The Effect of the CCERS STEM + C Project on Information Technology Efficacy in Terms of Gender and Grade Level

"Women must learn to play the game as men do."— *Eleanor Roosevelt*

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Abstract

Information technology has become ubiquitous in the 21st Century. Acquiring the skills and confidence to navigate the computational arena is all but obligatory for educational and professional success. Underrepresentation of women in the wide variety of fields associated with information technology is an authentic concern for both the individual and society as a whole. Various studies have emphasized the importance of stronger representative of marginalized groups to bolster creative thinking and a variety of perspectives. The CCERS STEM + C Program is a long-term hands-on environmental restoration project that has been embedded in the New York City Department of Education public schools. Students work to restore the native oyster population to New York Harbor through both field work and working with large sets of data on the open-access platform. One of the several areas studied throughout this program is the motivation and self-efficacy of the students, especially students who are underrepresented in the STEM and technology fields. Student surveys were initiated by 764 students with 513 participants and non-participants completing the survey. Aimed at eliciting levels of several self-reported factors, the survey included a subscale measuring levels of confidence in technological abilities. Results of the survey indicated that 9th grade female students have a higher level of self-efficacy and motivation than female students in the later high school grade levels. These results are consistent with the waning motivation and interest of female students in technology and STEM found in other studies.

Keywords: self-efficacy, gender equity, STEM, informational technology, restoration science

1. Introduction

1.1 Introduce the Problem

The representation of women in STEM occupations has steadily gained momentum in the last decade but parity still seems to be a distant reality. In 1970, women represented only 8% of the STEM workforce in the United States. Currently (STEMwomen, 2021), the percentage has increased to 28% but the imbalance clearly exists. In addition, the term STEM can be a misnomer, as women currently represent 47% of mathematics and 45% of the life and social science workforce. Lackluster increases are clearly seen in the area of engineering (15%) and computer science (25%), (National Science Foundation, 2015). Engineering, computing, and technology jobs represent both the fastest-growing and highest-paying jobs and there is no indication that this trend is tapering off. Since 1990, STEM employment has grown 79% (9.7 million to 17.3 million) and computer jobs have seen a whopping 338% increase over the same period (Funk & Parker, 2018). Both research and programmatic interventions focused on increasing STEM identity have been applied to address the challenge of expanding the participation of girls and women in STEM (Steinke, 2017). Still, at 15 years of age, only 0.5% of girls have the desire to become information technology experts in comparison to 5% of boys at the same age (Organization for Economic Cooperation and Development, 2018).

In the early 1990s, research was done on ten years of gender and ethnicity differences in computer science education in grades K-12(Sutton, 1991). For over two decades, the issue of gender equity has been studied with the exploration of many factors that influence the gender inequity in this field (Volman & van Eck, 2001). One study (Kirkpatrick &

Cuban, 1998) enrollment in computer classes was predominantly male, allowing for more experience with computers and therefore greater self-efficacy and confidence. In a 2005 study (Kekelis, Ancheta & Heber, 2005) interviews and focus groups were used to determine the types of technology projects appealed to girls, ages eleven to nineteen. Results indicated that the girls found the projects interesting but thought of them only as recreation activities. In a more recent study (Mosatche, Matloff-Nieves, Kekelis, & Lawner, 2013), three STEM programs for girls were studied, focusing on girls in grades 5 – 12. Of varying duration and location, the major findings that would bolster female interest, motivation and perseverance include creating an engaging and relevant curriculum, stimulating career investigation, in-depth and long-term investigations, exposure to role models and field work.

Factors that impact girls' interest and self-confidence in the core STEM academic subjects must be considered when contemplating a strategy for increasing women's representation in STEM occupations with a specific emphasis on information technology and computer science. Self-perceived competence is a pivotal factor in career choice and development because unless people believe they can produce desired outcomes by their actions, they have little incentive to select a career or persist in a career when faced with difficulties (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Perceived self-efficacy, interest, and persistence in a field, reinforce one another over time (Zeldin, Britner, & Pajares, 2008). Stereotypes about computer science and computer scientists have been well documented in American society, with assumptions that computer scientists are male, tech-oriented, and socially awkward (Cheryan, Plaut, Handron, & Hudson, 2013). Women's interest and persistence in STEM careers are particularly dependent on academic self-efficacy because, in the United States, such careers are considered masculine pursuits (Bernstein & Russo, 2008). Gender is a major factor in the information technology appeal. Studies show a lower retention of STEM career interest among females and a greater difficulty in attracting females to STEM fields during high school. During the high school years, the percentage of males interested in a STEM career remained stable (from 39.5 to 39.7), whereas for females it declined (from 15.7 to 12.7) (Sadler, Sonnert, Hazari, & Tai, 2012).

The increased use of technology has changed the culture of the 21st Century. The importance of ensuring a gender-equitable field in the area of computer and information sciences is paramount. Globally, the knowledge of computer science and computational tools has become essential for daily existence. The movement from the industrial age into the information age has created a dynamic advancement of technology, increasing demand and moving to ever more sophisticated developments. Technology is vital in conducting data analysis, making it possible to analyze data in a more reliable, effective manner and to conduct analysis on larger datasets than would otherwise be possible. Using computational tools to analyze data is becoming an especially important practice in this era of data-intensive communication (Weintrop, et al., 2016).

The potential for social and economic empowerment for women can be found in their proficiency and ownership of digital technology. Additional employment opportunities and economic and social benefits can be experienced through technological competence. Evidence shows that, with exposure to favorable conditions, women bring innovation, talent, and a broader perspective to the field of information technology (Hoogendoorn, Oosterbeek, & van Praag, 2013). The key to gender equality in the field of computer science and information technology is to introduce technology at an early age and provide continuing support throughout the technology pipeline. Early access to computers and information technology programs reduces intimidation by female students and reduces career bias against information technology career choices (Adya & Kaiser, 2005). Tutors, peer mentors, and successful accomplishments in technology all support and encourage women in this field. Research has determined that self-efficacy influences academic achievement across academic areas and levels (Pajares & Urdan 2006), and it is associated with things that influence motivation, like self-concept, achievement goals, and academic anxiety (Usher & Pajares, 2008). On the macro level, this increased participation from women augments the workforce economically, socially, and politically. On the micro level, it increases women's self-efficacy, social capital and economic parity (Timberlake, 2005).

The Curriculum and Community Enterprise for Restoration Science began as a citizen science project, incorporating the Billion Oyster project in 2014. This merger combined the restoration efforts of introducing a billion oysters into New York Harbor by the year 2035 with the initiation of an environmental science curriculum into the New York City public school system. This combination, along with the incorporation of several partnerships, enabled the project to take on a holistic approach to the restoration of New York Harbor and create opportunities for students in restoration science. Through technological advances in computer science, coupled with computational and design thinking, the computational component becomes a lens for engagement. Students become stewards of their community-based environmental science project and civil justice. Technology encourages students to reorganize scientific and mathematical ideas in new ways allowing them to create and solve problems of social significance (Yang & Baldwin, 2020). Students acquire the ability to think critically and collaborate with experts in the fields of information technology, environmental sustainability and community leaders fighting for social and environmental justice.

1.2 Primary and Secondary Hypotheses

Primary hypothesis: Does participation in CCERS activities increase female students' confidence (self-efficacy) in their technological abilities when compared to female non-CCERS students?

Secondary hypothesis: Does participation in CCERS activities increase students' confidence in their technological abilities, by grade level, when compared to non-CCERS students?

The research design consists of a student survey containing questions pertaining to the informational technology perceived confidence level of the surveyed students. The survey was administered to both the treatment and non-treatment subsets of female students in the four high school grade levels. The treatment groups were composed of students who participated in the CCERS STEM + C activities and the comparison groups were composed of students who did not participate in the CCERS STEM + C activities.

Theoretically, this study is intended to address students' self-efficacy in information technology and computer science. The findings of the study support early intervention in STEM academics and student emersion in extended environmental restoration projects embedded in local community issues. Findings are intended to highlight the CCERS STEM + C project as a replicable model for practical application.

2. Method

2.1 Procedure

A student survey containing confidence in technological abilities subscale was administered to all subjects of the study. Students' interest and persistence in technology has been the topic of several recent studies (Chen, 2017; Gupta & Bostrom, 2019). Students' attitudes about information technology as a possible career path have been shown to be directly related to student self-perception (Hur, Andrzejewski, & Marghitu, 2017). In crafting the survey, researchers worked alongside administrators, educations and science and technology specialists to refine the existing student survey instrument for the current phase of the project. The objective of the instrument refinement was to increase the response rate by reducing participant burden and length of time required to complete all necessary survey steps. Data collected from previous phases of the project were used to conduct item reduction analysis. The primary goal of this analysis was to obtain functional items (i.e., items that are correlated with each other, discriminate between individual cases, underscore single or multidimensional domain, and contribute significantly to the construct). The researchers determined the effect of deleting a given item or set of items by examining the item information and standard error function for the item pool. Further, the refined instrument was evaluated by key project personnel for content relevance, representativeness, and technical quality. Two key constructs are the foci of the research: motivation and preparation to pursue STEM careers. The survey was administered to students in the treatment groups and to those in the comparison groups. Each of these groups was subdivided into female and male students and further divided into grade levels 9 through 12. The treatment groups were composed of students who participated in the CCERS activities and the comparison groups were composed of students who did not participate in the CCERS activities.

Data were collected from August 2020 to July 2022, via an online survey (through the platform Alchemer, previously known as SurveyGizmo). The survey took the participants an average of 8 minutes to complete. Due to IRB restrictions, only middle school and high school students who provided parental consent were included in the sample. In addition, due to IRB and other restrictions, this report only examines the differences between respondents who participated in CCERS activities (i.e., treatment group) and respondents who did not participate in CCERS activities (i.e., comparison group).

2.1.1 Process for Engaging with the Online Survey

Clicking on the survey link would start the respondent on a 6-step process:

• Step one: A landing page, which provided the introduction to the survey and included screening questions to ensure that the students met participation requirements (e.g., middle or high school students)

• Step two: Obtain parental consent for their child to participate in the research

• Step three: Obtain student assent, where the student provides their consent to participate in the research study

• Step four: An evaluation survey, that captured which activities the respondents engaged in and included questions developed by the evaluation team to collect feedback on the activities

• Step five: A research survey, which included questions specific to the research study

• Step six: Reward page, where the respondent received a certificate for completing the survey

2.1.2 Technological Ability

Technological ability was a self-reported measure of participants' agreement with the following statements:

• I use technology in a way that enhances my everyday life

• I have the technical skills I need to use technology

• I can learn a new program (app) independently

• I have the technical skills I need to use technology

The response options were "strongly disagree," "disagree," "maybe," "agree," and "strongly agree," which were coded as 1-5, respectively. This variable was used to assess participants' technological abilities, with lower scores representing their lower perceived ability in technology and higher scores representing their higher perceived ability in technology. Because this scale had several disparate questions, Cronbach's alpha was calculated to examine its internal consistency. The alpha value is equal to 0.79, which is above the 0.7 considered to be acceptable, meaning the scale is internally consistent despite the questions being varied.

2.1.3 Science Self-efficacy

Science self-efficacy was a self-reported measure of participants' agreement with the following statements:

• I can make good observations during a science activity

• I can ask good questions about what is happening during a science activity

I feel confident about my ability to explain how to do scientific activities to others

• I think I could be a good scientist, and I am interested in learning about science

The response options were "strongly disagree," "disagree," "maybe," "agree," and "strongly agree," which were coded as 1-5, respectively. This variable will be used to assess participants' science self-efficacy, with lower scores representing less science self-efficacy and higher scores representing more science self-efficacy.

2.1.4 Self-efficacy in the Use of Technology

Self-efficacy was a self-reported measure of participant's agreement with the following statements:

• I have the technical skills I need to use technology

• I can learn a new program or application (app) independently

• I use technology in a way that enhances my everyday life

• I keep up with important new technologies

The response options were "strongly disagree," "disagree," "maybe," "agree," and "strongly agree," which were coded as 1-5, respectively. This variable will be used to assess participants' self-efficacy, with lower scores representing lower levels of self-efficacy and higher scores representing higher levels of self-efficacy.

2.2 Subjects

A total of 764 students opened the survey through the general link and arrived at the landing page in Step 1. A total of 513 respondents completed all the necessary steps for the surveys (i.e., step 2&3), including providing parental consent, and an important Internal Review Board stipulation for responses to be included in the research analyses (Table 1).

Table 1. Demographics Table by Participation

Demographics	Comparison Group N=90	CCERS Group N=423	Total N=513
Gender			
Male	40 (44.4%)	113 (26.7%)	153 (29.8%)
Female	24 (26.7%)	125 (29.6%)	149 (29.2%)
Do not wish to specify	-	24 (5.7%)	24 (4.7%)
No Response	26 (28.9%)	161 (28.1%)	187 (36.4%)
Grade			
6th	5 (5.6%)	-	5 (1.0%)
7th	-	1 (0.2%)	1 (0.2%)
8th	1 (1.1%)	1 (0.2%)	2 (0.4%)
9th	37 (41.1%)	35 (8.3%)	73 (14.2%)
10th	5 (5.6%)	107 (25.3%)	112 (21.8%)
11th	6 (6.7%)	39 (9.2%)	45 (8.8%)
12th	10 (11.1%)	53 (12.5%)	63 (12.3%)
No response	26 (28.9%)	187 (44.2%)	213 (1.4%)

3. Results

3.1 Disaggregation by Grade

CCERS respondents in the 12th grade, on average, reported higher confidence in their technological abilities (n=40, M=3.54, SD=.20) than non-CCERS respondents in the same grade (n= 10, M=3.00, SD =.45), (Figure 1).

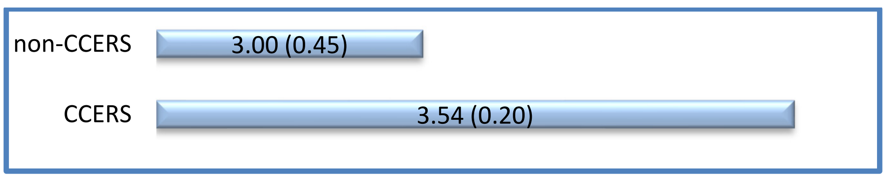

Figure 1. Average Score of 12th Grade Respondents' Confidence in Their Technological Abilities

Though non-significant, non-CCERS respondents in the 11th grade, reported slightly higher confidence in their technological abilities (n=6, M=4.20, SD=.34) than CCERS respondents in the same grade (n=30, M=3.84, SD=.45), (Figure 2).

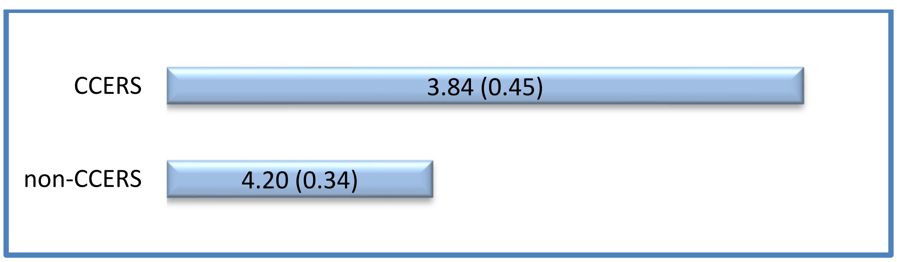

Figure 2. Average Score of 11th Grade Respondents' Confidence in Their Technological Abilities by Condition

CCERS respondent in the 10th grade, on average, reported higher confidence in their technological abilities (n=5, M=4.15, SD=.52) than non-CCERS respondents in the same grade (n=90, M=3.46, SD =.64), (Figure 3).

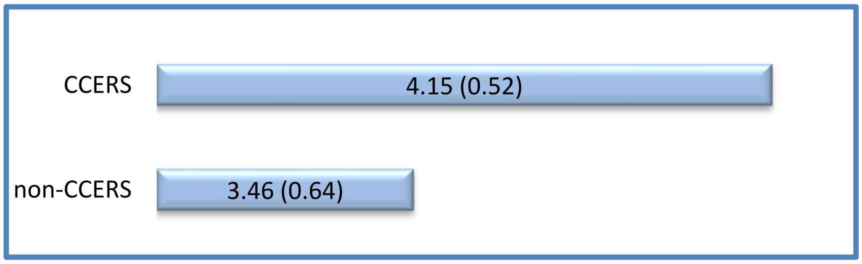

Figure 3. Ave.Rage Score of 10th Grade Respondents' Confidence in Their Technological Abilities by Condition

Though non-significant, non-CCERS respondents in the 9th grade, reported slightly higher confidence in their technological abilities (n=35, M=4.05, SD=.35) than CCERS respondents in the same grade (n=37, M=3.52, SD=.96), (Figure 4).

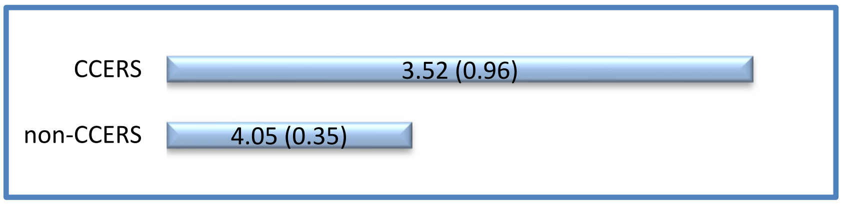

Figure 4. Average Score of 9th Grade Respondents' Confidence in Their Technological Abilities by Condition

3.2 Disaggregation by Gender

Female CCERS respondents, on average, reported higher confidence in their technological abilities (n=44, M=3.74, SD=.54) than non-CCERS female respondent (n=30, M=3.71, SD= .61), (Figure 5).

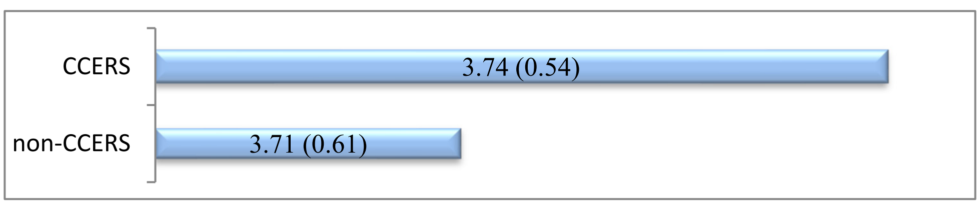

Figure 5. Average Score of Female Respondents' Confidence in Their Technological Abilities by Condition

Male CCERS respondents, on average, reported higher confidence in their technological abilities (n=44, M=3.95, SD=.64) than non-CCERS male respondent (n=40, M=3.63, SD= .55), (Figure 6).

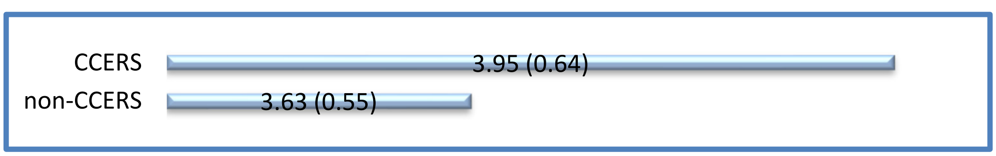

Figure 6. Average Score of Male Respondents' Confidence in Their Technological Abilities by Condition

4. Discussion

To address the issue of gender equity in STEM occupations, and more significantly, in the subset of STEM occupations that include information technology and computer science, it is important to understand where disengagement occurs in the educational pipeline for female students. Several studies have indicated that this decline occurs during middle school grades for all students. Ages 12-14 are typical for the junior high school years. In a study involving 24,000 students, survey results showed that the relationship between STEM intention and motivation is highly time-sensitive. Occupational intentions change dramatically between the 9th and 11th grades (Mangu, Lee, Middleton, & Nelson, 2015). Positive attitudes towards science identified in youth age 10 sharply decline by age 14

(Tai, Liu, Maltese & Fan, 2006). However, this decline is distinctively greater for female students. Numerous reports have noted that during high school years, the percentage of girls interested in STEM significantly declines (17% to 12%). In the United States, most disciplines in the technical and scientific workforce are predominantly male. The loss of women from STEM careers limits the perspectives and intellectual contributions that result from a diverse STEM workforce. Thus, the CCERS STEM + C model on middle and high school students may be a critical intervention that contributes to a more diverse STEM workforce.

Additionally, the self-perception of aptitude and ability in STEM academics is an area of concern for female students. Studies have indicated that there is a misconception that male students are more inclined to excel in STEM and therefore have less self-confidence in their own ability in STEM academics. A recent study found that women students rate technical skills as more masculine than non-technical skills in IT. This area is a possible source of intervention in earlier grades and is seen as an avenue to alter perception and possibly educational and career choice shifts for female students (Trauth, Cain, Joshi, Kvasny, & Booth, 2016). Women's persistence in science majors and careers was associated with high school math grades, college entrance exam scores, or college GPA (Camp, Gilleland, Pearson, & Putten, 2009). Studies find that women who are unsure of their science and math skills are less likely to persist in STEM career paths, as compared to women who are more confident in such skills (American Association of University Women, 2010). Successful academic performance has been linked to higher-level career aspirations among women in STEM majors (Gregor, Weigold, Martin-Wagar, & Campbell-Halfaker, 2021).

Through the ecological restoration of New York Harbor, the data collection experience has not only restored the quality of the water and the abundance of aquatic species, but it has also given students the opportunity to build on their STEM research skills. Building these skills and confidence in the application of these skills makes data science more accessible to them as they consider their academic and career paths. With the ability to bridge community-based knowledge and school-based knowledge through problem-based learning, students gain intellectual and meaningful learning through practical experience (Nguyen, Nguyen & Tran, 2020). Creating opportunities for students to not only develop content knowledge but to also have hands-on experiences, engage in STEM course content with peers, and identify as scientists seems particularly important (Griffin, 2018).

Findings from this study indicate that participation in CCERS activities may have varying levels of impact across different groups (e.g., different grades and gender). Specifically, it was observed that participation in CCERS activities is significantly related to higher reported scientific identity, a key predictor in STEM motivation and retention, further analysis revealed that the impact was even more significant for 11th-grade students in the treatment condition.

When examining career interest which is a key predictor for STEM motivation and interest, there was a similar pattern for 9th grade girls, where girls in the treatment condition reported higher levels of career interest than girls in any other grade or condition. Overall, these results demonstrate that certain groups may benefit more and can serve as target groups for the next iteration of the project. Focus on students in 11th grade or female students in 9th-grade may prove most impactful. Future project implementation could focus on these groups, in particular, to see if the greatest impacts are being sustained with these subsets of the project. Moreover, future longitudinal studies should measure the duration of such changes and determine what supports may be necessary to sustain these levels.

Disaggregation by grade and gender suggests that participation in CCERS activities may have varying levels of impact across different groups (e.g., different grades and gender). Research suggests (Hoxby, 2021) the quality of education in later grades maybe even more important for long-term outcomes, as the ability to handle advanced reasoning skills does not develop until well into their teenage years. When individuals feel capable and *i*nterested in math and science, they are more likely to pursue STEM occupations (Wang, Degol, & Ye, 2015).

In the interest of providing resipiscence for the lack of academic groundwork in STEM provide to underrepresented groups, programs such as the CCERS STEM + C should be embedded in the course of studies at an early age and with equity for all students. Successful academic performance predicts interest and persistence in STEM, especially for students who are minorities in STEM. A study found that high school and college first-year grade point averages (GPAs) were the best predictors of educational persistence among students who majored in science or engineering (Mendez, Buskirk, Lohr, & Haag, 2008). The practices of community-building and student-centered learning are among the many ways of creating a sustainable and cohesive environment where all students can grow, build confidence, and gain acceptance (Saleem, 2022).

References

Adya, M., & Kaiser, K. (2005). Early Determinants of Women in the IT Workforce: A Model of Girls' Career Choices. *Information Technology & People, 18*(3), 230-259. https://doi.org/10.1108/09593840510615860

American Association of University Women (2010). *Why so few? Women in science, technology, engineering and mathematics*. Washington, DC: AAUW. Retrieved from https://ww3.aauw.org/research/why-so-few/

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*(1), 187-206. https://doi.org/10.1111/1467–8624.00273

Bernstein, B. L., & Russo, N. F. (2008). Explaining too few women in STEM careers: A psychosocial perspective. In M. A. Paludi (Ed.), *The psychology of women at work: Challenges and solutions for our female workforce, Vol. 2: Obstacles and the identity juggle* (pp. 1-33). Westport, CT: Praeger/Greenwood.

Camp, A. G., Gilleland, D., Pearson, C., & Putten, J. V. (2009). Women's path into science and engineering majors: A structural equation model. *Educational Research and Evaluation, 15*(1), 63-77. https://doi.org/10.1080/13803610802591725

Chen, I.-S. (2017). Computer self-efficacy learning performance and the mediating roles of learning engagement. *Computers and Human Behavior, 72*, 362-370. https://doi.org/10.1016/j.chb.2017.02.059

Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles, 69*, 58-71. https://doi.org/10.1007/s11199-013-0296-x

Funk, C., & Parker, K. (2018). Women and Men in STEM Often at Odds over Workplace Equity, Chapter 1- Diversity in the STEM workforce varies widely across jobs. *Pew Research Center*. Retrieved from https://www.pewresearch.org

Gregor, M. A., Weigold, I. K., Martin-Wagar, C. A., & Campbell-Halfaker, D. (2021). Tenure Expectations and Career Aspirations Among Female Assistant Professors in STEM. *Journal of Career Development, 49*(4), 890-905. https://doi.org/10.1177/08948453211005032

Griffin, K. A. (2018). Addressing STEM Culture and Climate to Increase Diversity in STEM Disciplines. *Higher Education Today*, American Council on Education. Retrieved from Retrieved from https://www.higheredtoday.org/2018/04/23/addressing-stem-culture-climate-increase-diversity-stem-disciplines/

Gupta, S., & Bostrom, R. P. (2019). A Revision of Computer Self-Efficacy Conceptualizations in Information Systems. *the DATABASE for Advances in Information Systems, 50*(2), 71-93. https://doi.org/10.1145/3330472.3330478

Hoogendoorn, S., Oosterbeek, H., & van Praag, M. (2013). The Impact of Gender Diversity on the Performance of Business Teams: Evidence from a Field Experiment. *Management Science, 59*(7), iv-vii. https://doi.org/10.1287/mnsc.1120.1674

Hoxby, C. M. (2021). *Advanced Cognitive Skill Deserts in the U.S.: Their Likely Causes and Implications*. Brookings Paper on Economic Activity, BPEA Conference Drafts. Retrieved March 25, 2020, from https://www.brookings.edu/wp-content/uploads/2021/03/BPEASP21_Hoxby_conf-draft_updated.pdf

Hur, J. W., Andrzejewski, C. A., & Marghitu, D. (2017). Girls and computer science: experiences, perceptions, and career aspirations. *Computer Science Education, 27*(2), 100-120. https://doi,org/10.1080/08993408.2017.1376385

Kekelis, L. S., Ancheta, R. W., & Heber, E. (2005). Hurdles in the Pipeline: Girls and Technology Careers. *Frontiers: A Journal of Women Studies, 26*(1), 99-109. https://www.jstor.org/stable/4137438

Kirkpatrick, H., & Cuban, L. (1998). Should We Be Worried? What the Research Says About Gender Differences in Access, Use, Attitudes, and Achievement with Computers. *Educational Technology*, *38*(4), 56-61. Retrieved from http://www.jstor.org/stable/44429002

Mangu, M., Lee, A. R., Middleton, J., & Nelson, J. K. (2015). *Motivational factors predicting STEM and engineering career intentions for high school students*. 2015 IEEE Frontiers in Education Conference (FIE). https://doi.org/10.1109/FIE.2015.7344065

Mendez, G., Buskirk, T. D., Lohr, S., & Haag, S. (2008). Factors associated with persistence in science and engineering majors: An exploratory study using classification trees and random forests. *Journal of Engineering Education, 97*(1), 57-70. https://doi.org/10.1002/j.2168-9830.2008.tb00954.x

Mosatche, H. S., Matloff-Nieves, S., Kekelis, L., & Lawner, E. K. (2013). Effective STEM programs for adolescent girls – Three approaches and Many Lessons learned. *Afterschool Matters, 17*, 17-25. Retrieved from https://files.eric.ed.gov/fulltext/EJ1003839.pdf

Nguyen, T. P. L., Nguyen, T. H., & Tran, T. K. (2020). STEM Education in Secondary Schools: Teachers' Perspective towards Sustainable Development. *Sustainability, 12*(21), 1-16. https://doi.org/10.3390/su12218865

Organization for Economic Cooperation and Development (2018). Bridging the Digital Gender Divide – Include, Upskill, Innovate, 1-151. Retrieved 10-11 March, 2023, from https://www.oedc.org/going-digital, https://www.oedc.org/gender

Pajares, F., & Urdan, T. (2006). *Self-Efficacy Beliefs of Adolescents.* Information Age Publishing: Greenwich, CT.

Sadler, P., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and Volatility of STEM Career Interest in High School: A Gender Study. *Science Education, 96*(3), 411-427. https://doi.org/10.1002/sce.21007

Saleem, S. M. (2022). The Voice of One to the Voices of Many: The Story of a Black Girl in STEM. *Voices in Urban Education, 50*(2), 10-18. https://doi.org/10.33682/jdqz-xusa

Steinke, J. (2017). Adolescent Girls' STEM Identity Formation and Media Images of STEM Professionals: Considering the Influence of Contextual Cues. *Frontiers in Psychology, 8*(716), 1-15. https://doi.org/10.3389/fpsyg.2017.00716

STEMwomen (2021). *Women in STEM USA Statistics*. Retrieved from https://www.stemwomen.com/women-in-stem-usa-statistics

Sutton, R. E. (1991). Equity and Computers in the School: A Decade of Research. *Review of Educational Research, 61*, 475-503. https://doi.org/10.3102/00346543061004475

Tai, R. H., Liu, C.Q., Maltese, A.V., & Fan, X. (2006). Planning Early for Careers in Science. *Science, 312*(5777), 1143-1144. https://doi.org/10.1126/science.1128690

Timberlake, S. (2005) Social Capital and gender in the workplace. *Journal of Management Development, 24*(1), 34-44. https://doi.org/10.1108/02621710510572335

Trauth, E. M., Cain, C. C., Joshi, K. D., Kvasny, L., & Booth, K. M. (2016). The Influence of Gender-Ethnic Intersectionality on Gender Stereotypes about IT Skills and Knowledge. *ACM SIGMIS Database: the DATABASE for Advances in Information Systems, 47*(3), 9. https://doi.org/10.1145/2980783.2980785

Usher, E. L., & Pajares, F. (2008). Self-Efficacy for Self-Regulated Learning: A Validation Study. *Educational Psychology Measurement, 68*(3), 443-463. https://doi.org/10.1177/0013164407308475

Volman, M., & van Eck, E. (2001). Gender Equity and Information Technology in Education: The Second Decade. *Review of Education Research, 71*(4), 613-634. https://www.jstor.org/stable/.3516100

Wang, M. T., Degol, J. L., & Ye, F. (2015). Math achievement is important, but task values are critical too: Examining the intellectual and motivational factors leading to gender disparities in STEM careers. *Frontiers in Psychology, 36*(6), 1-9. https://doi.org/10.3389/fpsyq.2015.00036

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining Computational Thinking for Mathematics and Science Classrooms. *Journal of Science Education and Technology*, *25,* 127-147. https://doi.org/10.1007/s10956-015-9581-5

Yang, D., & Baldwin, S. J. (2020). Using technology to support student learning in an integrated STEM learning environment. *International Journal of Technology in Education and Science*, *4*(1), 1-11. https://doi.org/10.46328/ijtes.v4i1.22

Zeldin, A. L., Britner, S. L., & Pajares, F. (2008). A comparative study of the self-efficacy beliefs of successful men and women in mathematics, science, and technology careers. *Journal of Research in Science Teaching, 9*(45), 1036-1058. https://doi.org/10.1002/tea.20195