliminary investigation into the research questions, I anticipate that 100 students will participate in the survey.

PROCEDURES:
The study will include a survey questionnaire administered online. The request to participate will be sent via email with a follow-up to increase participation. The survey will include approximately 30 questions and will take 15-20 minutes to complete.

RISKS/DISCOMFORTS:
There are no anticipated risks to the students.

1

BENEFITS:
Potential benefits include a better understanding of students' course and career goals. The survey will contribute to improving course offerings to enhance students' opportunities to learn.

VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:
A student's participation in the survey questionnaire is entirely voluntary. There are no penalties if a student decides not to participate or choose to withdraw from the study.

CONFIDENTIALITY:
Any study records that identify a student will be kept confidential to the extent possible by law. The records from the survey may be reviewed by staff responsible for making sure the research is properly carried out including members of the Mercy College and Johns Hopkins University Institutional Review Boards. Otherwise, the records will be available only to people working on the study, unless you give permission for other people to see the records.

Survey data will be collected via password protected data system (Survey Monkey) that belongs to the principal investigator. Electronic data will be stored in the PI's computer, which is password protected and respondent names will not be associated with any of the responses nor will they appear in any of the published reports.

IF YOU HAVE QUESTIONS OR CONCERNS:
If you have questions about the research study please feel free to contact Sharon Mistretta via email: smistre2@jhu.edu.

Do you have any questions about your rights as a research participant? Phone or email the IRB Chair, Dr. Brian Baker, IRB Chair MCirb@mercy.edu or 718.678.8812

SIGNATURES
This letter of informed consent is to provide you with important information about your participation in this study. You are not required to provide an electronic signature.

By completing this survey or questionnaire, you are consenting to be in this research study. Your participation is voluntary and you can stop at any time.

* 1. Consent

- ◯ Yes, I consent to take the survey.
- ◯ No, I do not wish to continue.

* 2. What type of career do you think you would like to work in the future? (Drop down each box and indicate yes, no, or maybe. The first drop-down box of each row is to let us know if you are interested in this type of job. The second drop-down box of each row is to let us know if you believe that your current school could help you to prepare for this type of job.)

	Would you consider having this type of job in the future?	Does your school provide you with classes to learn skills to do this job someday?
Management - People in charge of running a business or school.		
Computer or Math Jobs - People who program computers or work with math.		
Architecture or Engineering - People who plan buildings or use their knowledge of science to solve problems.		
Life, Physical or Social Sciences - People who work in science such as doctors, chemists or psychologists.		
Education, Training or Library - People who are teachers, instructors or librarians.		
Sales - People who represent a company to encourage others to buy an item or service.		

Please enter any other job that you wish to obtain someday. Let us know if your school currently teaches you skills for this type of job.

* 3. Using the following list, indicate which courses you would be interested in taking. Please assume that all courses would be available at your current school. Drop down each menu and indicate yes, no, or maybe.

	Use the drop boxes in this column to indicate whether you would be interested in taking this course.
Calculus	
Computer Science	
Statistics	

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Use the drop boxes in this column to indicate whether you would be interested in taking this course.

Course	Interest
Biology	
Chemistry	
Environmental Science	
Physics: Electricity and Magnetism	
Physics: Mechanics	
Comparative Government and Politics	
European History	
Geography	
Economics	
Psychology	
United States Government and Politics	
United States History	
World History	
Art History	
Music Theory	
Studio Art - 2-D Design	
Studio Art - 3-D Design	
Studio Art - Drawing	
English Language and Composition	
English Literature and Composition	
World Language	
Research - Students choose a topic to research under the guidance of a teacher.	

Use the drop boxes in this column to indicate whether you would be interested in taking this course.

Seminar - Students choose a topic to study under the guidance of a teacher.

Please indicate a course that is not listed above that you are interested in taking. Assume that it is offered at your school.

* 4. Use the slider bar below to rate the importance in your decision to choose a career that is helpful to others and society.

1 not important 4 neutral 7 very important

* 5. Use the slider bar below to rate the importance in your decision to choose a career that gives you the opportunity to work with people rather than things.

1 not important 4 neutral 7 very important

* 6. Use the slider bar below to rate the importance in your decision to choose a career that gives you the opportunity to earn a high salary.

1 not important 4 neutral 7 very important

* 7. Use the slider bar below to rate the importance in your decision to choose a career that is a job that is interesting to you.

1 not important 4 neutral 7 very important

* 8. Use the slider bar below to rate the importance in your decision to choose a career that is a job that has many job openings in the field.

1 not important 4 neutral 7 very important

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* 9. Use the slider bar below to rate the importance in your decision to choose a career that is a job that you will be able to combine career and family.

1 not important 4 neutral 7 very important

* 10. Use the slider bar below to rate the importance in your decision to choose a career that is a job that will use your special abilities to the fullest.

1 not important 4 neutral 7 very important

* 11. Please read each statement in the left-hand column. Use the drop box next to the question to rate your agreement or disagreement with the statement.

	Your Level of Agreement
If you have children someday, is it your belief that both parent partners will take an equal share in caring for the children and working in a full-time career?	
If you have children someday, is it your belief that you would have to obtain a part-time job in order to take care of your children and your household.	
If you have children someday, is it your belief that you would have to quit your job and stay home full-time with the children?	
If you have children someday, is it your belief that your partner would have to quit their job and stay home full-time with the children?	
Is it your belief that your family expects you to obtain a good job in a high paying career?	
Is it your belief that you would be very satisfied to devote all of your time to your home and family?	

* 12. The following rows contain statements regarding your attitude toward Computer Programming. Please indicate your level of agreement with each statement by using the drop down menu provided in each row.

	Your level of agreement with the statement.
I am considering majoring in computer science in college.	
Students majoring in computer science are good at math and science.	

	Your level of agreement with the statement.
Students majoring in computer science are hard working.	
Students majoring in computer science are smart.	
It is very difficult for a women to combine a career as a computer scientist with a family life.	
If a female computer scientist takes time away from her career to stay home and raise children, she will never catch up again.	
If a male computer scientist takes time away from his career to stay home and raise children, he will never catch up again.	
Most computer scientists are more interested in numbers than people.	
Doing well in computer science courses enhances job/career opportunities.	
I could get good grades in computer science courses.	
I have lots of self-confidence when it comes to working with computers.	
I get a sinking feeling when trying to use a computer.	
I would feel at ease in a computer programming course.	

* 13. Using the slider bar below, rate how anxious you would feel when you have to use the math tables in the back of a textbook. Low Anxiety = 1 up to High Anxiety = 5.

1 3 Moderate Anxiety 5

* 14. Using the slider bar below, rate how anxious you would feel when you are thinking about an upcoming math test one day before class. Low Anxiety = 1 up to High Anxiety = 5.

1 3 Moderate Anxiety 5

* 15. Using the slider bar below, rate how anxious you would feel when you are watching a teacher work an algebraic equation on the blackboard. Low Anxiety = 1 up to High Anxiety = 5.

1 3 Moderate Anxiety 5

* 16. Using the slider bar below, rate how anxious you would feel when you are taking an examination in a math course. Low Anxiety = 1 up to High Anxiety = 5.

1 3 Moderate Anxiety 5

* 17. Using the slider bar below, rate how anxious you would feel when you are being given a homework assignment of many difficult problems that are due at the next class meeting. Low Anxiety = 1 up to High Anxiety = 5.

1 3 Moderate Anxiety 5

* 18. Using the slider bar below, rate how anxious you would feel when you are listening to a lecture in math class. Low Anxiety = 1 up to High Anxiety = 5.

1 3 Moderate Anxiety 5

* 19. Using the slider bar below, rate how anxious you would feel when you are listening to another student explain a math formula. Low Anxiety = 1 up to High Anxiety = 5.

1	3 Moderate Anxiety	5

* 20. Using the slider bar below, rate how anxious you would feel when you are being given a "pop" quiz in math class. Low Anxiety = 1 up to High Anxiety = 5.

1	3 Moderate Anxiety	5

* 21. Using the slider bar below, rate how anxious you would feel when you are starting a new chapter in a math textbook. Low Anxiety = 1 up to High Anxiety = 5.

1	3 Moderate Anxiety	5

* 22. Listed below are four subjects. Next to the subject, please rate your current teacher in that subject by selecting one of the columns provided.

	This class is not offered this year in my school.	This class is offered, but I am not taking it this year.	Currently take this course, but do not want to take another course with this teacher.	The teacher is very good.
Math	○	○	○	○
Science	○	○	○	○
Computer Science	○	○	○	○

If you have indicated that you would not want to take another course with a subject teacher, please provide a brief description of the reason.

* 23. Please use the drop-down boxes provided to indicate your opinion as to who is better at each subject.

	Who is better at this subject?
Math	
Science	
Computer Science	

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* 24. What is your gender?

- ◯ Female
- ◯ Male
- ◯ Transgender Male
- ◯ Transgender Female
- ◯ Would rather not answer this question.

* 25. What is your race? The following options are based on the choices contained in the US Census. Select all that apply or choose not to answer this question. Please enter your ethnicity, if you wish, in the next question.

- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Would rather not answer this question.

26. Please enter any information that you would like to share regarding your ethnicity.

* 27. What school do you attend? Please enter the name of your school, the town, and state in which it is located.

Student Course and Career Goals Survey

End of Survey

Appendix C

Email Communication with Dr. Sylvia Beyer

Re: Permission to Use Survey in Your Article

Sylvia Beyer <beyer@uwp.edu>

Tue 2/28/2017 4:11 PM

To:Sharon Mistretta <smistre2@jhu.edu>;

Hi Sharon,

you have my permission to use the materials in the Appendix of the article as long as you clearly attribute the source. Please be aware that some of the items in the Appendix come from existing scales. One of the tables in the paper details this. If you have any questions, let me know.

Good luck with your work.

Sylvia

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Sylvia Beyer, Ph.D.
Professor of Psychology
Department of Psychology
University of Wisconsin-Parkside
Kenosha, WI 53141
fax: (262) 595-2120
e-mail: beyer@uwp.edu
URL: www.uwp.edu/~beyer

> On Feb 28, 2017, at 14:28, Sharon Mistretta <smistre2@jhu.edu> wrote:
>
> Hello, Dr. Beyer,
>
> I am a doctoral student at Johns Hopkins University studying toward my EdD in the Integration of Technology, K- 16. I came across your 2014 article, "Why are Women Underrepresented in Computer Science?"
>
> May I have your permission to use the survey in Appendix 1 of the article?
>
> All the best,
> Sharon Mistretta
> 2016 Cohort
> Instructional Design for Online Teaching and Learning
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Appendix D

Qualitative Variables, Descriptions, Values, and Correlations

Table 28

Qualitative Variables, Descriptions, Values, and Correlations

RQ	IQ	Variable	Description	Value	Correlations
All	All	Gender	Female	1	How does gender correlate to stereotype threat, choice of major, math anxiety?
All	All		Male	2	How does gender correlate to stereotype threat, choice of major, math anxiety?
All	All	Race	Black	1	How does race correlate to future maternal role with career?
All	All		White	2	How does race correlate to future maternal role with career?
All	All		Asian	3	How does race correlate to future maternal role with career?
All	All	Ethnicity	No Ethnicity Declared	1	How does ethnicity correlate to stereotype threat?
All	All		Hispanic	2	How does ethnicity correlate to stereotype threat?
All	All	Socioeconomic Level (SES)	low	1	How does SES correlate to stereotype threat, prepared for career?
All	All		middle	2	How does SES correlate to stereotype threat, prepared for career?
All	All		high	3	How does SES correlate to stereotype threat, prepared for career?
RQ1 RQ1.1 RQ1.2 RQ2	IQ2 IQ4 IQ5 IQ8	Major	STEM	1	How does selection of major correlate to: Gender Math Anxiety
RQ1 RQ1.1 RQ1.2	IQ2 IQ4 IQ5		Non-STEM	2	How does selection of major correlate to:

(continued)

RQ	IQ	Variable	Description	Value	Correlations
RQ2	IQ8				Gender Math Anxiety
RQ2 RQ3	IQ2 IQ4 IQ9	Maternal Employment	Full-time	1	How does maternal employment correlate to role models?
RQ2 RQ3	IQ2 IQ4 IQ9		Part-time	2	How does maternal employment correlate to role models?
RQ2 RQ3	IQ2 IQ4 IQ9		Does not work outside the home.	3	How does maternal employment correlate to role models?
RQ1.1 RQ1.2 RQ4 RQ4.1	IQ3 IQ4 IQ5 IQ7	Math Anxiety	Yes	1	How does math anxiety correlate to selection of major, and computer programming interest?
RQ1.1 RQ1.2 RQ4 RQ4.1	IQ3 IQ4 IQ5 IQ7		No	2	How does math anxiety correlate to selection of major?
RQ1 RQ1.1	IQ2 IQ5 IQ7	High School Prepared You for Career?	Yes	1	How does high school prep correlate to gender, and course selection?
RQ1 RQ1.1	IQ2 IQ5 IQ7		No	2	How does high school prep correlate to gender, and course selection?
RQ1 RQ1.2	IQ2 IQ4	Male Climate in Classes?	Yes	1	How does climate correlate to perceptions of stereotype threat?
RQ1 RQ1.2	IQ2 IQ4		No	2	How does climate correlate to perceptions of stereotype threat?
RQ1 RQ1.2	IQ2 IQ4		Not Applicable	3	How does climate correlate to perceptions of stereotype threat?
RQ1.2 RQ4.1	IQ2 IQ8	Change Major?	Yes	1	How does major correlate to computer programming interest?
RQ1.2 RQ4.1	IQ2 IQ8		No	2	How does major correlate to computer programming?
RQ1.2 RQ4.1	IQ2 IQ8		Not Applicable	3	How does major correlate to computer programming?
RQ1.2 RQ4.1	IQ2 IQ8	Reason for Change	Major Too Hard	1	How does change correlate to gender?

(continued)

RQ	IQ	Variable	Description	Value	Correlations
RQ1.2 RQ4.1	IQ2 IQ8		Different Interest	2	How does change correlate to gender?
RQ1.2 RQ4.1	IQ2 IQ8		Not Applicable	3	How does change correlate to gender?
	IQ10	Emerged theme: “Applicable Math”	Participant indicated this theme	1	How does emerged theme correlate to courses and careers?
	IQ10	Emerged theme: “More science”	Participant indicated this theme	1	How does emerged theme correlate to courses and careers?

Appendix E

Quantitative Data Variables, Descriptions, Values, and Correlations

Table 29

Quantitative Data Variables, Descriptions, Values, and Correlations

Needs Assessment Research Question (NARQ)	Variable	Description	Value	Correlations
All	Gender	Female	1	How does gender correlate to stereotype threat, choice of major, math anxiety?
All		Male	2	How does gender correlate to stereotype threat, choice of major, math anxiety?
All	Race	Black	1	How does race correlate to future maternal role with career?
All		White	2	How does race correlate to future maternal role with career?
All		Asian	3	How does race correlate to future maternal role with career?
All	Ethnicity	No Ethnicity Declared	1	How does ethnicity correlate to stereotype threat?
All		Hispanic	2	How does ethnicity correlate to stereotype threat?
NARQ1 NARQ1.1 NARQ1.2 NARQ2	Career Occupational groups (Vilorio, 2014, p.4)	Management	1	How does selection of career interest correlate to: Gender and survey paired question: Does your school provide you with classes to learn skills to do this job someday?

(continued)

Needs Assessment Research Question (NARQ)	Variable	Description	Value	Correlations
				Career = affordance Classes = effectivities
NARQ1 NARQ1.1 NARQ1.2 NARQ2	Career Occupational groups (Vilorio, 2014, p.4)	Computer or Math	2	How does selection of career interest correlate to: Gender and survey paired question: Does your school provide you with classes to learn skills to do this job someday? Career = affordance Classes = effectivities
NARQ1 NARQ1.1 NARQ1.2 NARQ2	Career Occupational groups (Vilorio, 2014, p.4)	Architecture or Engineering	3	How does selection of career interest correlate to: Gender and survey paired question: Does your school provide you with classes to learn skills to do this job someday? Career = affordance Classes = effectivities
NARQ1 NARQ1.1 NARQ1.2 NARQ2	Career Occupational groups (Vilorio, 2014, p.4)	Life, Physical or Social Sciences	4	How does selection of career interest correlate to: Gender and survey paired question: Does your school provide you with classes to learn skills to do this job someday? Career = affordance Classes = effectivities
NARQ1 NARQ1.1 NARQ1.2 NARQ2	Career Occupational groups (Vilorio, 2014, p.4)	Education, Training, or Library	5	How does selection of career interest correlate to: Gender and survey paired question:

(continued)

Needs Assessment Research Question (NARQ)	Variable	Description	Value	Correlations
				Does your school provide you with classes to learn skills to do this job someday? Career = affordance Classes = effectivities
NARQ1 NARQ1.1 NARQ1.2 NARQ2	Career Occupational groups (Vilorio, 2014, p.4)	Sales	6	How does selection of career interest correlate to: Gender and survey paired question: Does your school provide you with classes to learn skills to do this job someday? Career = affordance Classes = effectivities
NARQ1	Course Interest Based on AP Courses (College Board, 2017)	Category A: Rigorous STEM Electives: Math & Computer Science: 1. AP Calculus AB 2. AP Calculus BC 3. AP Computer Science A 4. AP Computer Science Principles 5. AP Statistics Science: 6. AP Biology 7. AP Chemistry 8. AP Environmental Science 9. AP Physics C: Electricity and Magnetism 10. AP Physics C: Mechanics	A	How does course interest correlate to gender?

(continued)

Needs Assessment Research Question (NARQ)	Variable	Description	Value	Correlations
		11. AP Physics 1: Algebra-Based 12. AP Physics 2: Algebra-Based		
NARQ1	Course Interest Based on AP Courses (College Board, 2017)	Category B: Communal Electives: Social Science Electives: 13. AP Comparative Government and Politics 14. AP European History 15. AP Human Geography 16. AP Macroeconomics 17. AP Microeconomics 18. AP Psychology 19. AP United States Government and Politics 20. AP United States History 21. AP World History Arts: 22. AP Art History 23. AP Music Theory 24. AP Studio Art: 2-D Design 25. AP Studio Art: 3-D Design 26. AP Studio Art: Drawing English:	B	How does course interest correlate to gender?

(continued)

Needs Assessment Research Question (NARQ)	Variable	Description	Value	Correlations
		27. AP English Language and Composition 28. AP English Literature and Composition		
NARQ1	Course Interest Based on AP Courses (College Board, 2017)	Category C: Blended Careers: Two AP Courses allow students to work with an advisor on real world topics that interest them. 29. AP Research 30. AP Seminar	C	How does course interest correlate to gender?
NARQ3	Maternal Role	Attitudes toward partners sharing childcare responsibilities	Likert 1-7	How does Likert score compare to gender?
NARQ4 NARQ4.1	Computer Science	Attitudes toward computer science	Likert 1 to 7	How does Likert score compare to gender?
NARQ1.1 NARQ1.2 NARQ4 NARQ4.1	Math Anxiety	Perception of level of anxiety	Likert 1 - 5	How does Likert score compare to gender?
NARQ1.2	Subject Teacher	Ratings of math, science, and computer science teachers.	Class not offered = 1; Class offered, but not taking it = 2; Do not want to take another course with	Is computer science offered, and are students taking the course?

(continued)

Needs Assessment Research Question (NARQ)	Variable	Description	Value	Correlations
			teacher = 3; Teacher is very good = 4;	
NARQ1.1 NARQ4 NARQ4.1	Stereotype Threat	Who is better at math, science, and computer science	Males = 1; Females = 2; Both equal = 3;	How is this answered based on gender of participant?

Appendix F

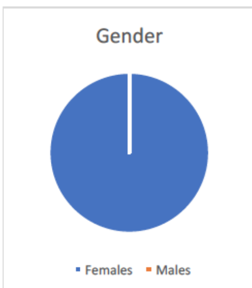
Qualitative Data Excel Pie Charts and Qualitative Data Descriptive Statistics

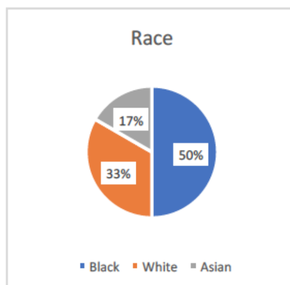
Pseudonym	Gender	Race	Ethnicity	Socioeconomic Status	Grade	Major	Maternal Employment	Math Anxiety	High School Prepare You for Career?	Male Climate?	Changed Major?	Reason for Change?
C	1	1	2	2	13	1	1	1	2	1	1	2
J	1	2	1	3	14	2	1	2	1	2	1	1
M	1	2	1	2	13	1	1	1	2	1	2	3
S	1	3	1	2	13	1	1	1	2	1	1	1
R	1	1	1	2	12	1	1	1	2	3	3	3
B	1	1	2	1	9	2	3	2	2	3	3	3

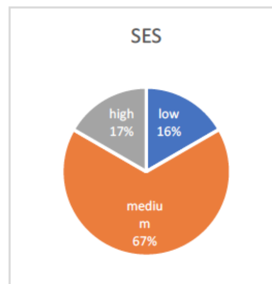
Gender:	
Females	6
Males	0

Race:	
Black	3
White	2
Asian	1

SES:	
low	1
medium	4
high	1







Math Anxiety	
Mean	1.3333
Standard Err	0.2108
Median	1
Mode	1
Standard De	0.5164
Sample Vari	0.2667
Kurtosis	-1.875
Skewness	0.9682
Range	1
Minimum	1
Maximum	2
Sum	8
Count	6

High School Prepare You for Career?	
Mean	1.833
Standard Error	0.167
Median	2
Mode	2
Standard Deviatio	0.408
Sample Variance	0.167
Kurtosis	6
Skewness	-2.45
Range	1
Minimum	1
Maximum	2
Sum	11
Count	6

Male Climate?	
Mean	1.83333333
Standard Err	0.40138649
Median	1.5
Mode	1
Standard De	0.98319208
Sample Vari	0.96666667
Kurtosis	-2.3900119
Skewness	0.45593925
Range	2
Minimum	1
Maximum	3
Sum	11
Count	6

Appendix G

SPSS Frequency Report – Interest in Computer Science Career

Table 30

SPSS Frequency Report – Interest in Computer Science Career

N	Valid	7
	Missing	0
Mean		1.286
Median		1.0
Mode		1.0

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Would not consider	5	71.4	71.4	71.4
	Might or might not consider	2	28.6	28.6	100.0
	Total	7	100.0	100.0	

Note. Computer or Math Jobs – People who program computers or work with math. – Would you consider having this type of job in the future?

Appendix H

Interest in Calculus

Table 31

Interest in Calculus A

		Calculus Use the drop boxes in this column to indicate whether you would be interested in taking this course.	Statistics Use the drop boxes in this column to indicate whether you would be interested in taking this course.	Biology Use the drop boxes in this column to indicate whether you would be interested in taking this course.	Chemistry Use the drop boxes in this column to indicate whether you would be interested in taking this course.	Environmental Science Use the drop boxes in this column to indicate whether you would be interested in taking this course.
N	Valid	7	7	7	7	7
	Missing	0	0	0	0	0

Table 32

Interest in Calculus B

		Physics: Electricity and Magnetism Use the drop boxes in this column to indicate whether you would be interested in taking this course.	Physics: Mechanics Use the drop boxes in this column to indicate whether you would be interested in taking this course.	Computer Science Use the drop boxes in this column to indicate whether you would be interested in taking this course.
N	Valid	7	7	7
	Missing	0	0	0

Table 33

Frequency Table – Calculus

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very Interested	4	57.1	57.1	57.1
	Possibly Interested	3	42.9	42.9	100.0
	Total	7	100.0	100.0	

Table 34

Interest in Physics – Electricity and Magnetism

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very Interested	4	57.1	57.1	57.1
	Possibly Interested	2	28.6	28.6	85.7
	Not Interested	1	14.3	14.3	100.0
	Total	7	100.0	100.0	

Table 35

Interest in Physics – Mechanics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very Interested	4	57.1	57.1	57.1
	Possibly Interested	2	28.6	28.6	85.7
	Not Interested	1	14.3	14.3	100.0
	Total	7	100.0	100.0	

Table 36

Interest in Computer Science

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very Interested	4	57.1	57.1	57.1
	Possibly Interested	1	14.3	14.3	71.4
	Not Interested	2	28.6	28.6	100.0
	Total	7	100.0	100.0	

Table 37

Math Anxiety

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	14.3	14.3	14.3
	2	2	28.6	28.6	42.9
	3	3	42.9	42.9	85.7
	5	1	14.3	14.3	100.0
	Total	7	100.0	100.0	

Note. Participants used a slider bar to rate how anxious they feel when they are thinking about an upcoming math test one day before class. Low Anxiety = 1 up to High Anxiety = 5.

Table 38

Partners Share in Career and Childcare

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 - Somewhat agree	1	14.3	14.3	14.3
	6 - Agree	2	28.6	28.6	42.9
	7 - Strongly Agree	4	57.1	57.1	100.0
	Total	7	100.0	100.0	

Note. Particpants used a slider bar to indicate level of agreement regarding if is it their belief that both parent partners should take an equal share in caring for children and working in a full-time career.

Table 39

Doing Well in Computer Science Courses Enhances Job/Career Opportunities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3 – Somewhat disagree	1	14.3	14.3	14.4
	4 – Neither agree or disagree	2	28.6	28.6	42.9
	Somewhat agree	1	14.3	14.3	57.1
	Agree	2	28.6	28.6	85.7
	Strongly Agree	1	14.3	14.3	100.0
	Total	7	100.0	100.0	

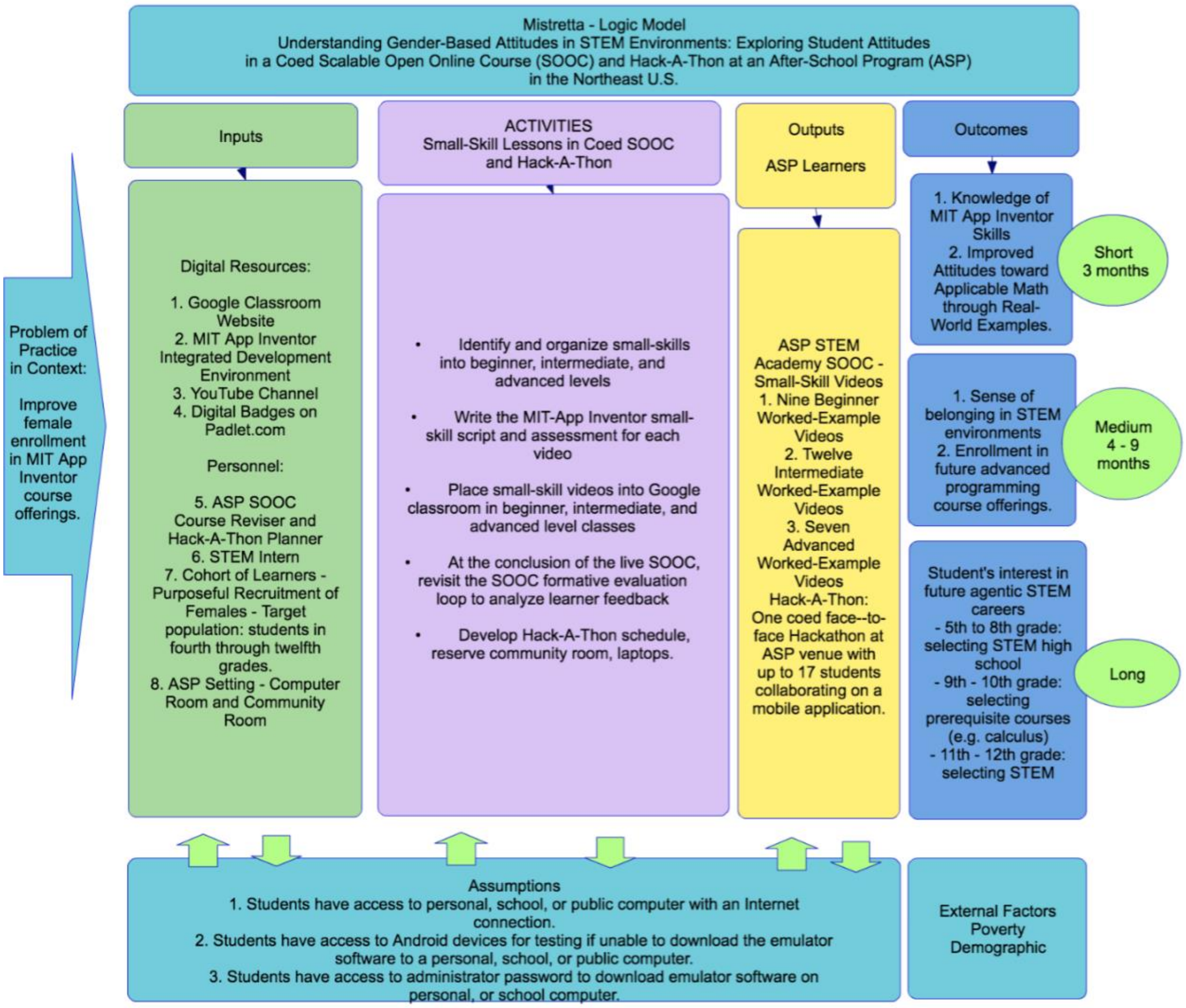
Table 40

Computer Science - Who is Better at This Subject?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Males	2	28.6	28.6	28.6
	Both males and females have an equal chance to excel.	5	71.4	71.4	100.0
	Total	7	100.0	100.0	

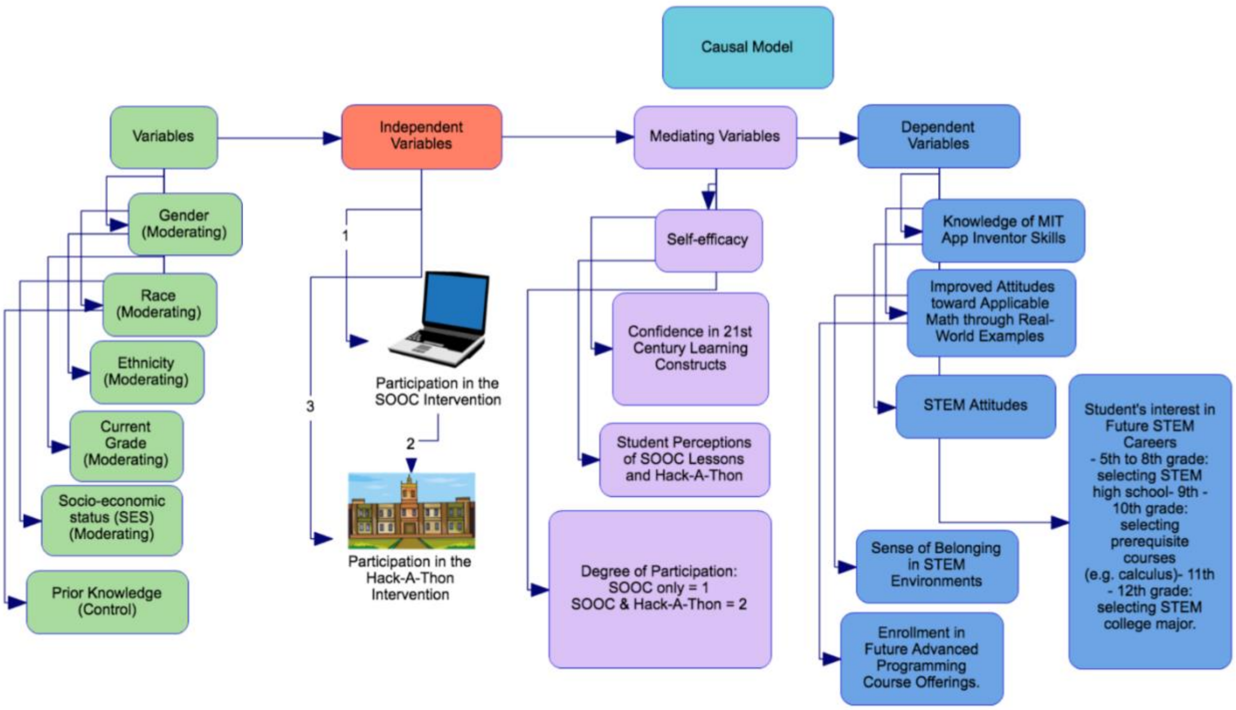
Appendix I

Logic Model



Appendix J

Causal Model



Appendix K

Interview Questions

- Tell me about your SOOC experience.
  - Why did you choose to participate in the SOOC?
- Do you have any suggestions as to how to improve the SOOC?
- Tell me about your Hack-A-Thon experience.
  - Why did you choose to participate in the Hack-A-Thon?
- What was the best part of the Hack-A-Thon?
- Tell me about your experience in working in a team environment at the Hack-A-Thon
  - Do you have any suggestions as to how to improve the Hack-A-Thon?
- Tell me what comes to mind when you hear the word STEM?
  - Is that what you thought when you started the program?
  - Is that what you think now that you finished the program?
- Here are some questions regarding your school and programming:
  - What does your school do in relation to programming class at school?
  - What does you school do in relation to engineering class at school?
  - Tell me about your math class.
  - Tell me about your science class.
  - Tell me about your school's programming classes.
    - (Potential Probe) What ones have you taken?
    - (Potential Probe) What are your plans regarding programming courses that you could take?
  - Are you interested in taking more computer programming courses? Why or Why not?
- What do you see yourself doing after high school?
- How are your current courses preparing you for after high school?
  - (Potential Probe) How could course better prepare you for adulthood?
- Do you plan to attend college?
  - What do you think you will study in college?
- What is your dream curriculum for school next year?
- Invite questions regarding this research process.

Appendix L

Process Evaluation Data Collection Matrix

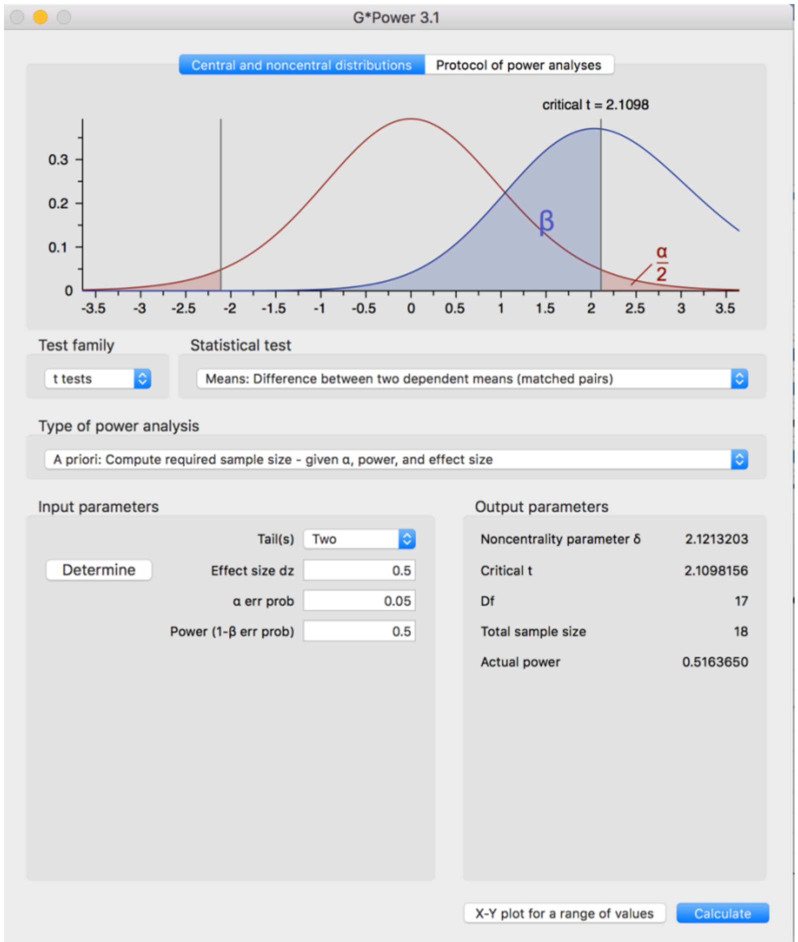
Table *41*

Process Evaluation Data Collection Matrix

Process Evaluation Indicator	Data Source(s)	Data Collection Tool	Frequency	Responsibility
Progress Indicator	Quantitative: Student Star Ratings.	SurveyMonkey	Throughout SOOC.	Sharon Mistretta
	Digital badges earned.	Padlet	Throughout SOOC.	Sharon Mistretta
	Hack-A-Thon Focus Group Transcripts.	Transcribed notes archived in Otter.ai and Evernote.	During the Hack-A-Thon.	Sharon Mistretta
Device Indicator	Quantitative: Parent Demographic Survey of SES and available student Internet device.	SurveyMonkey	Once at beginning of intervention.	Sharon Mistretta
Student Attitude toward STEM Indicator	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a, 2012b)	SurveyMonkey	Pre-and Post-intervention	Sharon Mistretta
Influence Indicator	Qualitative: Hack-A-Thon Interview Transcripts.	Qualitative: Otter.ai and Evernote	During the Hack-A-Thon.	Sharon Mistretta

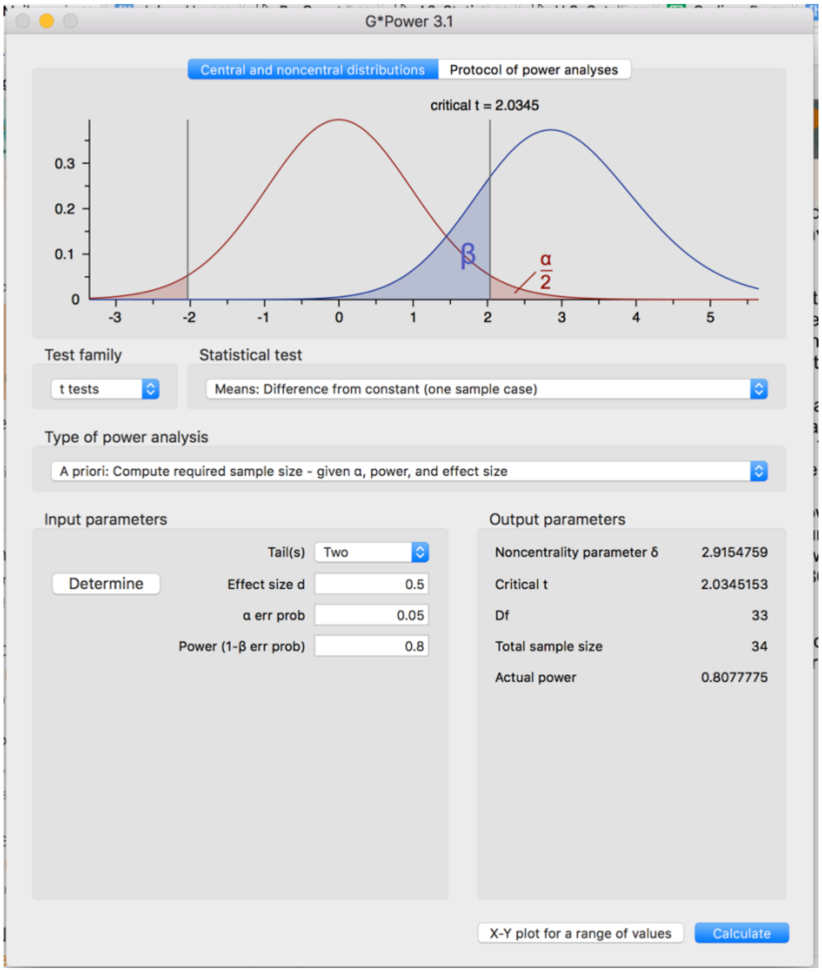
Appendix M

A Priori Calculation of Required Sample Size for Intervention with Power of 0.5



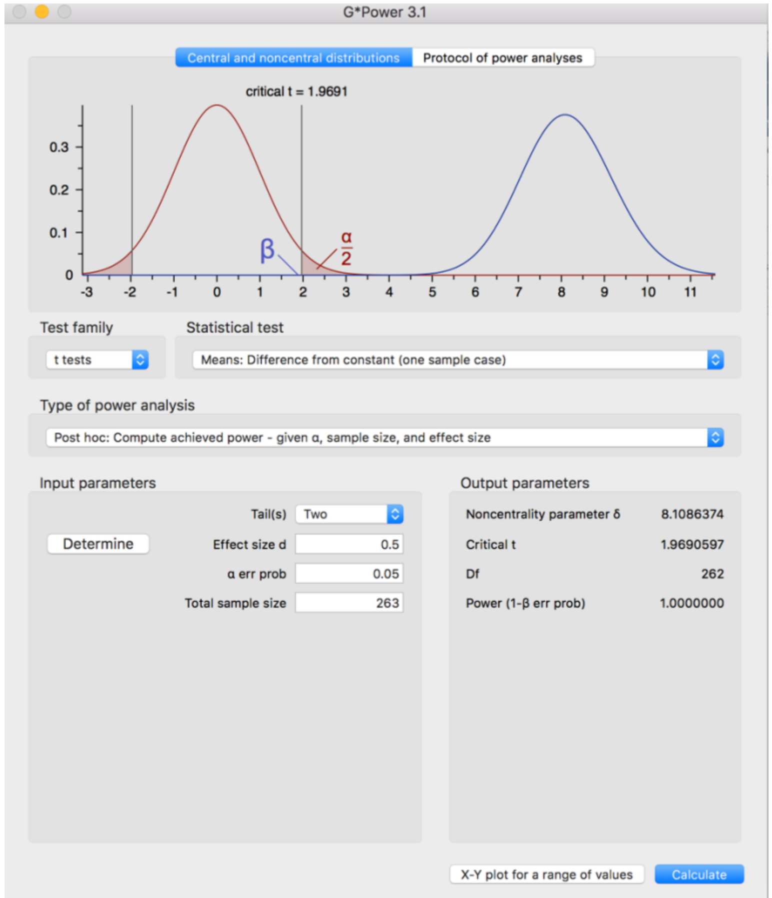
Appendix N

A Priori Calculation of Required Sample Size for Intervention with Power of 0.8



Appendix O

Post Hoc Calculation of Achieved Power of Yerdelen et al. (2016) Effect Size of 0.5



Appendix P

Outcome Evaluation Data Collection Matrix

Table 42

Outcome Evaluation Data Collection Matrix

Outcome Indicator	Role of Indicator	Data Source(s)	Frequency	Responsibility
Math Attitudes	Outcome	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta
		Qualitative: Student Interview Transcripts	Post intervention	Sharon Mistretta
Science Attitudes	Outcome	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta
		Qualitative: Student Interview Transcripts	Post intervention	Sharon Mistretta
Engineering Attitudes	Outcome	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta
Technology Attitudes	Outcome	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta
		Qualitative: Student Interview Transcripts	Post intervention	Sharon Mistretta

(continued)

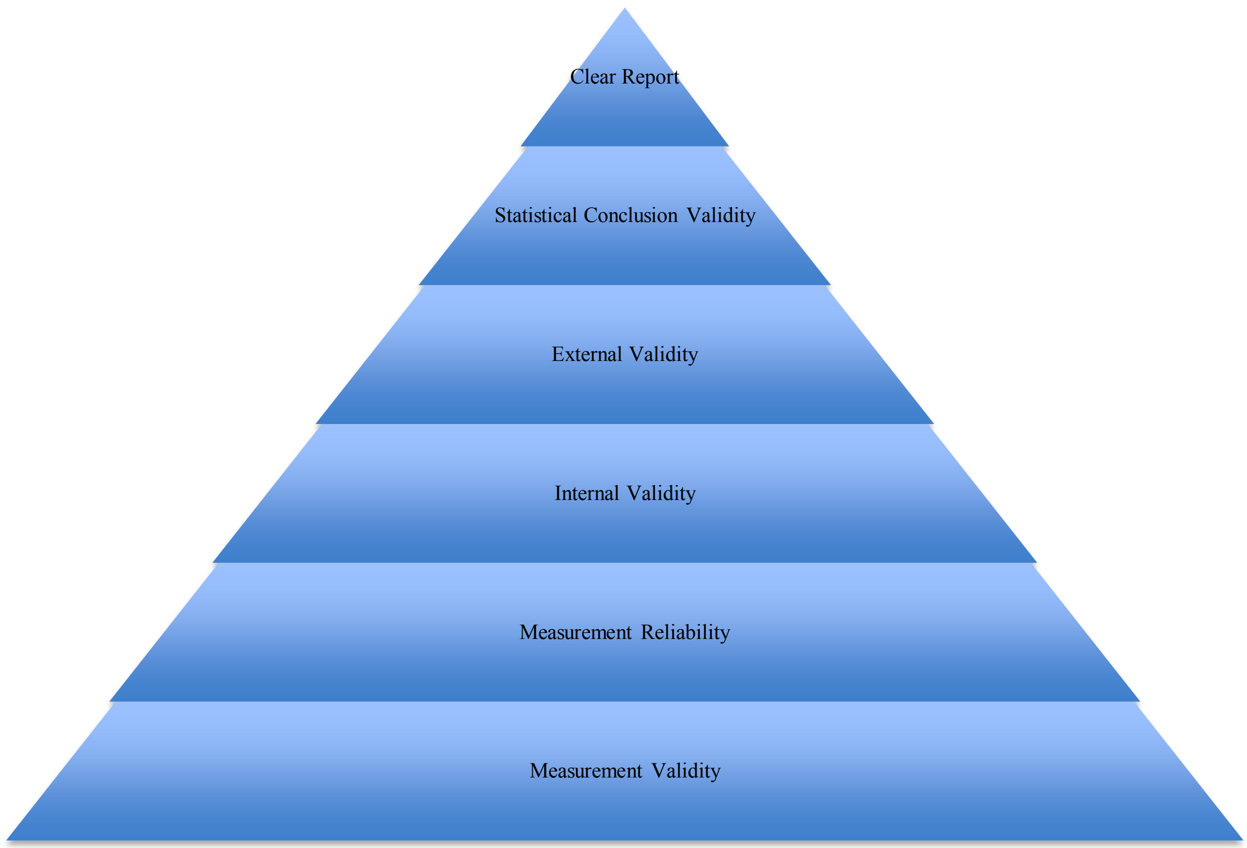
Outcome Indicator	Role of Indicator	Data Source(s)	Frequency	Responsibility
21st Century Learning Attitudes	Outcome	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta
		Qualitative: Student Interview Transcripts	Post intervention	Sharon Mistretta
Interest in STEM Careers	Outcome	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta
		Qualitative: Student Interview Transcripts	Post intervention	Sharon Mistretta
Gender	Moderating variable	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta
Race	Moderating variable	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta
Ethnicity	Moderating variable	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta
Grade	Moderating variable	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Pre-and Post-intervention	Sharon Mistretta

(continued)

Outcome Indicator	Role of Indicator	Data Source(s)	Frequency	Responsibility
		Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Post intervention	Sharon Mistretta
Prior Knowledge	Control variable	Qualitative Interviews	Post intervention	Sharon Mistretta

Appendix Q

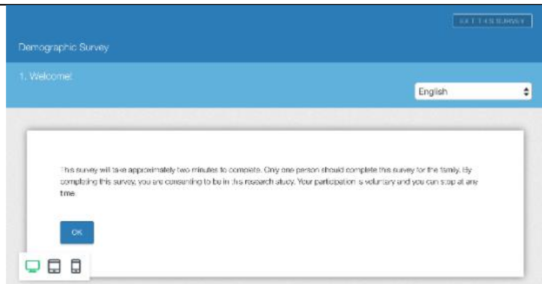
The Pyramid of Strength (Wholey et al., 2010)

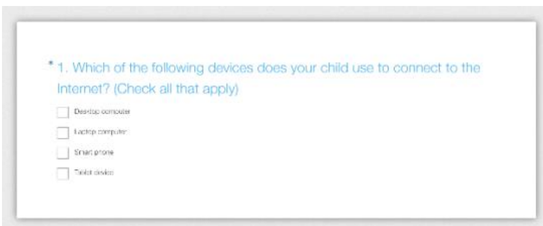


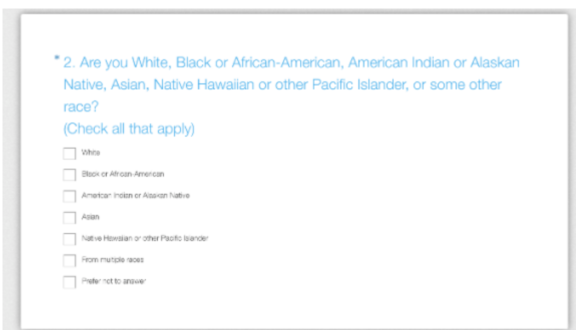
Appendix R

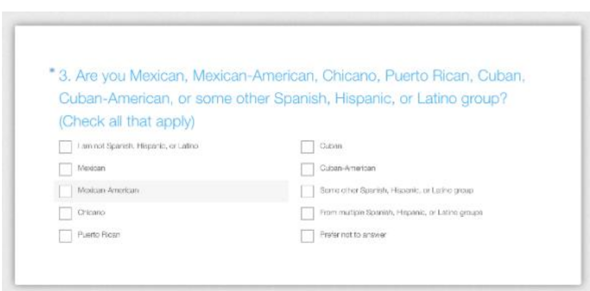
Parental Survey in English and Spanish

Parental Survey – English Block

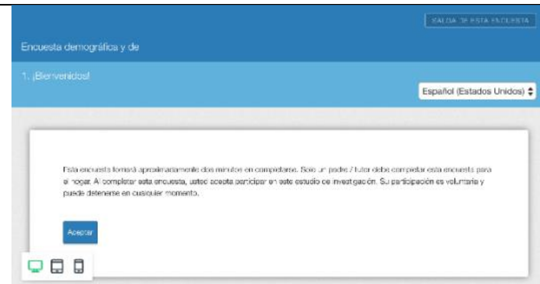


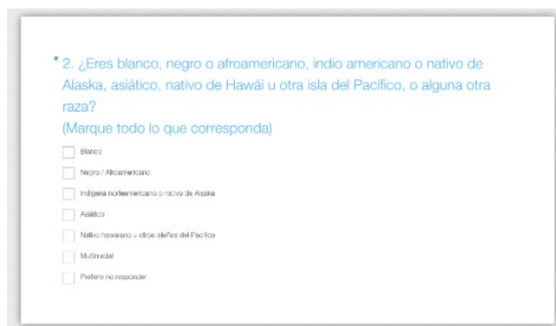




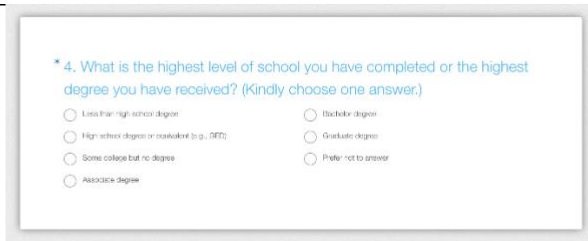


Parental Survey – Spanish Block



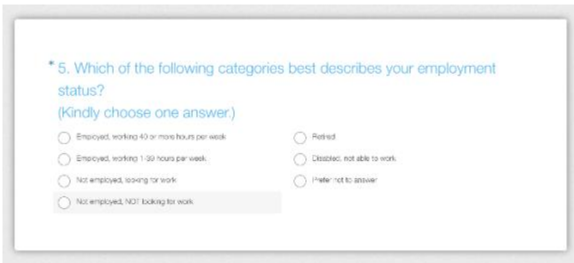


Parental Survey – English Block	Parental Survey – Spanish Block



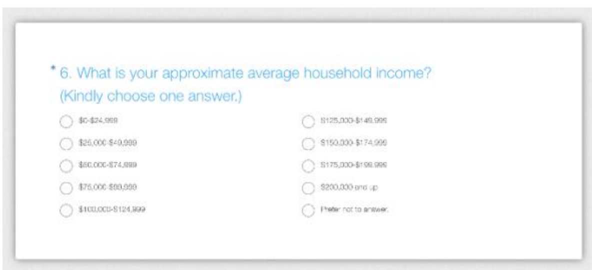
* 4. What is the highest level of school you have completed or the highest degree you have received? (Kindly choose one answer.)

- Less than high school degree
- High school degree or equivalent (e.g., GED)
- Some college but no degree
- Associate degree
- Bachelor degree
- Graduate degree
- Prefer not to answer



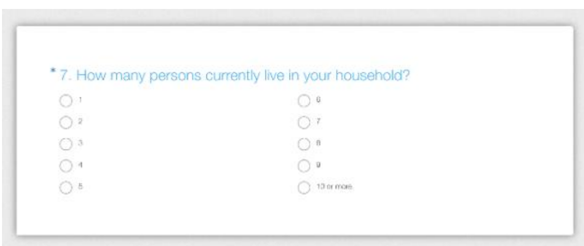
* 5. Which of the following categories best describes your employment status?
(Kindly choose one answer.)

- Employed, working 40 or more hours per week
- Employed, working 1-39 hours per week
- Not employed, looking for work
- Not employed, NOT looking for work
- Retired
- Disabled, not able to work
- Prefer not to answer



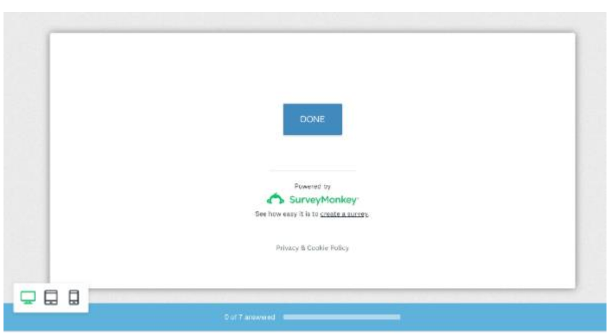
* 6. What is your approximate average household income?
(Kindly choose one answer.)

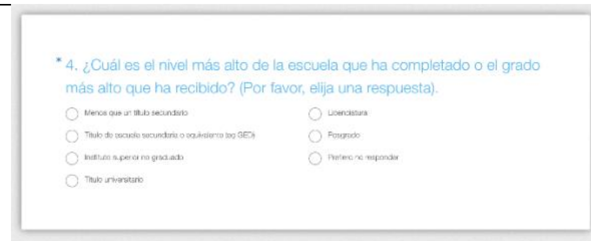
- $0-$24,999
- $25,000-$49,999
- $50,000-$74,999
- $75,000-$99,999
- $100,000-$124,999
- $125,000-$149,999
- $150,000-$174,999
- $175,000-$199,999
- $200,000 and up
- Prefer not to answer.



* 7. How many persons currently live in your household?

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 or more



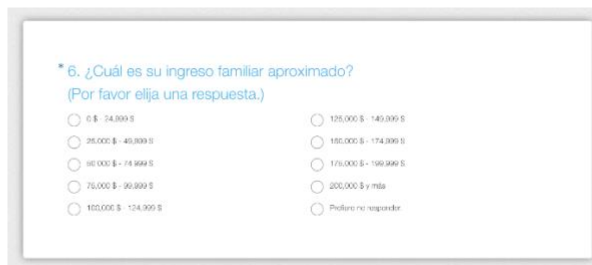


* 4. ¿Cuál es el nivel más alto de la escuela que ha completado o el grado más alto que ha recibido? (Por favor, elija una respuesta).

- Menos que un título secundario
- Título de escuela secundaria o equivalente (eg GED)
- Instituto superior no graduado
- Título universitario
- Licenciatura
- Posgrado
- Prefiero no responder

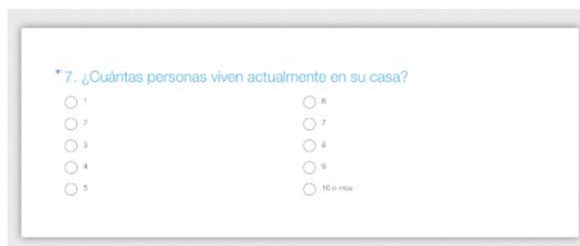
* 5. ¿Cuál de las siguientes categorías describe mejor su situación laboral? (Por favor, elija una respuesta).

- Empleado, trabajando 40 horas o más por semana
- Empleado, trabajando entre 1-39 horas por semana
- Desempleado, en busca de trabajo
- Desempleado, NO en busca de trabajo
- Jubilado
- Discapacitado, sin capacidad para trabajar
- Prefiero no responder



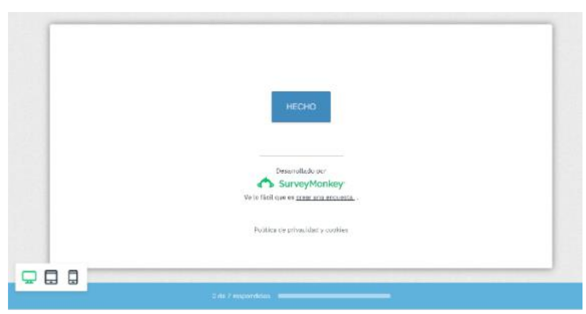
* 6. ¿Cuál es su ingreso familiar aproximado?
(Por favor elija una respuesta.)

- 0 $ - 24,999 $
- 25,000 $ - 49,999 $
- 50 000 $ - 74 999 $
- 75,000 $ - 99,999 $
- 100,000 $ - 124,999 $
- 125,000 $ - 149,999 $
- 150,000 $ - 174,999 $
- 175,000 $ - 199,999 $
- 200,000 $ y más
- Prefiero no responder



* 7. ¿Cuántas personas viven actualmente en su casa?

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 o más



Appendix S

Parental Informed Consent Permission Form in English and Spanish

Johns Hopkins University

Homewood Institutional Review Board (HIRB)

Parental Informed Consent Permission Form

Title:	Understanding Gender-Based Attitudes in STEM Environments
Principal Investigator:	Dr. Yolanda Abel, Johns Hopkins University School of Education
Date:	8/9/18

PURPOSE OF RESEARCH STUDY:

- The purpose of this research study is to better understand gender-based attitudes in science, technology, engineering, and math (STEM) environments. We anticipate that approximately 20 students will participate in this study.

PROCEDURES:

Each student:

- completes a pre-study, online survey regarding STEM attitudes.
- creates a personal account on the MIT App Inventor website using their personal Gmail email account.
- takes an online assessment regarding current programming skill level to assess prior knowledge and place in beginner, intermediate or advanced track lessons.
- uses a unique username and password to access small-skill videos on a scaled, open, online course (SOOC) regarding programming Android mobile applications.
- accesses the SOOC according to their personal schedule. They can repeat the video instruction as many times as they wish to complete worked examples to advance to the next skill level. The SOOC is available for 28 consecutive days.
- develops Android mobile applications on their personal MIT App Inventor website account.
- tests the developing programs on their Android/iOS mobile devices or on a software emulator available on the MIT App Inventor website.
- reaches out to the instructor via email (smistre2@jhu.edu) to request clarifications and feedback.
- receives instructor feedback and modify their developing program accordingly.
- takes a brief assessment to determine if they mastered the skills necessary to advance to the next level.
- receives digital badges and certificates upon the successful completion of each skill level.
- completes a post-study survey regarding STEM attitudes.
- attends a Hack-A-Thon held at Oasis – A Haven for Women and Children in Paterson, N.J. to develop real-world Android mobile applications in a team environment.
- participates in a post-Hack-A-Thon focus group regarding attitudes toward STEM environments.

RISKS/DISCOMFORTS:

- ***The risks associated with participation in this study are no greater than those encountered in daily life.***

BENEFITS:

- Students will gain knowledge regarding programming of Android mobile applications.
- At the Hack-A-Thon, students can code real-world applications in a team environment.

VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:

Your child's participation in this study is entirely voluntary. You choose whether to participate, and we will also ask your child whether he or she agrees to take part in the study. If you decide not to allow your child to participate, or your child chooses not to participate, there are no penalties, and your child will not lose any benefits to which they would otherwise be entitled.

If you and your child choose to allow your child to participate in the study, you or your child can stop participation at any time, without any penalty or loss of benefits. If you want to withdraw from the study, or your child wants to stop participating, please email Sharon Mistretta at smistre2@jhu.edu.

CIRCUMSTANCES THAT COULD LEAD US TO END YOUR PARTICIPATION:

Under certain circumstances we may decide to end your child's participation before he or she has completed the study. Specifically, we may stop your child's participation if they do not conduct themselves with respect for others in online and/or face-to-face collaborations. All students are expected to:

- Be respectful of instructors and fellow participants.
- Always use appropriate language in text, speech, audio or image formats.
- There may also be other circumstances that would lead us to end your participation.

CONFIDENTIALITY:

Any study records that identify you or your child will be kept confidential to the extent possible by law. The records from your child's participation may be reviewed by people responsible for making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies such as the National Institutes of Health and the Office for Human Research Protections. (All of these people are required to keep your identity and the identity of your child confidential.) Otherwise, records that identify you or your child will be available only to people working on the study, unless you give permission for other people to see the records.

Electronic survey and focus group data will be stored in Sharon Mistretta's computer, which is password protected, and respondent names will not be associated with any of the responses nor will they appear in any of the published reports.

COSTS

There are no monetary costs to enroll in this program. The only cost is your child's free time spent viewing the small-skill videos in the SOOC, completing the worked examples in MIT App Inventor, and attending a Hack-A-Thon event at Oasis – A Haven for Women and Children in Paterson, N.J.

COMPENSATION:

You or your child will not receive any payment or other compensation for participating in this study.

IF YOU HAVE QUESTIONS OR CONCERNS:

This study is being conducted by Sharon Mistretta who is a doctoral student at Johns Hopkins University School of Education and who is affiliated with the education department of Oasis – A Haven for Women and Children in Paterson, N.J. The principal investigator of this study is Dr. Yolanda Abel, an associate professor at Johns Hopkins University School of Education. Dr. Abel is not affiliated with Oasis – A Haven for Women and Children in Paterson, N.J.

You and your child can ask questions about this research study now or at any time during the study, by talking to the researcher(s) working with you and your child or by calling Sharon Mistretta, doctoral student investigator, at (201) 838-1379.

If you have questions about your child's rights as a research participant or feel that your child has not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

SIGNATURES

WHAT YOUR SIGNATURE MEANS:

Your signature below means that you understand the information in this consent form. Your signature also means that you agree to allow your child to participate in the study. Your child's signature indicates that he or she agrees to participate in the study. By signing this consent form, you and your child have not waived any legal rights your child otherwise would have as a participant in a research study.

Child's Name

Child's Signature (if applicable) **Date**

Signature of Parent/Guardian **Date**

Signature of Person Obtaining Consent (Investigator or HIRB-Approved Designee) **Date**

Universidad Johns Hopkins

Junta de Revisión Institucional de Homewood (HIRB)

Formulario de permiso de consentimiento informado de los padres

Título:	Comprender las actitudes basadas en el género en entornos STEM
Investigador principal:	Dr. Yolanda Abel, Escuela de Educación de la Universidad Johns Hopkins
Fecha:	8/9/18

OBJETIVO DEL ESTUDIO DE INVESTIGACIÓN:

- El propósito de este estudio de investigación es comprender mejor las actitudes basadas en el género en los entornos de ciencia, tecnología, ingeniería y matemáticas (STEM). Anticipamos que aproximadamente 20 estudiantes participarán en este estudio.

PROCEDIMIENTOS:

Cada estudiante:

- completa un estudio previo, en línea • completa una encuesta en línea previa al estudio sobre las actitudes de STEM.
- crea una cuenta personal en el sitio web de MIT App Inventor utilizando su cuenta de correo electrónico personal de Gmail.
- realiza una evaluación en línea con respecto al nivel de habilidad de programación actual para evaluar el conocimiento previo y ubicarlo en las lecciones de nivel inicial, intermedio o avanzado.
- usa un nombre de usuario y una contraseña únicos para acceder a videos de pequeñas habilidades en un curso escalado, abierto y en línea (SOOC) con respecto a la programación de aplicaciones móviles de Android.
- accede al SOOC según su horario personal. Pueden repetir la instrucción de video tantas veces como deseen completar ejemplos trabajados para avanzar al siguiente nivel de habilidad. El SOOC está disponible por 28 días consecutivos.
- desarrolla aplicaciones móviles Android en su cuenta personal de MIT App Inventor.
- prueba los programas en desarrollo en sus dispositivos móviles Android / iOS o en un emulador de software disponible en el sitio web de MIT App Inventor.
- se comunica con el instructor por correo electrónico (smistre2@jhu.edu) para solicitar aclaraciones y comentarios.
- recibe retroalimentación del instructor y modifica su programa de desarrollo en consecuencia.
- realiza una breve evaluación para determinar si dominaron las habilidades necesarias para avanzar al siguiente nivel.
- recibe insignias y certificados digitales luego de completar con éxito cada nivel de habilidad.
- completa una encuesta posterior al estudio sobre las actitudes de STEM.

- asiste a un Hack-A-Thon celebrado en Oasis - Un refugio para mujeres y niños en Paterson, N.J. para desarrollar aplicaciones móviles de Android en el mundo real en un entorno de equipo.
- participa en un grupo de enfoque post-Hack-A-Thon / entrevista sobre las actitudes hacia los entornos STEM.

RIESGOS/MALOS CONFLICTOS:

- Los riesgos asociados con la participación en este estudio no son mayores que los encontrados en la vida diaria.

BENEFICIOS:

- Los estudiantes obtendrán conocimiento con respecto a la programación de aplicaciones móviles Android.
- En Hack-A-Thon, los estudiantes pueden codificar aplicaciones del mundo real en un entorno de equipo.

PARTICIPACIÓN VOLUNTARIA Y DERECHO A RETIRAR:

La participación de su hijo en este estudio es completamente voluntaria. Usted elige si participa o no, y también le preguntaremos a su hijo si acepta participar en el estudio. Si decide no permitir que su hijo participe, o si su hijo decide no participar, no hay sanciones, y su hijo no perderá ningún beneficio al que de otro modo tendrían derecho.

Si usted y su hijo eligen permitir que su hijo participe en el estudio, usted o su hijo pueden dejar de participar en cualquier momento, sin ninguna penalización o pérdida de beneficios. Si desea retirarse del estudio, o si su hijo desea dejar de participar, envíe un correo electrónico a Sharon Mistretta a smistre2@jhu.edu.

CIRCUNSTANCIAS QUE PODRIAN CONDUCIRNOS A FINALIZAR SU PARTICIPATION:

Bajo ciertas circunstancias, podemos decidir finalizar la participación de su hijo antes de que él o ella haya completado el estudio. Específicamente, podemos detener la participación de su hijo si no se conducen con respeto hacia los demás en colaboraciones en línea y / o cara a cara. Se espera que todos los estudiantes:

- Sea respetuoso de los instructores y compañeros participantes.
- Utilice siempre el lenguaje apropiado en formatos de texto, voz, audio o imagen.
- También puede haber otras circunstancias que nos lleven a terminar su participación.

CONFIDENCIALIDAD:

Cualquier registro del estudio que lo identifique a usted o a su hijo se mantendrá confidencial en la medida de lo posible por ley. Los registros de la participación de su hijo pueden ser revisados por personas responsables de asegurarse de que la investigación se realice correctamente, incluidos miembros de la Junta de Revisión Institucional de Homewood de la Universidad Johns Hopkins y funcionarios de organismos gubernamentales como los Institutos Nacionales de Salud y la Oficina de Investigación Humana. Protecciones (Todas estas personas deben mantener confidencial su identidad y la identidad de su hijo). De lo contrario, los registros que lo identifican a usted o a su hijo estarán disponibles solo para las personas que trabajan en el estudio, a menos que otorgue permiso para que otras personas vean los archivos.

La encuesta electrónica y los datos de los grupos focales se almacenarán en la computadora de Sharon Mistretta, que está protegida por contraseña, y los nombres de los encuestados no se asociarán con ninguna de las respuestas ni aparecerán en ninguno de los informes publicados.

COSTOS

No hay costos monetarios para inscribirse en este programa. El único costo es el tiempo libre de su hijo para ver los videos de habilidades pequeñas en el SOOC, completar los ejemplos trabajados en MIT App Inventor y asistir a un evento Hack-A-Thon en Oasis - Un refugio para mujeres y niños en Paterson, N.J.

COMPENSACION:

Usted o su hijo no recibirán ningún pago u otra compensación por participar en este estudio.

SI TIENE PREGUNTAS O PREOCUPACIONES:

Este estudio está dirigido por Sharon Mistretta, estudiante de doctorado en la Escuela de Educación de la Universidad Johns Hopkins y afiliada al departamento de educación de Oasis - Un refugio para mujeres y niños en Paterson, Nueva Jersey. El investigador principal de este estudio es el Dr. Yolanda Abel, profesora asociada de la Facultad de Educación de la Universidad Johns Hopkins. El Dr. Abel no está afiliado a Oasis - Un refugio para mujeres y niños en Paterson, N.J.

Usted y su hijo pueden hacer preguntas sobre este estudio de investigación ahora o en cualquier momento durante el estudio, hablando con el (los) investigador (es) que trabajan con usted y con su hijo o llamando a Sharon Mistretta, investigadora de doctorado, al (201) 838- 1379.

Si tiene preguntas sobre los derechos de su hijo como participante en la investigación o siente que su hijo no recibió un trato justo, llame a la Junta de Revisión Institucional de Homewood de la Universidad Johns Hopkins al (410) 516-6580.

FIRMAS

LO QUE SU FIRMA SIGNIFICA:

Su firma a continuación significa que usted comprende la información en este formulario de consentimiento. Su firma también significa que acepta permitir que su hijo participe en el estudio. La firma de su hijo indica que él o ella acepta participar en el estudio. Al firmar este formulario de consentimiento, usted y su hijo no han renunciado a los derechos legales que su hijo tendría como participantes en un estudio de investigación.

El nombre del niño

Firma del niño (si corresponde) **Fecha**

Firma del padre / tutor **Fecha**

Firma de la persona que obtiene el consentimiento **Fecha**
(Investigador o Designado Aprobado por HIRB)

Johns Hopkins University

Homewood Institutional Review Board (HIRB)

Assent Form

Title:	Understanding Gender-Based Attitudes in STEM Environments
Principal Investigator:	Dr. Yolanda Abel, Johns Hopkins University School of Education
Date:	8/9/18

We want to tell you about a research study we are doing. A research study is a way to learn more about something. We would like to find out more about attitudes in science, technology, engineering, and math (STEM) classes. You are being asked to join the study because you have an interest in learning how to program.

If you agree to join this study, you will be asked to log into a scalable, open, online course (SOOC) in MIT App Inventor. In the beginning of the course, we will ask you some questions about what you already know about programming. Then, we will place you in a beginner, intermediate, or advanced level section of the course. You will learn how to program mobile Android applications in MIT App Inventor by viewing brief videos and coding the example in the video in your MIT App Inventor account. You can test your applications on your Android phone, Android tablet, Apple iPhone, or iPad. If you do not have one of these devices, you can download emulator software from the MIT App Inventor website to test your applications right on your computer. All of the videos can be viewed by you according to your personal schedule. The videos can be repeated as many times as you wish to complete the example application. We will ask you another set of questions when you are ready to advance to the next level. The instructor, Mrs. Mistretta, is available by email at smistre2@jhu.edu for questions and feedback about your programming. At the end of the course, you are invited to attend a face-to-face Hack-A-Thon at Oasis – A Haven for Women and Children in Paterson, N.J. During participation in this study, we ask everyone to:

- Be respectful of instructors and fellow participants.
- Always use appropriate language in text, speech, audio or image formats.

There are no risks or discomforts in participating in this study.

There are no monetary costs to enroll in this program. The only cost is your free time spent viewing the small-skill videos in the SOOC, completing the worked examples in MIT App Inventor, and attending a Hack-A-Thon event at Oasis – A Haven for Women and Children.

We expect that the study will help you by help you to gain knowledge about programming mobile Android applications and a chance to work with a team of students who also participated in this study to program a real-world STEM application at a Hack-A-Thon that you are invited to attend at Oasis – A Haven for Women and Children. We may learn something that will help other children with taking STEM courses someday. This study will help us learn more about what you think of STEM classes.

You do not have to join this study. It is up to you. You can say okay now and change your mind later. All you have to do is tell us you want to stop. No one will be mad at you if you don't want to be in the study or if you join the study and change your mind later and stop.

Before you say **yes or no** to being in this study, we will answer any questions you have. If you join the study, you can ask questions at any time. Just tell the researcher, Sharon Mistretta, that you have a question. Here are the ways that you can contact the researcher:

Phone: 201-838-1379

Email: smistre2@jhu.edu

In person: tell anyone at Oasis – A Haven for Women and Children that you wish to speak to Sharon Mistretta.

If you want to be in this study, please sign your name, and place today's date next to your name.

You will get a copy of this form to keep.

______________________________	______________________
Sign your name here	**Date**

Universidad Johns Hopkins
Junta de Revisión Institucional de Homewood (HIRB)

Formulario de asentimiento

Título:	Comprender las actitudes basadas en el género en entornos STEM
Investigador principal:	Dr. Yolanda Abel, Escuela de Educación de la Universidad Johns Hopkins
Fecha:	8/9/18

Queremos contarte sobre un estudio de investigación que estamos haciendo. Un estudio de investigación es una forma de aprender más sobre algo. Nos gustaría saber más acerca de las actitudes en las clases de ciencias, tecnología, ingeniería y matemáticas (STEM). Se le ha pedido que se una al estudio porque tiene interés en aprender a programar.

Si acepta unirse a este estudio, se le pedirá que inicie sesión en un curso en línea escalable y abierto (SOOC) en MIT App Inventor. Al comienzo del curso, le haremos algunas preguntas sobre lo que ya sabe sobre programación. Luego, lo ubicaremos en una sección de nivel principiante, intermedio o avanzado del curso. Aprenderá cómo programar aplicaciones móviles de Android en MIT App Inventor al ver videos breves y codificar el ejemplo en el video en su cuenta MIT App Inventor. Puede probar sus aplicaciones en su teléfono Android, tableta Android, iPhone de Apple o iPad. Si no tiene uno de estos dispositivos, puede descargar el software del emulador desde el sitio web de MIT App Inventor para probar sus aplicaciones directamente en su computadora. Todos los videos pueden ser vistos de acuerdo a su horario personal. Los videos pueden repetirse tantas veces como desee para completar la aplicación de ejemplo. Le haremos otras preguntas cuando esté listo para avanzar al próximo nivel. La instructora, la Sra. Mistretta, está disponible por correo electrónico en smistre2@jhu.edu para preguntas y comentarios sobre su programación. Al final del curso, se le invita a asistir a un Hack-A-Thon presencial en Oasis - Un refugio para mujeres y niños en Paterson, N.J. Durante la participación en este estudio, le pedimos a todos que:

- Sea respetuoso de los instructores y compañeros participantes.
- Utilice siempre el lenguaje apropiado en formatos de texto, voz, audio o imagen.

No hay riesgos o incomodidades al participar en este estudio.

No hay costos monetarios para inscribirse en este programa. El único costo es su tiempo libre dedicado a ver videos de habilidades pequeñas en el SOOC, completar los ejemplos trabajados en MIT App Inventor y asistir a un evento de Hack-A-Thon en Oasis - Un refugio para mujeres y niños.

Esperamos que el estudio lo ayude a obtener conocimientos sobre la programación de aplicaciones móviles de Android y la oportunidad de trabajar con un equipo de estudiantes que también participó en este estudio para programar una aplicación de STEM en el mundo real en Hack-A-Thon. que está invitado a asistir a Oasis - Un refugio para mujeres y niños. Podemos aprender algo que ayude a otros niños a tomar cursos STEM algún día. Este estudio nos ayudará a aprender más sobre lo que piensas de las clases de STEM.

No tiene que unirse a este estudio. Es tu decisión. Puedes decir que está bien ahora y cambiar de opinión más tarde. Todo lo que tienes que hacer es decirnos que quieres parar. Nadie se enojará contigo si no quieres estar en el estudio o si te unes al estudio y cambias de opinión más tarde y te detienes. Antes de decir sí o no a este estudio, responderemos cualquier pregunta que tenga. Si te unes al estudio, puedes hacer preguntas en cualquier momento. Simplemente dígale a la investigadora, Sharon Mistretta, que tiene una pregunta. Estas son las formas en que puede contactar al investigador:

Teléfono: 201-838-1379

Correo electrónico: smistre2@jhu.edu

En persona: dile a alguien en Oasis - Un refugio para mujeres y niños que deseas hablar con Sharon Mistretta.

Si desea participar en este estudio, firme su nombre y coloque la fecha de hoy junto a su nombre. Obtendrá una copia de este formulario para conservar.

______________________________________ ___________________________

Firme su nombre aquí **Fecha**

Appendix T

VoiceThread Recruitment Script in English and Spanish

Understanding Gender-Based Attitudes in STEM Environments

VoiceThread Recruitment Script

Active Link to VoiceThread Video: https://voicethread.com/share/10516797/

Slide 1- English: Hello! My name is Sharon Mistretta. Welcome to a presentation regarding an opportunity for Oasis After-School Program students in fourth through 12th grades to learn how to program mobile Android applications using MIT App Inventor! You are being asked to consider enrolling your student as a participant in a **research study** with Johns Hopkins University School of Education. The purpose of this research study is to better understand gender-based attitudes in STEM environments. STEM is an acronym for science, technology, engineering, and math.

Your student's participation is voluntary, there is no cost to enroll in the program, and your student can stop at any time.

Slide 1 – Spanish: ¡Hola! Mi nombre es Sharon Mistretta. ¡Bienvenido a una presentación sobre la oportunidad para los estudiantes del Programa Oasis Después del colegio de cuarto a doceavo grado de aprender cómo programar aplicaciones móviles de Android usando MIT App Inventor! Se le pide que considere inscribir a su estudiante como participante en un estudio de investigación con la Escuela de Educación de la Universidad Johns Hopkins. El propósito de este estudio de investigación es comprender mejor las actitudes basadas en el género en entornos STEM. STEM es un acrónimo de ciencia, tecnología, ingeniería y matemáticas.

La participación de su estudiante es voluntaria, no hay costo para inscribirse en el programa, y su estudiante puede detenerse en cualquier momento.

Slide 2 - English: The course in MIT App Inventor is presented in online format in a platform called a SOOC. This acronym stands for scalable, open, online course. The course lasts for 28-days and provides your student with individual access to video-based programming instruction to learn how to code mobile Android applications. Three skill levels are available to students in beginner, intermediate, and advanced course work. Your student can log into the SOOC during the 28-days according to their schedule. The video lessons are self-paced and your student can view instruction as many times as they wish to complete worked examples of MIT App Inventor applications. Your student will learn how to program Android applications used in real-world settings. After the 28-day, self-paced course, your student will receive an invitation to a Hack-A-Thon at Oasis located at 59 Mill Street in Paterson, N.J. Students will gather to form teams to design and develop authentic STEM applications.

Slide 2 – Spanish: El curso en MIT App Inventor se presenta en formato en línea en una plataforma llamada SOOC. Este acrónimo significa curso en línea escalable, abierto. El curso tiene una duración de 28 días y le brinda a su estudiante acceso individual a las instrucciones de programación basadas en video para aprender cómo codificar las aplicaciones móviles de Android. Tres niveles de habilidades están disponibles para los estudiantes en el trabajo de principiante, intermedio y avanzado. Su estudiante puede iniciar sesión en el SOOC durante los 28 días según su horario. Las lecciones en video son a su propio ritmo y su estudiante puede ver las instrucciones tantas veces como desee para completar los ejemplos trabajados de las aplicaciones de MIT App Inventor. Su alumno aprenderá a programar aplicaciones de Android utilizadas en entornos reales. Después del curso de 28 días, a su propio ritmo, su estudiante recibirá una invitación a Hack-A-Thon en Oasis ubicado en 59 Mill Street en Paterson, N.J. Los estudiantes se reunirán para formar equipos para diseñar y desarrollar aplicaciones STEM auténticas.

Slide 3 - English: The SOOC and Hack-A-Thon are taught by Mrs. Sharon Mistretta, a doctoral student at Johns Hopkins University, and a technology teacher with experience instructing Pre-K3 through master's degree students.

Slide 3 – Spanish: El SOOC y Hack-A-Thon son enseñados por la Sra. Sharon Mistretta, estudiante de doctorado en la Universidad Johns Hopkins, y una maestra de tecnología con experiencia en la instrucción de Pre-K3 a través de los estudiantes de maestría.

Slide 4 - English: How can your child participate? The eligibility requirements are as follows:

- Is your child in fourth through 12th grades and enrolled in the Oasis After-School Program?
- The computer rooms and laptop devices are available to your child throughout the week at Oasis to view video lessons and work on an Android Mobile Applications using MIT App Inventor.
- If you have a computer with Internet access at home, then your child can view the lessons on their own computer.
- The program begins on October 1st and ends on November 3rd of 2018

Slide 4 – Spanish: ¿Cómo puede participar su hijo? Los requisitos de elegibilidad son los siguientes:

- ¿Está su hijo de cuarto a doceavo grado y está inscrito en el programa Oasis Después del colegio?

- Las salas de computadoras y los dispositivos portátiles están disponibles para su hijo durante toda la semana en Oasis para ver lecciones en video y trabajar en una aplicación móvil Android usando MIT App Inventor.
- Si tiene una computadora con acceso a Internet en el hogar, su hijo puede ver las lecciones en su propia computadora.
- El programa comienza el 1 de octubre y finaliza el 3 de noviembre de 2018

Slide 5 - English: What are some of the benefits to participation?

- Your student will gain knowledge regarding programming of Android mobile applications.
- At the Hack-A-Thon, your student can code real-world STEM applications in a team environment.

Slide 5 – Spanish: ¿Cuáles son algunos de los beneficios de la participación?

- Su estudiante obtendrá conocimiento con respecto a la programación de aplicaciones móviles Android.
- En Hack-A-Thon, su estudiante puede codificar las aplicaciones STEM del mundo real en un entorno de equipo.

Slide 6 - English: What will your student receive?

- As your student advances from beginner, to intermediate, to advanced levels, they will be awarded digital badges and STEM Certificates of Completion.

Slide 6 – Spanish: ¿Qué recibirá su hijo?

- A medida que su estudiante avanza desde el nivel principiante, intermedio hasta avanzado, se le otorgarán insignias digitales y certificados de finalización STEM.

Slide 7 - English: Hack-A-Thon

- All participants are invited to attend a one-day Hack-A-Thon held at Oasis located at 59 Mill Street in Paterson. Students will gather to form teams to design and develop authentic STEM applications. The date of the Hack-A-Thon will be announced at the end of October 2018.

Slide 7 – Spanish: Hack-A-Thon

- Todos los participantes están invitados a asistir a un Hack-A-Thon de un día en Oasis ubicado en 59 Mill Street en Paterson. Los estudiantes se reunirán para formar equipos para diseñar y desarrollar aplicaciones STEM auténticas. La fecha del Hack-A-Thon se anunciará a fines de octubre de 2018.

Slide 8 - English: How do you sign up your child for this program?

- Obtain an informed consent form to enroll your student at the Parent Bazaar held in August 2018 at Oasis, located at 59 Mill Street in Paterson, N.J. Or, email Sharon Mistretta at smistre2@jhu.edu. The education department at Oasis will also have a supply of the forms.
- Then, read and sign the form in the signature box provided. You can return the form to me in person, Sharon Mistretta, at the parent bazaar in August 2018. Or, you can drop the form off to the education department at Oasis.

Slide 8 – Spanish: ¿Cómo inscribir a su hijo para este programa?

- Obtenga un formulario de consentimiento informado para inscribir a su estudiante en el Bazar de Padres celebrado en agosto de 2018 en Oasis, ubicado en 59 Mill Street en Paterson, N.J. O envíe un correo electrónico a Sharon Mistretta a smistre2@jhu.edu. El departamento de educación de Oasis también tendrá un suministro de los formularios.

- Luego, lea y firme el formulario en el cuadro de firma provisto. Puede devolverme el formulario en persona, Sharon Mistretta, en el bazar para padres en agosto de 2018. O puede dejar el formulario en el departamento de educación de Oasis.

Slide 9 - English:

- Once I receive your signed informed consent, then I will meet with your student on Monday, October 1st in the Oasis 2nd floor computer room to get them started!

Slide 9 – Spanish:

- Una vez que reciba su consentimiento informado firmado, me reuniré con su estudiante el lunes, 1 de octubre en la sala de computadoras del segundo piso de Oasis para que comiencen.

Slide 10 - English: Thank you so much for considering participation in my study!

Slide 10 – Spanish: ¡Muchas gracias por considerar la participación en mi estudio!

Appendix U

Adult Informed Consent Form in English and Spanish

Johns Hopkins University
Homewood Institutional Review Board (HIRB)

Adult Informed Consent Form

Title:	Understanding Gender-Based Attitudes in STEM Environments
Principal Investigator:	Dr. Yolanda Abel, Johns Hopkins University School of Education
Date:	8/9/18

PURPOSE OF RESEARCH STUDY:

- The purpose of this research study is to better understand gender-based attitudes in science, technology, engineering, and math (STEM) environments. We anticipate that approximately 20 students will participate in this study.

PROCEDURES:

Each student:

- completes a pre-study, online survey regarding STEM attitudes.
- creates a personal account on the MIT App Inventor website using their personal Gmail email account.
- takes an online assessment regarding current programming skill level to assess prior knowledge and place in beginner, intermediate or advanced track lessons.
- uses a unique username and password to access small-skill videos on a scaled, open, online course (SOOC) regarding programming Android mobile applications.
- accesses the SOOC according to their personal schedule. They can repeat the video instruction as many times as they wish to complete worked examples to advance to the next skill level. The SOOC is available for 28 consecutive days.
- develops Android mobile applications on their personal MIT App Inventor website account.
- tests the developing programs on their Android/iOS mobile devices or on a software emulator available on the MIT App Inventor website.
- reaches out to the instructor via email (smistre2@jhu.edu) to request clarifications and feedback.
- receives instructor feedback and modify their developing program accordingly.
- takes a brief assessment to determine if they mastered the skills necessary to advance to the next level.

- receives digital badges and certificates upon the successful completion of each skill level.
- completes a post-study survey regarding STEM attitudes.
- attends a Hack-A-Thon held at Oasis – A Haven for Women and Children in Paterson, N.J. to develop real-world Android mobile applications in a team environment.
- participates in a post-Hack-A-Thon focus group/interview regarding attitudes toward STEM environments.

RISKS/DISCOMFORTS:

- ***The risks associated with participation in this study are no greater than those encountered in daily life.***

BENEFITS:

- Students will gain knowledge regarding programming of Android mobile applications.
- At the Hack-A-Thon, students can code real-world applications in a team environment.

VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:

Your participation in this study is entirely voluntary: You choose whether to participate. If you decide not to participate, there are no penalties, and you will not lose any benefits to which you would otherwise be entitled.

If you choose to participate in the study, you can stop your participation at any time, without any penalty or loss of benefits. If you want to withdraw from the study, please email Sharon Mistretta at smistre2@jhu.edu.

CIRCUMSTANCES THAT COULD LEAD US TO END YOUR PARTICIPATION:

Under certain circumstances we may decide to end your participation before you have completed the study. Specifically, we may stop your participation if you do not conduct yourself with respect for others in online and/or face-to-face collaborations. All students are expected to:

- Be respectful of instructors and fellow participants.
- Always use appropriate language in text, speech, audio or image formats.
- There may also be other circumstances that would lead us to end your participation.

CONFIDENTIALITY:

Any study records that identify you will be kept confidential to the extent possible by law. The records from your participation may be reviewed by people responsible for making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies such as the National Institutes of Health and the Office for Human Research Protections. (All of these people are required to keep your identity confidential.) Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

Electronic survey and focus group/interview data will be stored in Sharon Mistretta's computer, which is password protected, and respondent names will not be associated with any of the responses nor will they appear in any of the published reports.

COSTS

There are no monetary costs to enroll in this program. The only cost is your free time spent viewing the small-skill videos in the SOOC, completing the worked examples in MIT App Inventor, and attending a Hack-A-Thon event at Oasis – A Haven for Women and Children in Paterson, N.J.

COMPENSATION:

You will not receive any payment or other compensation for participating in this study.

IF YOU HAVE QUESTIONS OR CONCERNS:

This study is being conducted by Sharon Mistretta who is a doctoral student at Johns Hopkins University School of Education and who is affiliated with the education department of Oasis – A Haven for Women and Children in Paterson, N.J. The principal investigator of this study is Dr. Yolanda Abel, an associate professor at Johns Hopkins University School of Education. Dr. Abel is not affiliated with Oasis – A Haven for Women and Children in Paterson, N.J.

You can ask questions about this research study now or at any time during the study, by talking to the researcher(s) working with you or by calling Sharon Mistretta, doctoral student investigator, at (201) 838-1379.

If you have questions about your rights as a research participant or feel that you have not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

SIGNATURES

WHAT YOUR SIGNATURE MEANS:

Your signature below means that you understand the information in this consent form. Your signature also means that you agree to participate in the study.

By signing this consent form, you have not waived any legal rights you otherwise would have as a participant in a research study.

Participant's Signature **Date**

Signature of Person Obtaining Consent **Date**
(Investigator or HIRB Approved Designee)

Universidad Johns Hopkins

Junta de Revisión Institucional de Homewood (HIRB)

Formulario de consentimiento informado para adultos

Título:	Comprender las actitudes basadas en el género en entornos STEM
Investigador principal:	Dr. Yolanda Abel, Escuela de Educación de la Universidad Johns Hopkins
Fecha:	8/9/18

OBJETIVO DEL ESTUDIO DE INVESTIGACIÓN:

- El propósito de este estudio de investigación es comprender mejor las actitudes basadas en el género en los entornos de ciencia, tecnología, ingeniería y matemáticas (STEM). Anticipamos que aproximadamente 20 estudiantes participarán en este estudio.

PROCEDIMIENTOS:

Cada estudiante:

- completa un estudio previo, en línea • completa una encuesta en línea previa al estudio sobre las actitudes de STEM.
- crea una cuenta personal en el sitio web de MIT App Inventor utilizando su cuenta de correo electrónico personal de Gmail.
- realiza una evaluación en línea con respecto al nivel de habilidad de programación actual para evaluar el conocimiento previo y ubicarlo en las lecciones de nivel inicial, intermedio o avanzado.
- usa un nombre de usuario y una contraseña únicos para acceder a videos de pequeñas habilidades en un curso escalado, abierto y en línea (SOOC) con respecto a la programación de aplicaciones móviles de Android.
- accede al SOOC según su horario personal. Pueden repetir la instrucción de video tantas veces como deseen completar ejemplos trabajados para avanzar al siguiente nivel de habilidad. El SOOC está disponible por 28 días consecutivos.
- desarrolla aplicaciones móviles Android en su cuenta personal de MIT App Inventor.
- prueba los programas en desarrollo en sus dispositivos móviles Android / iOS o en un emulador de software disponible en el sitio web de MIT App Inventor.
- se comunica con el instructor por correo electrónico (smistre2@jhu.edu) para solicitar aclaraciones y comentarios.
- recibe retroalimentación del instructor y modifica su programa de desarrollo en consecuencia.
- realiza una breve evaluación para determinar si dominaron las habilidades necesarias para avanzar al siguiente nivel.
- recibe insignias y certificados digitales luego de completar con éxito cada nivel de habilidad.
- completa una encuesta posterior al estudio sobre las actitudes de STEM.

- asiste a un Hack-A-Thon celebrado en Oasis - Un refugio para mujeres y niños en Paterson, N.J. para desarrollar aplicaciones móviles de Android en el mundo real en un entorno de equipo.
- participa en un grupo de enfoque post-Hack-A-Thon / entrevista sobre las actitudes hacia los entornos STEM.

RIESGOS/MALOS CONFLICTOS:

- Los riesgos asociados con la participación en este estudio no son mayores que los encontrados en la vida diaria.

BENEFICIOS:

- Los estudiantes obtendrán conocimiento con respecto a la programación de aplicaciones móviles Android.
- En Hack-A-Thon, los estudiantes pueden codificar aplicaciones del mundo real en un entorno de equipo.

PARTICIPACIÓN VOLUNTARIA Y DERECHO A RETIRAR:

Su participación en este estudio es completamente voluntaria: usted elige si desea participar. Si decide no participar, no hay sanciones, y no perderá ningún beneficio al que de otra manera tendría derecho. Si elige participar en el estudio, puede detener su participación en cualquier momento, sin ninguna multa o pérdida de beneficios. Si desea retirarse del estudio, envíe un correo electrónico a Sharon Mistretta a smistre2@jhu.edu.

CIRCUNSTANCIAS QUE PODRIAN CONDUCIRNOS A FINALIZAR SU PARTICIPATION:

En determinadas circunstancias, podemos decidir finalizar su participación antes de completar el estudio. Específicamente, podemos detener su participación si no se conduce con respeto hacia los demás en colaboraciones en línea y / o cara a cara. Se espera que todos los estudiantes:

• Sea respetuoso de los instructores y compañeros participantes.
• Utilice siempre el lenguaje apropiado en formatos de texto, voz, audio o imagen.
• También puede haber otras circunstancias que nos lleven a terminar su participación.

CONFIDENCIALIDAD:

Cualquier registro de estudio que identifique que se mantendrá confidencial en la medida de lo posible por ley. Los registros de su participación pueden ser revisados por personas responsables de asegurarse de que la investigación se realice correctamente, incluidos miembros de la Junta de Revisión Institucional de Homewood de la Universidad Johns Hopkins y funcionarios de organismos gubernamentales como los Institutos Nacionales de Salud y la Oficina de Protección de Investigaciones Humanas. . (Todas estas personas deben mantener su identidad confidencial.) De lo contrario, los registros que lo identifiquen estarán disponibles solo para las personas que trabajan en el estudio, a menos que otorgue permiso para que otras personas vean los registros. La encuesta electrónica y los datos del grupo de enfoque / entrevista se almacenarán en la computadora de Sharon Mistretta, que está protegida con contraseña, y los nombres de los encuestados no se asociarán con ninguna de las respuestas ni aparecerán en ninguno de los informes publicados.

COSTOS

No hay costos monetarios para inscribirse en este programa. El único costo es su tiempo libre dedicado a ver los videos de habilidades pequeñas en el SOOC, completar los ejemplos trabajados en MIT App Inventor y asistir a un evento Hack-A-Thon en Oasis - Un refugio para mujeres y niños en Paterson, N.J.

COMPENSACION:

No recibirá ningún pago u otra compensación por participar en este estudio.

SI TIENE PREGUNTAS O PREOCUPACIONES:

Este estudio está dirigido por Sharon Mistretta, estudiante de doctorado en la Escuela de Educación de la Universidad Johns Hopkins y afiliada al departamento de educación de Oasis - Un refugio para mujeres y niños en Paterson, Nueva Jersey. El investigador principal de este estudio es el Dr. Yolanda Abel, profesora asociada de la Facultad de Educación de la Universidad Johns Hopkins. El Dr. Abel no está afiliado a Oasis - Un refugio para mujeres y niños en Paterson, N.J.

Puede hacer preguntas sobre este estudio de investigación ahora o en cualquier momento durante el estudio, hablando con los investigadores que trabajan con usted o llamando a Sharon Mistretta, investigadora de doctorado, al (201) 838-1379.

Si tiene preguntas sobre sus derechos como participante en la investigación o siente que no ha sido tratado de manera justa, llame a la Junta de Revisión Institucional de Homewood en la Universidad Johns Hopkins al (410) 516-6580.

FIRMAS

LO QUE SU FIRMA SIGNIFICA:

Su firma a continuación significa que usted comprende la información en este formulario de consentimiento. Su firma también significa que acepta participar en el estudio.

Al firmar este formulario de consentimiento, no ha renunciado a ningún derecho legal que de otro modo tendría como participante en un estudio de investigación.

Firma del participante **Fecha**

Firma de la persona que obtiene el consentimiento **Fecha**
(Investigador o Designado Aprobado por HIRB)

Appendix V

Participant Recruitment Posters in English and Spanish

- Scan this QR code with your phone to be contacted.
- View online instructional videos in Oasis computer labs
- Progress from beginner, intermediate, and advanced levels
- Develop working apps in MIT App Inventor
- Earn 30 digital badges
- Receive STEM certificates of completion
- Participate in a Hack-A-Thon at Oasis in November
- Enroll now by asking the education department for an enrollment form, emailing Mrs. Mistretta at smistre2@jhu.edu, or scanning the QR code and select English or Spanish contact form!

- Escanee este código QR con su teléfono para ser contactado.
- Vea videos instructivos en línea en los laboratorios de computación de Oasis
- Progreso desde niveles principiante, intermedio y avanzado
- Desarrollar aplicaciones que funcionen en MIT App Inventor
- Gana 30 insignias digitales
- Recibir certificados STEM de finalización
- Participa en un Hack-A-Thon en Oasis en noviembre
- ¡Inscríbase ahora pidiéndole al departamento de educación un formulario de inscripción, enviando un correo electrónico a la Sra. Mistretta a smistre2@jhu.edu, o escaneando el código QR y seleccionando el formulario de contacto en español!

Appendix W

Contact Forms – Navigate From QR code in English and Spanish

Appendix X

SOOC Lesson Interval Survey

Appendix Y

Summary Matrix of Alignment of Research Questions, Indicators, and Data Sources

Table 43

Summary Matrix of Alignment of Research Questions, Indicators, and Data Sources

Indicator	RQ	Operational-ization of Indicator	Data Source(s)	Data Collection Tool	Frequency
(P) Progress Indicator	IRQ1 IRQ2 IRQ3	The extent to which a student completes small-skill video lessons.	Quantitative: Student Star Ratings.	Survey Monkey	Throughout SOOC.
			Digital badges earned.	Padlet	Throughout SOOC.
			Google Classroom Level Achieved	Google Classroom Login Data	
			Hack-A-Thon Focus Group/Interview Transcripts.	Otter.ai and Evernote	During Hack-A-Thon
(P) Device Indicator	IRQ2	A covariate between the family's self-declared SES and available devices with Internet access to complete programming assignments.	Quantitative: Parent Demographic Survey of SES and available student Internet device.	Survey Monkey	Once at beginning of intervention.

Indicator	RQ	Operationalization of Indicator	Data Source(s)	Data Collection Tool	Frequency
(P) Influence Indicator	IRQ2	*External* assistance regarding other sources of programming experience	Qualitative: Interviews	Otter.ai and Evernote	Post intervention
(O) Math Attitudes	IRQ1 IRQ3	Self-efficacy (Bandura, 1986) related to math and expectations of value (Eccles & Wigfield, 2002) in the future gained from success in math (Friday Institute for Educational Innovation, 2012a; 2012b).	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Survey Monkey	Pre- and Post-intervention
			Qualitative: Focus/ Interview	Otter.ai and Evernote	During Hack-A-Thon
(O) Science Attitudes	IRQ2	Self-efficacy (Bandura, 1986) related to science and expectations of value (Eccles & Wigfield, 2002) in the future gained from success in math (Friday Institute for	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Survey Monkey	Pre- and Post intervention
			Qualitative: Focus/ Interview	Otter.ai and Evernote	Post intervention

Indicator	RQ	Operational-ization of Indicator	Data Source(s)	Data Collection Tool	Frequency
		Educational Innovation, 2012a; 2012b).			
(O) Engineer-ing Attitudes	IRQ2	Self-efficacy (Bandura, 1986) related to engineering and expectations of value	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Survey Monkey	Pre- and Post- Intervention
		(Eccles & Wigfield, 2002) in the future gained from success in math (Friday Institute for Educational Innovation, 2012a; 2012b).	Qualitative: Focus/ Interviews	Otter.ai and Evernote	
(O) Techno-logy Attitudes	IRQ1 IRQ2 IRQ3	Self-efficacy (Bandura, 1986) related to technology and expectations of value (Eccles &	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Survey Monkey	Pre- and Post intervention
		Wigfield, 2002) in the future gained from success in math (Friday Institute for Educational	Qualitative: Focus/ Interviews	Otter.ai and Evernote	Post intervention

Indicator	RQ	Operational-ization of Indicator	Data Source(s)	Data Collection Tool	Frequency
		Innovation, 2012a; 2012b).			
(O) 21st Century Learning Attitudes	IRQ2	Attitudes pertaining to working well with others (Friday Institute for Educational Innovation, 2012a; 2012b).	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b) Focus/ Interview	Survey Monkey	Pre- and Post- Intervention
			Qualitative: Focus/ Interviews	Otter.ai and Evernote	Post Intervention
(O) Interest in STEM Careers	IRQ1 IRQ2 IRQ3	Interest in 12 categories consisting of communal careers that help others (Diekman et al., 2016) and agentic (Eagly, 2013) careers associated with rigor and math.	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Survey Monkey	
			Qualitative: Focus/ Interview	Otter.ao and Evernote	Post Intervention
(O) Student Attitude toward STEM Indicator	IRQ1 IRQ2 IRQ3	An *average* of S-STEM survey categories (O) Math, Science, Engineering, Technology, 21st Century	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a, 2012b)	Survey Monkey	Pre- and Post- Intervention

Indicator	RQ	Operationalization of Indicator	Data Source(s)	Data Collection Tool	Frequency
		Learning, STEM Careers			
(M) Gender	IRQ1 IRQ2 IRQ3	Aligned with S-STEM survey categories of female and male (Friday Institute for Educational Innovation, 2012a; 2012b).	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Survey Monkey	Pre- and Post- Intervention
(M) Race	IRQ2	Aligned with S-STEM survey categories of White, Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, or Would rather not answer this question. (Friday Institute for Educational Innovation, 2012a; 2012b).	Quantitative: S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b)	Survey Monkey	Pre- and Post intervention

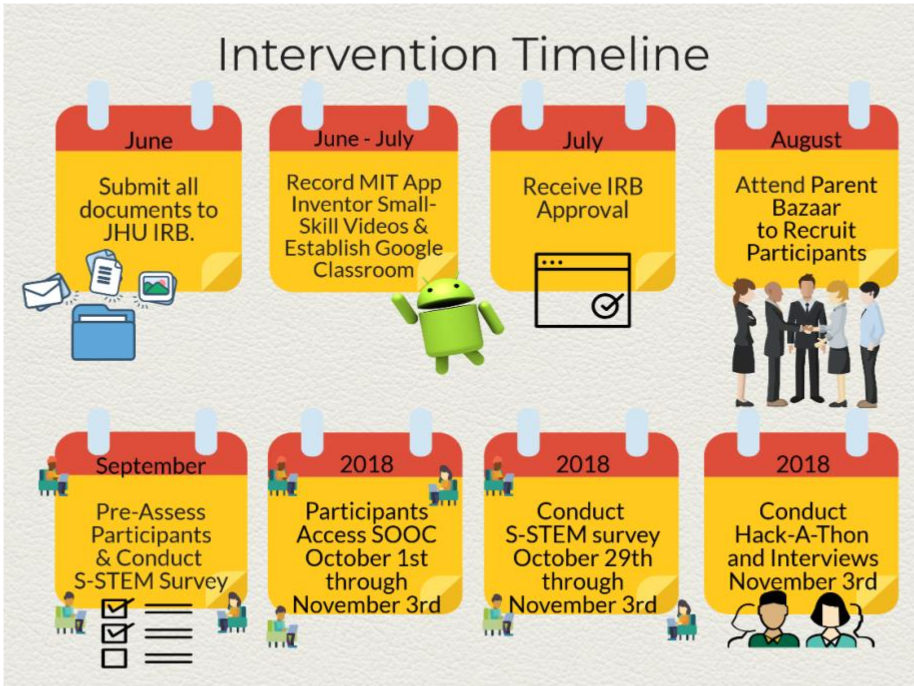
Indicator	RQ	Operational-ization of Indicator	Data Source(s)	Data Collection Tool	Frequency
(M) Ethnicity	IRQ2	1. Aligned with S-STEM text box to self-describe (Friday Institute for Educational Innovation, 2012a; 2012b).	Quantitative: 1. S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b) 2. Parent survey	Survey Monkey	Pre- and Post- Intervention
		2. Parent Survey – checkboxes to select all that apply (Survey Monkey standard question): Mexican, Mexican-American, Chicano, Puerto Rican, Cuban, Cuban-American, other Spanish, Hispanic, or Latino group.	Quantitative: Parent Survey	Survey Monkey	Pre- and Post intervention
(M) Socio-Economic Status	IRQ1	Parent Survey – multiple choice using Survey Monkey standard income	Quantitative: Parent Survey	Survey Monkey	Pre- and Post- Intervention

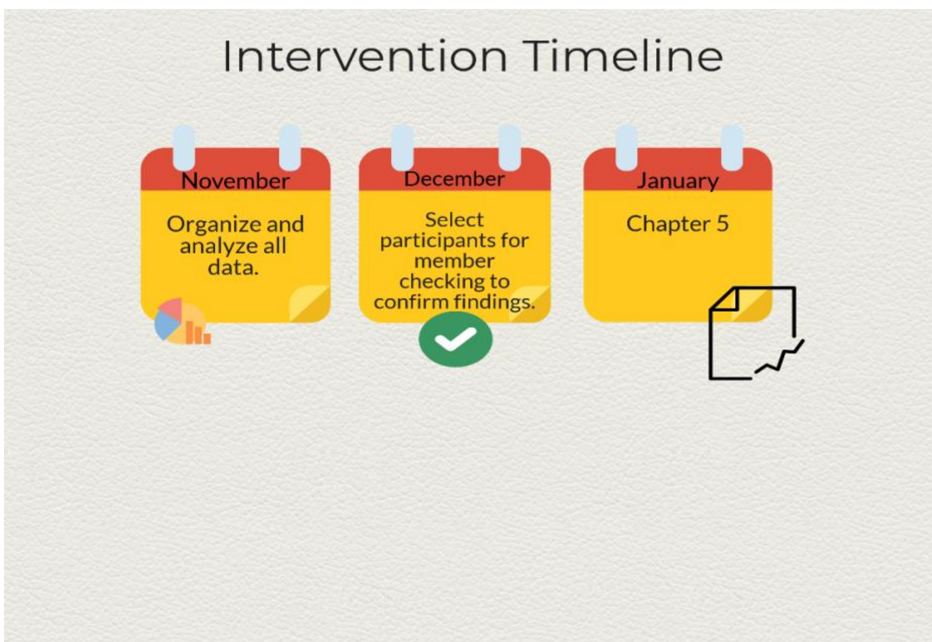
Indicator	RQ	Operational-ization of Indicator	Data Source(s)	Data Collection Tool	Frequency
		ranges (see Appendix R).			
(M) Grade	IRQ1 IRQ2 IRQ3	Fourth through 12th grades (Friday Institute for Educational Innovation, 2012a; 2012b).	1. S-STEM Surveys (Friday Institute for Educational Innovation, 2012a; 2012b) 2.Focus/ Interview	Survey Monkey	Pre- and Post-Intervention
(C) Prior Knowledge		Outside influences such as other online instruction websites or school offerings.	Focus/ Interview	Otter.ai and Evernote	Pre- and Post-Intervention

Note. (P) = process, (O) = outcome, (M) = moderating, (C) = control; IRQ1 = programming; IRQ2 = threat; IRQ3 = math.

Appendix Z

Intervention Timeline – June 2018 Through January 2019





Appendix AA

S-STEM Survey – Fourth and Fifth Grades, and Sixth Through 12th Grades

Student Attitudes toward STEM (S-STEM) Survey

Upper Elementary (4-5th)

There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Math

* 1. Math has been my worst subject.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 2. When I'm older, I might choose a job that uses math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 3. Math is hard for me.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 4. I am the type of student who does well in math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 5. I can understand most subjects easily, but math is difficult for me.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 6. In the future, I could do harder math problems.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 7. I can get good grades in math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 8. I am good at math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Student Attitudes toward STEM (S-STEM) Survey

Upper Elementary (4-5th)

There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Science

* 9. I feel good about myself when I do science.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 10. I might choose a career in science.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 11. After I finish high school, I will use science often.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 12. When I am older, knowing science will help me earn money.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 13. When I am older, I will need to understand science for my job.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 14. I know I can do well in science.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 15. Science will be important to me in my future career.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 16. I can understand most subjects easily, but science is hard for me to understand.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 17. In the future, I could do harder science work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Student Attitudes toward STEM (S-STEM) Survey
Upper Elementary (4-5th)
There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Engineering and Technology

Engineers use math and science to invent things and solve problems. Engineers design and improve things like bridges, cars, machines, foods, and computer games. Technologists build, test, and maintain (or take care of) the designs that engineers create.

* 18. I like to imagine making new products.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 19. If I learn engineering, then I can improve things that people use every day.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 20. I am good at building or fixing things.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 21. I am interested in what makes machines work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 22. Designing products or structures will be important in my future jobs.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 23. I am curious about how electronics work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 24. I want to be creative in my future jobs.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 25. Knowing how to use math and science together will help me to invent useful things.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 26. I believe I can be successful in engineering.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Student Attitudes toward STEM (S-STEM) Survey

Upper Elementary (4-5th)

There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

21st Century Learning

* 27. I can lead others to reach a goal.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 28. I like to help others do their best.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 29. In school and at home, I can do things well.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 30. I respect all children my age even if they are different from me.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 31. I try to help other children my age.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 32. When I make decisions, I think about what is good for other people.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 33. When things do not go how I want, I can change my actions for the better.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 34. I can make my own goals for learning.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 35. I can use time wisely when working on my own.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 36. When I have a lot of homework, I can choose what needs to be done first.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 37. I can work well with all students, even if they are different from me.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Student Attitudes toward STEM (S-STEM) Survey

Upper Elementary (4-5th)

There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Your Future

Below is a list of types of work that you could do when you are older. As you read about each type of work, you will know if you think that work is interesting. Fill in the circle under the words that describe how interested you are in doing that when you are older.

There are no "*right*" or "*wrong*" answers. The only correct responses are those that*are true for you*.

* 38. **Physics**: People study motion, gravity and what things are made of. They also study energy, like how a swinging bat can make a baseball switch directions. They study how different liquids, solids and gas can be turned into heat or electricity.

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 39. **Environmental Work**: People study how nature works. They study how waste and pollution affect the environment. They also invent solutions to these problems.

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 40. **Biology:** People work with animals and plants and how they live. They also study farm animals and the food that they make, like milk. They can use what they know to invent products for people to use.

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 41. **Veterinary Work:** People who prevent disease in animals. They give medicines to help animals et better and for animal and human safety.

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 42. **Mathematics:** People use math and computers to solve problems. They use it to make decisions in businesses and government. They use numbers to understand why different things happen like why some people are healthier than others.

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 43. **Medicine:** People learn how the human body works. They decide why someone is sick or hurt and give medicines to help the person get better. They teach people about health, and sometimes they perform surgery.

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 44. **Earth Science:** People work with the air, water, rocks and soil. Some tell us if there is pollution and how to make the earth safer and cleaner. Other earth scientists forecast the weather.

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 45. **Computer Science:** People write instructions to run a program that a computer can follow. They design computer games and other programs. They also fix and improve computers for other people.

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 46. **Medical Science:** People study human diseases and work to find answers to human health problems.

- Not at all interested
- Not so interested
- Interested
- Very interested

* 47. **Chemistry:** People work with chemicals. They invent new chemicals and use them to make new products, like paints, medicine, and plastic.

- Not at all interested
- Not so interested
- Interested
- Very interested

* 48. **Energy/Electricity**: People invent, improve and maintain ways to make electricity or heat. They also design the electrical and other power systems in buildings and machines.

- Not at all interested
- Not so interested
- Interested
- Very interested

* 49. **Engineering:** People use science, math, and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working.

- Not at all interested
- Not so interested
- Interested
- Very interested

Student Attitudes toward STEM (S-STEM) Survey

Upper Elementary (4-5th)

There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

About Yourself

* 50. How well do you expect to do this year in your English/Language Arts Class?

- Not very well
- OK/pretty well
- Very well

51. How well do you expect to do this year in your Math Class?

- Not very well
- OK/pretty well
- Very well

* 52. How well do you expect to do this year in your Science Class?

- Not very well
- OK/pretty well
- Very well

* 53. Do you plan to go to college?

- Yes
- No
- Not Sure

* 54. Do you plan to take advanced science, technology, engineering, and math (STEM) classes in future years in school?

- Yes
- No
- Not Sure

* 55. Do you plan to take advanced computer programming classes in future years in school?

- Yes
- No
- Not Sure

* 56. Do you know any adults who work as scientists?

- Yes
- No
- Not Sure

* 57. Do you know any adults who work as engineers?

- Yes
- No
- Not Sure

* 58. Do you know any adults who work as mathematicians?

- Yes
- No
- Not Sure

* 59. Do you know any adults who work as technologists?

- Yes
- No
- Not Sure

* 60. What is your gender?

- Female
- Male

61. What is your race? The following options are based on the choices contained in the US Census. Select all that apply or choose not to answer this question. Please enter your ethnicity, if you wish, in the next question.

- White
- Black or African American
- American Indian or Alaska Native
- Asian
- Native Hawaiian or Other Pacific Islander
- Would rather not answer this question.

62. Please enter any information that you would like to share regarding your ethnicity.

* 63. Create a unique code name for yourself and type the name in the box below.

64. What grade are you in?

- Fourth Grade
- Fifth Grade
- Other

Student Attitudes toward STEM (S-STEM) Survey

Upper Elementary (4-5th)

There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Thank you for taking this survey!

Student Attitudes toward STEM (S-STEM) Survey
Middle and High School (6-12th)
There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Math

* 1. Math has been my worst subject.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 2. I would consider choosing a career that uses math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 3. Math is hard for me.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 4. I am the type of student who does well in math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 5. I can handle most subjects well, but I cannot do a good job with math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 6. I am sure I could do advanced work in math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 7. I can get good grades in math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 8. I am good at math.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Student Attitudes toward STEM (S-STEM) Survey
Middle and High School (6-12th)
There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Science

* 9. I am sure of myself when I do science.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 10. I would consider a career in science.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 11. I expect to use science when I get out of school.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 12. Knowing science will help me earn a living.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 13. I will need science for my future work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 14. I know I can do well in science.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 15. Science will be important to me in my life's work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 16. I can handle most subjects well, but I cannot do a good job with science.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 17. I am sure I could do advanced work in science.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Student Attitudes toward STEM (S-STEM) Survey
Middle and High School (6-12th)
There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Engineering and Technology

Engineers use math, science, and creativity to research and solve problems that improve everyone's life and to invent new products. There are many different types of engineering, such as chemical, electrical, computer, mechanical, civil, environmental, and biomedical. Engineers design and improve things like bridges, cars, fabrics, foods, and virtual reality amusement parks. Technologists implement the designs that engineers develop; they build, test, and maintain products and processes.

* 18. I like to imagine creating new products.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 19. If I learn engineering, then I can improve things that people use every day.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 20. I am good at building or fixing things.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 21. I am interested in what makes machines work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 22. Designing products or structures will be important in my future work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 23. I am curious about how electronics work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 24. I would like to use creativity and innovation in my future work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 25. Knowing how to use math and science together will help me to invent useful things.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 26. I believe I can be successful in a career in engineering.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

21st Century Learning

* 27. I am confident I can lead others to accomplish a goal.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 28. I am confident I can encourage others to do their best.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 29. I am confident I can produce high-quality work.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 30. I am confident I can respect the differences of my peers.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 31. I am confident I can help my peers.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 32. I am confident I can include others' perspectives when making decisions.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 33. I am confident I can make changes when things do not go as planned.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 34. I am confident I can set my own learning goals.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 35. I am confident I can manage my time wisely when working on my own.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 36. When I have many assignments, I can choose which ones need to be done first.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

* 37. I am confident I can work well with students from different backgrounds.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Student Attitudes toward STEM (S-STEM) Survey
Middle and High School (6-12th)
There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Your Future

Below is a list of types of work that you could do when you are older. As you read about each type of work, you will know if you think that work is interesting. Fill in the circle under the words that describe how interested you are in doing that when you are older.

There are no "*right*" or "*wrong*" answers. The only correct responses are those that*are true for you*.

* 38. **Physics**: is the study of basic laws governing the motion, energy, structure, and interactions of matter. This can include studying the nature of the universe. (aviation engineer, alternative energy technician, lab technician, physicist, astronomer)

- Not at all interested
- Not so interested
- Interested
- Very interested

* 39. **Environmental Work**: involves learning about physical and biological processes that govern nature and working to improve the environment. This includes finding and designing solutions to problems like pollution, reusing waste and recycling. (pollution control analyst, environmental engineer or scientist, erosion control specialist, energy systems engineer, and maintenance technician)

- Not at all interested
- Not so interested
- Interested
- Very interested

* 40. **Biology and Zoology:** involve the study of living organisms (such as plants and animals) and the processes of life. This includes working with farm animals and in areas like nutrition and breeding. (biological technician, biological scientist, plant breeder, crop lab technician, animal scientist, geneticist, zoologist)

- Not at all interested
- Not so interested
- Interested
- Very interested

* 41. **Veterinary Work:** involves the science of preventing or treating disease in animals (veterinary assistant, veterinarian, livestock producer, animal caretaker)

- Not at all interested
- Not so interested
- Interested
- Very interested

* 42. **Mathematics:** is the science of numbers and their operations. It involves computation, algorithms, and theory used to solve problems and summarize data. (accountant, applied mathematician, economist, financial analyst, mathematician, statistician, market researcher, stock market analyst)

- Not at all interested
- Not so interested
- Interested
- Very interested

* 43. **Medicine:** involves maintaining health and preventing and treating disease. (physician's assistant, nurse, doctor, nutritionist, emergency medical technician, physical therapist, dentist)

- Not at all interested
- Not so interested
- Interested
- Very interested

* 44. **Earth Science:** is the study of earth, including the air, land, and ocean. (geologist, weather forecaster, archaeologist, geoscientist)

- Not at all interested
- Not so interested
- Interested
- Very interested

* 45. **Computer Science:** consists of the development and testing of computer systems, designing new programs and helping others to use computers. (computer support specialist, computer programmer, computer and network technician, gaming designer, computer software engineer, information technology specialist)

- Not at all interested
- Not so interested
- Interested
- Very interested

* 46. **Medical Science:** involves researching human disease and working to find new solutions to human health problems. (clinical laboratory technologist, medical scientist, biomedical engineer, epidemiologist, pharmacologist)

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 47. **Chemistry:** uses math and experiments to search for new chemicals, and to study the structure of matter and how it behaves. (chemical technician, chemist, chemical engineer)

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 48. **Energy:** involves the study and generation of power, such as heat or electricity. (electrician, electrical engineer, heating, ventilation, and air conditioning (HVAC) technician, nuclear engineer, systems engineer, alternative energy systems installer or technician)

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

* 49. **Engineering:** involves designing, testing, and manufacturing new products (like machines, bridges, buildings, and electronics) through the use of math, science, and computers. (civil, industrial, agricultural, or mechanical engineers, welder, auto-mechanic, engineering technician, construction manager)

- ◯ Not at all interested
- ◯ Not so interested
- ◯ Interested
- ◯ Very interested

Student Attitudes toward STEM (S-STEM) Survey
Middle and High School (6-12th)
There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

About Yourself

* 50. How well do you expect to do this year in your English/Language Arts Class?

- ◯ Not very well
- ◯ OK/pretty well
- ◯ Very well

51. How well do you expect to do this year in your Math Class?

- ◯ Not very well
- ◯ OK/pretty well
- ◯ Very well

* 52. How well do you expect to do this year in your Science Class?

- ◯ Not very well
- ◯ OK/pretty well
- ◯ Very well

* 53. Do you plan to go to college?

- ◯ Yes
- ◯ No
- ◯ Not Sure

* 54. Do you plan to take advanced science, technology, engineering, and math (STEM) classes in future years in school?

- ◯ Yes
- ◯ No
- ◯ Not Sure

* 55. Do you plan to take advanced computer programming classes?

- ◯ Yes
- ◯ No
- ◯ Not Sure

* 56. Do you know any adults who work as scientists?

- ◯ Yes
- ◯ No
- ◯ Not Sure

* 57. Do you know any adults who work as engineers?

- ◯ Yes
- ◯ No
- ◯ Not Sure

* 58. Do you know any adults who work as mathematicians?

- ◯ Yes
- ◯ No
- ◯ Not Sure

* 59. Do you know any adults who work as technologists?

- ◯ Yes
- ◯ No
- ◯ Not Sure

* 60. What is your gender?

- ◯ Female
- ◯ Male

61. What is your race? The following options are based on the choices contained in the US Census. Select all that apply or choose not to answer this question. Please enter your ethnicity, if you wish, in the next question.

- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Would rather not answer this question.

62. Please enter any information that you would like to share regarding your ethnicity.

* 63. Create a unique code name for yourself and type the name in the box below.

* 64. What grade are you in?

- Sixth Grade
- Seventh Grade
- Eighth Grade
- High School Freshman
- High School Sophomore
- High School Junior
- High School Senior
- Other

Student Attitudes toward STEM (S-STEM) Survey
Middle and High School (6-12th)
There are lists of statements on the following pages. Please select your answer based on how you feel about each statement.

Thank you for taking this survey!

Appendix BB

Individual Investigator Agreement

Individual Investigator Agreement

Name of Institution with the Federalwide Assurance (FWA): Johns Hopkins University

Applicable FWA #: 00005834

Individual Investigator's Name: Demi Matos

Research Covered by this Agreement: # HIRB00007654 : "*Understanding Gender-Based Attitudes in STEM Environments*"

---

(1) The above-named Individual Investigator has reviewed: 1) *The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research* (or other internationally recognized equivalent; see section B.1. of the Terms of the Federalwide Assurance (FWA) for International (Non-U.S.) Institutions); 2) the U.S. Department of Health and Human Services (HHS) regulations for the protection of human subjects at 45 CFR part 46 (or other procedural standards; see section B.3. of the Terms of the FWA for International (Non-U.S.) Institutions); 3) the FWA and applicable Terms of the FWA for the institution referenced above; and 4) the relevant institutional policies and procedures for the protection of human subjects.

(2) The Investigator understands and hereby accepts the responsibility to comply with the standards and requirements stipulated in the above documents and to protect the rights and welfare of human subjects involved in research conducted under this Agreement.

(3) The Investigator will comply with all other applicable federal, international, state, and local laws, regulations, and policies that may provide additional protection for human subjects participating in research conducted under this agreement.

(4) The Investigator will abide by all determinations of the Institutional Review Board (IRB) designated under the above FWA and will accept the final authority and decisions of the IRB, including but not limited to directives to terminate participation in designated research activities.

(5) The Investigator will complete any educational training required by the Institution and/or the IRB prior to initiating research covered under this Agreement.

(6) The Investigator will report promptly to the IRB any proposed changes in the research conducted under this Agreement. The investigator will not initiate changes in the research without prior IRB review and approval, except where necessary to eliminate apparent immediate hazards to subjects.

(7) The Investigator will report immediately to the IRB any unanticipated problems involving risks to subjects or others in research covered under this Agreement.

(8) The Investigator, when responsible for enrolling subjects, will obtain, document, and maintain records of informed consent for each such subject or each subject's legally authorized representative as required under HHS regulations at 45 CFR part 46 (or any other international or national procedural standards selected on the FWA for the institution referenced above) and stipulated by the IRB.

1

(9) The Investigator acknowledges and agrees to cooperate in the IRB's responsibility for initial and continuing review, record keeping, reporting, and certification for the research referenced above. The Investigator will provide all information requested by the IRB in a timely fashion.

(10) The Investigator will not enroll subjects in research under this Agreement prior to its review and approval by the IRB.

(11) Emergency medical care may be delivered without IRB review and approval to the extent permitted under applicable federal regulations and state law.

(12) This Agreement does not preclude the Investigator from taking part in research not covered by this Agreement.

(13) The Investigator acknowledges that he/she is primarily responsible for safeguarding the rights and welfare of each research subject, and that the subject's rights and welfare must take precedence over the goals and requirements of the research.

Individual Investigator: Demi Matos, of Oasis – A Haven for Women and Children, Inc.
Address: 58 Mill St. Paterson, NJ 07501; (973) 881-8307

Demi Matos
Signature date

Mayra Rodriguez 09/25/18
Signature of parent or guardian date

Principal Investigator: Yolanda Abel, Ph.D.

Address: 2800 N. Charles Street phone #: 410-516-6002

Baltimore (City) MD (State/Province) 21218 (Zip/Country)

Signature 9/25/18 date

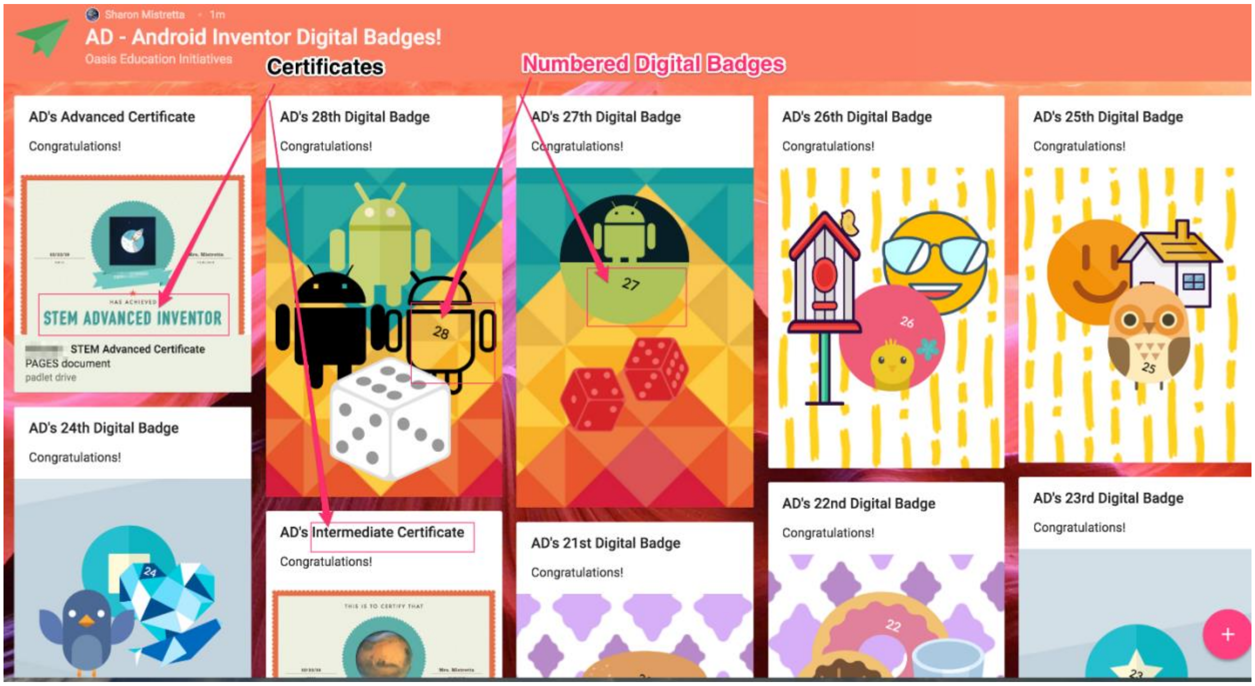
FWA Institutional Official:

John P. Toscano, Vice Dean for Natural Sciences and Institutional Official
Johns Hopkins University
3400 N. Charles St. Wyman Park Building N615
Baltimore MD 21218
410-516-8215

John P. Toscano 9/6/2018
Signature date

Appendix CC

Consecutively Numbered Digital Badges and Certificates

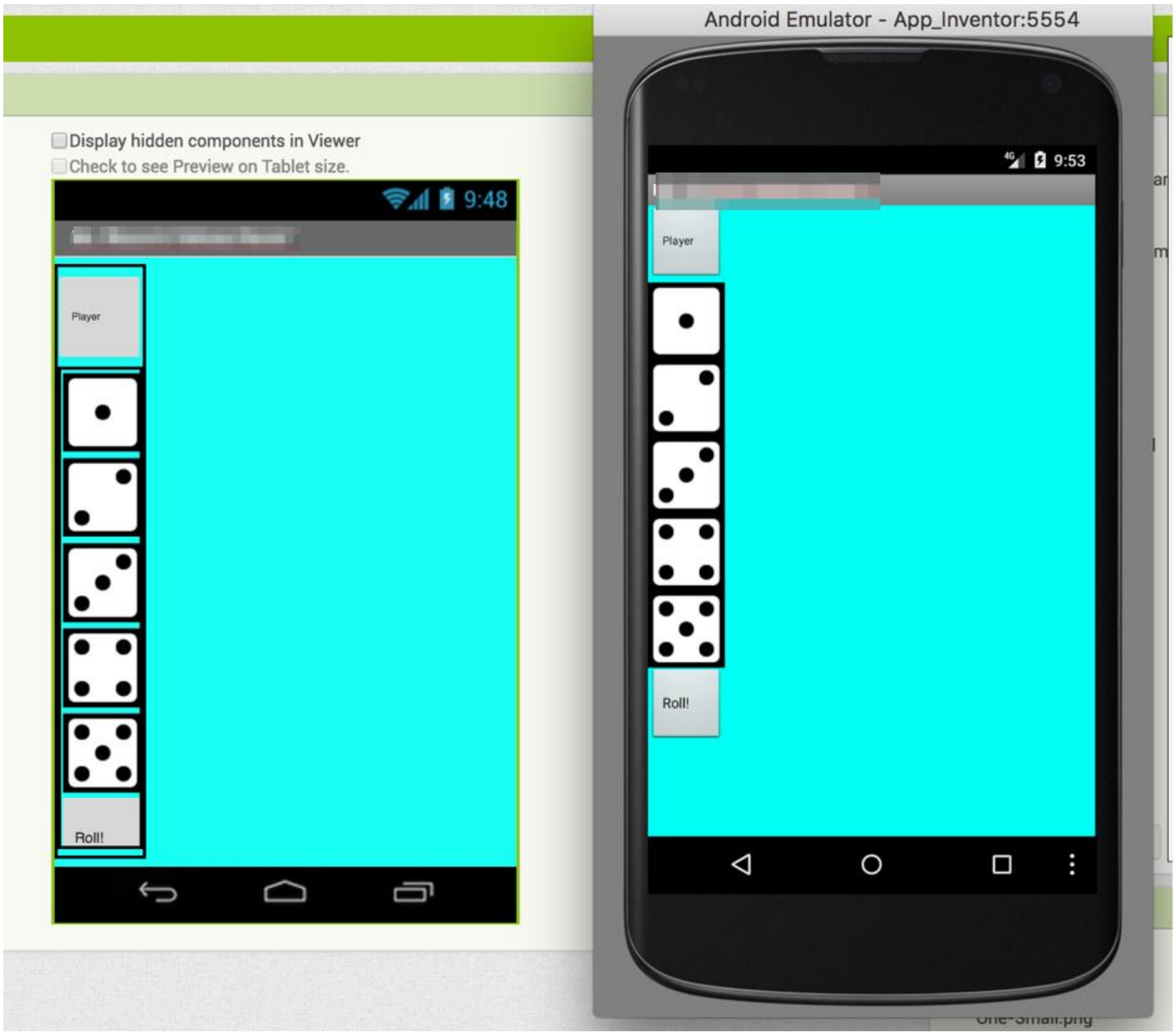


Appendix DD

ASP Computer Room

Appendix EE

MIT App Inventor Emulator with Beginner Level Dice Game

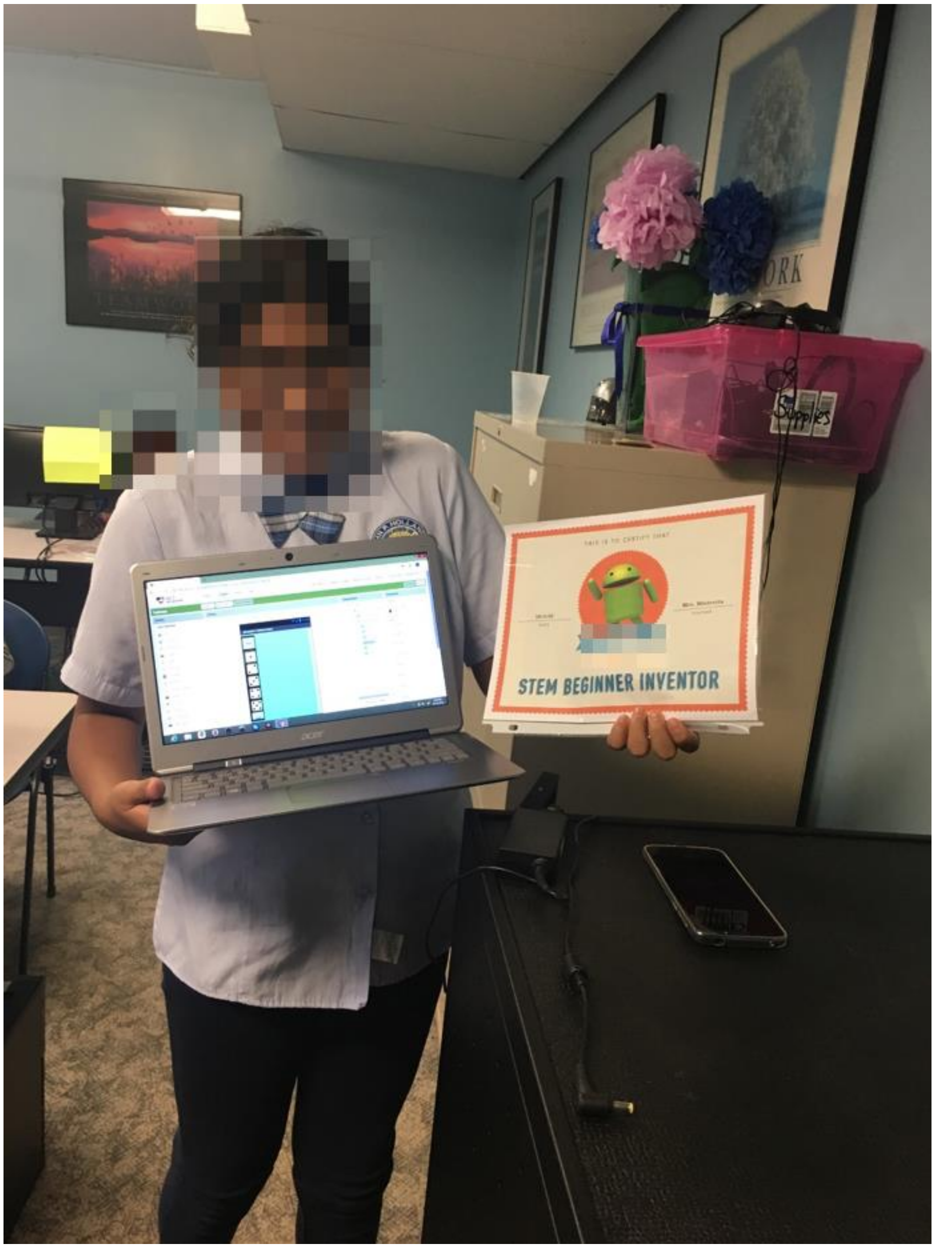


Appendix FF

Android Inventor Participant Watching and Listening to Video Using Earbuds

Appendix GG

Inventor 17 - First Participant to Complete the Beginner Level



Appendix HH

Qualitative Codes of Interview Transcripts

Table 44

Qualitative Codes of Interview Transcripts

Category	First Iteration	Second Iteration	Final Code
Science	experiments building health musical instrument weathering helps other people projects	experiments engineering	equates experiments with engineering (EEE)
Technology	games typing Google classroom play Google accounts activity few computers	games online learning systems	limited exposure to technology (LET)
Engineering	science experiments don't know	science	equates engineering with science (EES)
Math	hard, easy teacher problems	problems	teacher-centered well-structured problems (WSP)
Careers	help other people model programmer engineer actress policeman doctor marine biologist don't know baker	help others math-intensive field	(Communal) (Agentic)
STEM	part of a plant unaware survey	no knowledge	STEM-Blinders (SB)

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Vita

SHARON MISTRETTA

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SUMMARY OF QUALIFICATIONS

Creative Technology Teacher and IT Strategist specializing in iOS App Development and Robotics. Adept at working with a diverse student population to create differentiated instruction within a student-centered learning environment. Experienced at seeking out and working with faculty to create technology supported lesson plans. Well versed in managing the strategic planning of a school's Information Technology needs.

EDUCATION

Johns Hopkins University, Baltimore, MD
Doctoral Candidate, EdD Technology Integration in K-16 Education, Expected May, 2019

Columbia University, Teachers College, New York, NY
Masters of Arts in Computing in Education, May, 2008

Fairleigh Dickinson University, Teaneck, NJ
Bachelors of Arts in English Literature, 1979

Certificates:

NASA Endeavor - STEM Teaching Certificate
Columbia University, Teachers College
Certificate in STEM Leadership - December 2014

NYU School of Continuing and Professional Studies
Certificate in iOS App Development - May 2014

Rutgers University Graduate School of Education, Center for Effective School Practices Alternate Route Training, October 2010 to May 2011

RELATED EXPERIENCE

NASA Endeavor - U.S. Satellite Laboratory, Rye, N.Y.
Instructor - May 2016 to present - Coding, Robotics and 1:1 Devices
TA - September 2015 to April 2016 - Exploring Mars, Physics for Real Beginners, Life in Space: NASA ISS and Astrobiology

- Conduct online WebEx classes for teachers in the implementation of technology in the K - 12 classrooms.
- Implement ROBOTC – Robot Virtual Worlds, Lego EV3, Vex, Finch, Ozobot to teach robotic coding techniques to teachers.
- Provide online and flipped lesson instruction in Scratch, MIT App Inventor, Java, and Objective C programming.
- Develop online lesson plans, assignments, discussion prompts, and rubrics.
- Review, provide feedback and grade graduate required elements as posted.

Mercy College - New York, N.Y.
Instructor - July 2016 to May 2018 - STEM Academy

- Utilizing Robot Virtual Worlds, instruct students, grades 7 - 16 in programming and robotic techniques.
- Transition virtual code to physical Vex IQ Clawbot robots.
- Instruct Android mobile applications in MIT App Inventor
- Instruct 3D modeling in TinkerCad
- Create team building opportunities for students to collaborate successfully.
- Reinforce the integration of each of the STEM subject disciplines.

Immaculate Heart Academy, Township of Washington, N.J. Technology Faculty - September 2014 to June 2016

- Utilize the "5E" Instructional Model and the Next Generation of Science Standards to assist my Java and iOS Application Programming, Web Design and Computer Applications.
- Create "flipped lessons" to promote active learning and provide my students with review opportunities and increased levels of understanding of lesson units.
- Integrate authentic NASA data into assigned projects to inform students about real world issues while teaching technology skills, analysis and interpretation of data.
- Introduce and foster the development of student problem solving skills using the engineering design process. Students practice solving well-defined problems and increase competency in solving less structured design challenges.
- Mentored student teams during the 2015 NJIT Science Olympiad including Bridge Building (5th place), Complex Machines and the "Wright Stuff" model airplane glider.
- Moderate the IHA Robotics "Team Artemis" 2015 Google MoonBot Competition - Finalist.
- Moderate the IHA Destination Imagination 2016 Competition - Second and Third Place Teams.

Saint Joseph Regional High School, Montvale, N.J. Technology Faculty - September 2013 to May, 2014

- Introduction to Programming and iOS App writing course began with lessons in Objective C to prepare my students with the tools necessary to understand the fundamentals of coding.
- Utilized Xcode IDE to teach best practices in logic and coding techniques.
- iOS App writing built upon my students' knowledge of object oriented programming as projects were introduced to create Apps that utilized View Controllers imbedded in Navigation and Tab Bar Scenes. Frameworks in the UIKit, Foundation and CoreGraphics were introduced and implemented.
- Aptana Studio 3 IDE was utilized to facilitate JavaScript and jQuery programming.

Information Media Specialist – September 2011 to October 2013

- Established and directed New Media Center from its inception in September 2011. Supervised all aspects of the installation and maintenance of thirty-eight computer Media Suite.
- Established subscriptions and developed the New Media Center webpage on the SJR website that provides access to student webpages, online databases of eLibrary, eBrary, Visual Thesaurus, Replica Edition of the New York Times, Global Collections of worldwide libraries, Primary Sources Collection, Access to Online SJR Textbooks, Axis360 eBooks.
- Supervised student-produced Voice Thread Podcast projects to support English, Theology and Spanish Courses.
- Implemented Turn It In subscription and conducted student seminars to facilitate research and the correct use of MLA formatting for student assignments.
- Implemented Geometers Sketchpad and Virtual Chemistry Lab software to support Math and Science curriculum.

- Collaborated with faculty to integrate technology into lesson plans. Conducted faculty orientation programs to support teacher webpages and homework postings.
- Maintained community database of emails to facilitate distribution of school communications to parents and other stakeholders.
- Created and implemented surveys to poll faculty, parents and students for Middle States Accreditation.

Tenakill Middle School, Closter, N.J.
Technology Teacher & Technology Coordinator, grades 5 - 8, September 2010 to June, 2011

- Provided in-depth instruction to my fifth and sixth grade students in Technology class including Microsoft Office, iMovie Podcasts, Alice object-oriented 3D programming environment and Google SketchUp. Incorporated New Jersey Core Curriculum Standards for Technology into my lesson plans.
- Carefully observed my students' learning styles and implemented Individual Education Plans to fully engage all of my students according to their abilities and potential.
- Advised a daily, student-produced broadcast of morning announcements, news items and special features on a closed-circuit cable TV network.
- Implemented Rosetta Stone Software to deliver Spanish Instruction to 150 students.
- Maintained thirty-five iMac Technology Lab, laptop carts and faculty classroom configurations.

Holy Family Catholic Academy, Norwood, N.J.
Technology Teacher, Grades Pre-K through Eighth, September 2008 to June 2010

- Created and implemented student-centered curriculum units utilizing differentiated instruction. Incorporated SmartBoard Notebook files into daily lesson plans.
- Taught fourth through eighth grade students how to develop and maintain wikis to edit technology terms and to learn web design.
- Developed and maintained Excel Workbook units utilizing authentic data obtained on the Internet to provide meaningful learning. Comparison Pricing using bar graphs, Population Analysis using pie charts and Water Treatment Companies using line graphs provided my students with the opportunity to manipulate real time data to construct knowledge.

Reach the World Organization, A foundation that places teachers in the NYC Public School System Intern with Columbia University, Teachers College, New York, NY, 2006 – 2008

- Created student-centered lesson plans which utilized software and internet-based technology with teachers in the New York City Public School System.
- Developed an Excel based lesson to learn about water quality using data from tests conducted by the Reach the World crew of the Makulu on four rivers in Africa. Students entered data compiled by the Makulu crew and graphed results.
- Developed a Legacy Instructional Design Model for a student-centered Astronomy Unit.

<u>BUSINESS EXPERIENCE</u>

United Jersey Bank, Ridgefield Park, NJ - Project Manager, 1984 – 1992
Manufacturers Hanover Trust, New York, NY - Technical Officer, 1981 - 1984
Datamatics Consultants, Englewood Cliffs, NJ - Senior Programmer/Analyst, 1979 – 1981

<u>TECHNOLOGY SKILLS</u>

iOS App Writing, Objective C, Xcode, Java, NetBeans, JavaScript, HTML5, Responsive Web Design, jQuery, Java, COBOL, Basic, Fortran, Microsoft Office Suite, iWork Suite, Google SketchUp CAD software, Blogs, Dreamweaver, Aptana Studio, Wikis, Web-quests, Endnote, Engineering Encounters Bridge Builder, Smart Board, Voice Thread, TinkerCad and MakerBot 3D Printing, ROBOTC Virtual Worlds. Proficient in both Mac and Windows operating systems.

CERTIFICATIONS & Awards
2016 - Outstanding Educator Award - North Jersey Media - The Record
ETS Praxis Recognition of Excellence in Elementary Education: Content Knowledge Elementary School Teacher in Grades K - 5 (823624)
Elementary School with Subject Matter Specialization: Language Arts/Literacy in Grades 5-8 (824330) 2015 Top Thirty Finalist Team - Google MoonBot Competition
2016 Second and Third Place Teams - Destination Imagination Competition