Students' Self-Efficacy and Confidence in Technological Abilities Resulting from Participation in "The Curriculum and Community Environmental Restoration Science (STEM + Computer Science)"

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Abstract

The rationale for this research is the ever-increasing reliance on technology in all aspects of life, but especially in the realm of education. Technology tools, use, and approaches that support inclusive student learning are supported by the empirical evidence found in this report. The research emphasized self-efficacy levels achieved in the student learning of technology-supported integrated science, technology, engineering, and mathematics (STEM). The Curriculum and Community Environmental Restoration Science STEM + Computer Science (CCERS) makes use of web-based authentic STEM content, providing interactive technology on a dynamic environmental science platform and providing real-world environmental conundrums. Results of this study indicate that CCERS respondents have higher confidence in their technological abilities than those of the non-CCERS respondents. In addition, under-represented groups (URG) CCERS respondents, on average, have higher confidence in their technological abilities than URG non-CCERS respondents. This suggests that CCERS has a positive impact on participants' confidence in their technological abilities, a key indicator in pursuing STEM careers. This study provides practical implications for current and future research in technology-supported learning in integrated STEM learning environments and student outcomes.

Keywords: technological self-efficacy, educational equity, STEM career motivation, underrepresented groups

1. Introduction

1.1 Introduce the Problem

The term digital divide was first used in a speech given by then-President Clinton in 1996 (Clinton, 1996). Defined as the inequality of access to information technology, the term quickly gained in popularity and momentum. Just as with most imbalances that pertain to upward mobility, the digital divide is most prevalent in populations that identify as low-income, underrepresented groups. Although initially used to describe access to information technology, the digital divide is composed of several factors that lead to disparities and social stratification, such as availability, affordability, quality of service, and digital literacy. Often these gaps fall along the line of other disparities such as income and gender-based inequality. The digital divide has especially pronounced effects on children whose parents' socioeconomic situation controls their ability to participate in technology-based materials. Nearly all schools in the United States expect some form of technology to complete assignments outside of the classroom and COVID-19 has exacerbated this trend (Bruce, 2020). Digital literacy has replaced the term digital divide due to the array of factors that represent digital inclusiveness. Instead of merely describing one's ability to access technology, digital literacy encompasses a range of factors that include access, techniques, and skills related to technology. The expression is associated with the increasing utilization of digital technologies and their widely recognized importance in nearly all spheres of life, including social, domestic, and work (Iqbal, Hardaker, Sabki, & Elbeltagi, 2014). There is a growing recognition of the importance of digital literacy and its potential to increase self-efficacy, self-regulation, and student agency and voice (Alioon & Delialioğlu, 2019).

Even as technology is increasingly utilized to enhance curricula, students in low-income neighborhoods struggle with insufficient infrastructure and a shortage of current software and devices. Virtual learning in the age of COVID-19 has added a layer of inequity in that lower-income students have lost nearly double the months of learning that average-income students have lost. Underrepresented populations of students are more likely to come from lower-income communities, compounding the conundrum. Black and Latinx students were less likely to succeed in a virtual learning environment not supported by in-school instruction. Issues of technological inadequacies and a lack of a strong at-home support system have been cited as possible causes (Winston, 2021).

This year, for the first time since the National Assessment of Educational Progress (NAEP) tests began tracking student achievement in the 1970s, student achievement fell by the largest margin in thirty years in both mathematics and reading. The declines spanned almost all races and income levels but were markedly worse for the lowest-performing students. While top performers in the 90th percentile showed a modest drop — three points in mathematics — students in the bottom 10th percentile dropped by 12 points in mathematics, four times the impact (Mervosh, 2022). On the flip side, the pandemic can be seen as having a positive effect on the field of education. New ideas and technologies developed during the pandemic are expected to outlive it (Lempinen, 2020). Technology is now seen through the lens of the delivery of academic content that is engaging to both students and educators (Allen, 2020). Teachers can become co-creators of knowledge, coaches, mentors, and evaluators (Janssen, 2020). Research indicates that technology plays a critical role in student learning (Russell, Lucas & Mc Robbie, 2003). Studies have shown a significant increase in achievement scores of students using technology as a learning tool (Lei & Zhao, 2007). Additional research in science classrooms implies that the use of technology has a positive influence on a wide variety of student learning outcomes, including an understanding of science concepts and scientific reasoning skills (Dani & Koenig, 2008). With this increased reliance on technology in education, the crux of the problem remains the inequality of access for underrepresented, low-income populations to obtain an equal, high-quality education that is afforded to their peers. Studies have been conducted (Henderson, Selwyn & Aston, 2017; Selwyn, 2016) on the role of digital technology on student engagement and retention. Providing opportunities for students to express agency in their learning, through activity and technology choice, as well as through collaborative activities, enhances content engagement (Bond & Bedenlier, 2019).

From a cultural perspective, there are several concerns in the integration of technology in learning, including the understanding and use of technology and designing learning experiences where learning can flourish and learners retain agency in the learning process (Sulecio de Alvarez & Dickson-Deane, 2018). The importance of integrating technology in schools has been addressed in many recent educational reforms given that a substantive body of research demonstrates the efficacy of technology to enhance science learning, (Guzey & Roehrig, 2012). The ability to use technology to enhance STEM content and related skills is paramount in creating a population that is prepared for 21st-century STEM knowledge and possible STEM careers. Culturally relevant and context-appropriate learning experiences, coupled with modern technologies, are particularly important in under-served or under-resourced communities where access to STEM experiences is limited. Each step of students' educational pathway must include the potential for STEM career choices through insight and dynamic intervention to ensure the learners' self-confidence in technological abilities and STEM cognitive abilities.

1.2 Importance of the Problem

Never has technological ability been more crucial. The COVID-19 pandemic illuminated the global reliance on technology, not only for economic growth and stability but more importantly, for the future of consistent and sustainable education. Technology must be used as a pedagogical tool and, as such, an equalizing force in education. Using technology as a supplemental learning resource, both inside and outside the classroom, can increase student engagement and motivation, expand experiences, and accelerate learning by acting as a supplementary learning resource (U.S. Department of Education, 2017). Technology lends itself to motivating and engaging students in STEM content subject areas. STEM content is especially disposed to motivation and engagement through the use of technology. The techniques and tools that technology provides support the inquiry process and augment real-world situations in the STEM disciplines. The use of technology and subject content mutually influence one another (Koehler & Mishra, 2009). Integrated STEM learning, technology, content, and career training often become intertwined and inseparable in a technology-supported environment. The collaboration of instructors and subject-matter experts creating an innovative STEM learning environment helps students solve real-world (Nag, Katz, & Saenz-Otero, 2013).

1.3 Integration of Technology in STEM Education

To ensure that learners are prepared for 21st-century STEM knowledge and possible STEM careers, each step of students' educational pathway must include the potential for STEM career choices. Education and mentoring of all students allow the exploration of different pathways and personalization of their career outcomes. This environment gives students access to the actual nature of work in the STEM field and pertinent information necessary to consider and pursue these careers. This strategy would also serve as a motivator to those who are not aware that STEM careers involve people skills, creativity, and problem-solving (Blotnicky, Franz-Odendaal, French & Joy, 2018). The level of STEM career knowledge an individual has will directly affect one's intentions of pursuing a STEM career in the future (Zhang & Barnett, 2015). Research has shown that equipping students with STEM career knowledge early increases their motivation to take more science and mathematics courses in high school (Harackiewicz, Barron, Tauer & Elliot, 2012).

Similarly, engagement in technologies that facilitate the experiential learning needed in the STEM disciplines in grades pre-K through adulthood assuages the preconceived mindset that STEM disciplines are difficult and appropriate for only some to pursue. Technologies have universal implications and break down the barriers typically imagined in laboratories and fieldwork. In so doing, the enhancement of students' self-efficacy has led to students pursuing real-world problems of personal interest through the lens of technology-driven STEM content. Such focus can have a significant social impact across society through self-directed learning and technological access to information.

The Curriculum and Community Enterprise for the Environmental Restoration Science STEM + Computer Science (CCERS STEM + C) program is a comprehensive, technology-rich conservation program engaging New York City public school students in the restoration of oysters in New York Harbor. With the aid of technology, data on the oysters as well as biotic and abiotic factors of the aquatic ecosystem is collected, analyzed, and interpreted. There are over 5600 students involved in the program, many identifying as being members of underrepresented groups and living in low-income sections of the city. The focus of the program is to engage these students in high-interest STEM content and technology. The motive for this enticement is to increase the diversity of STEM post-secondary degrees and the STEM employment pool. Diversity, equity, and inclusion can be attained by engaging students in experiential, real-world conundrums such as those found in the CCERS STEM + Computer Science Project.

1.4 Supporting Innovative Policies targeting Underserved and Marginalized Groups

Research results suggest that programs designed with a culturally responsive curriculum, are effective in promoting the career development of culturally diverse and underrepresented students. Students in these programs experience significant self-efficacy changes that better prepare them for STEM career pathways (Cadenas, Cantu, Lynn, Spence, & Ruth, 2020). A recent study found that by modifying a curriculum to include active learning closed the achievement gap between underrepresented minority students and non-underrepresented minority and led to an increase in science self-efficacy for all students (Ballen et al., 2017). Today's students must represent all dimensions of America's diverse society to facilitate equity and inclusion because today's students will become tomorrow's STEM faculty, workforce, and innovators. Schools not only teach students academic skills but also intuitive skills, like perseverance and teamwork, which are necessary for generating social mobility. In a recent OECD (Organization for Economic Co-operation and Development) Working Paper (Gottschalk & Weise, 2023), the need for digital skills that include operational skills, information-navigation skills, social interaction skills and creative skills for all students, are necessary in making education more equitable and inclusive. Educational systems must focus on ensuring equity in terms of access to digital resources and promoting digital skills, as well as using digital technologies that are designed with inclusion in mind.

1.5 How Does the Study Relate to Previous Work

This study is an extension of others that focus on the issues of equality and inclusion of digital literacy, especially in the school-level domain. To understand this, the experiences of all learners in using technology need to be comprehended (Webb, 2006). All groups, including women, low-income, first-generation, and other underserved student groups, enter learning environments that are culturally and linguistically relevant to them, and that are engaging and welcoming. Several innovators have eliminated practices that sort students into groups based on background or prior knowledge. Differences in foundational knowledge are instead mitigated individually through faculty mentoring or other strategies, allowing students to engage in self-directed learning based on individual preferences and pacing in a personalized way. The COVID-19 Pandemic led to some extensive work on the expansion of technology at an unprecedented pace. One such expansion was orchestrated through the partnership between Phoenix College, the City of Phoenix, the Greater Phoenix Economic Council, and the Phoenix Union School District. This partnership resulted in the Phoenix Digital Education Connection Canopy, which allowed the city to launch a citywide Wi-Fi network using the K-12 school system's fiber network, providing 250,000 families in Phoenix with free Wi-Fi access (Phoenix College, 2021). Digital tools, such as platforms that host open educational resources, contain higher quality materials that promote the inclusion of students and support teachers' professional learning (Brussino, 2022). Research has also been conducted on the relationship of self-efficacy and successful participation in educational activities. Learners' perception and acceptance of emerging technologies are important factors that affect their effective learning (Huang & Liaw, 2018). In a recent study (Pan, 2020), correlational analyses corroborated the links between technology proficiency and technological self-efficacy and attitude. Self-efficacy plays an important role in successful participation in educational activities.

1.6 What Are the Primary and Secondary Hypotheses

Hypothesis 1: Science research participation and engagement with scientists via CCERS will positively influence students' confidence in their technological abilities compared to non-CCERS students.

Hypothesis 2: Science research participation and engagement with scientists via CCERS will positively influence students' confidence in technological abilities among underrepresented groups compared to non-CCERS URG students.

2. Methodology

2.1 Participants

A student survey which contains confidence in technological abilities subscale was administered to all subjects of the study. The survey was administered to students in the treatment groups and to those in the comparison groups. Each of these groups was subdivided into students and underrepresented students (URG). Underrepresented groups (URG) were identified as those who self-identified as one of the following: a woman, person with disabilities, or as and underrepresented minority (Black, Hispanic, American Indian or Alaskan Native). The treatments 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.

2.2 Data Collection

Data was collected from August 2020 to July 17, 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).

2.2.1 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 student)

• 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

A total of 764 students opened the survey through the general link and arrived at the landing page in Step 1. A total of 514 respondents completed all the necessary steps for the surveys (i.e., steps 2&3), including providing parental consent, an important IRB stipulation for responses to be included in the research analyses. See Table 1.

Table 1. Demographics Table by Participation

Demographics	Comparison Group N=90	CCERS Group N=423	Total N=514
Gender			
Male	40 (44.4%)	113 (26.7%)	153 (29.8%0
Female	24 (26.7%)	125 (29.6%)	150 (29.2%)
Do not wish to specify	-	24 (5.7%)	24 (4.7%)
No Response	26 (28.9%)	161 (28.1%)	187 (36.4%)
Ethnicity/Race			
American Indian or Alaska Native	3 (3.3%)	5 (1.2%)	8 (1.6%)
Asian	7 (7.8%)	37 (8.8%)	44 (8.6%)
Black or African American	10 (11.1%)	32 (7.6%)	42 (8.2%)
Hispanic/Latino	15 (216.7%)	74 (17.5%)	89 (17.3%)
White (non-Hispanic or Latino)	26 (28.9%)	75 (17.7%)	101 (19.7%)
Other	3 (3.3%)	13 (3.1%)	17 (3.3%)
Do not wish to specify	-	30 (7.1%)	30 (5.8%)
No response	26 (28.9%)	157 (37.1%)	183 (35.6%)
First Generation			
Yes	17 (18.9%)	70 (16.6%)	87 (16.9%)
No	32 (35.6%)	165 (39.0%)	198 (38.5%)
No response	41 (45.6%)	188 (44.4%)	229 (44.6%)
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%)

2.3 Data Analysis

In Research Question 1, the sample was divided into the CCERS respondents who participated in CCERS activities (treatment) and a group who did not participate in CCERS activities (comparison). Total student respondents numbered 514 across both conditions, with 423 respondents in the CCERS treatment group and 90 in the comparison group. For Research Question 2, the sample included only respondents who identified as members of an underrepresented group1 (URG). A total of 201 respondents across both conditions identified as part of a URG, with 140 URG respondents in the CCERS treatment group and 61 URG respondents in the comparison group.

2.3.1 Creation of Variables

For each of the research questions, indices were created by averaging items on the survey's subscales. Where appropriate, Cronbach's alpha was calculated to ensure internal consistency.

2.3.2 Career Interest

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

• Scientists make a meaningful difference in the world

• A career in science would enable me to work with others in meaningful ways

• I am interested in jobs related to science

• I am interested in pursuing a career in science, technology, or engineering.

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 participant's career interest, with lower scores representing less career interest and higher scores representing more career interest.

2.3.3 Engagement

Engagement in STEM is the sum of a series of yes/no questions regarding whether participants engaged in a variety of behaviors. Engagement behaviors here included:

• Volunteering/interning in a STEM field

• Receiving direct guidance on projects from a scientist

• Watching videos made by scientists

• Attending any talks where a scientist spoke

• Reading articles written by scientists

• Listening to podcasts by scientists

Additionally, "yes" was coded as 1, and "no" was coded as 2 for this variable's responses, higher scores meant fewer engagement behaviors. Because this was out-of-sync with other variables, engage was reverse-coded to make higher scores reflective of higher engagement behaviors.

2.3.4 Technological Abilities

The self-reported technological ability is a measure of participant's 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 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 participant's technological abilities, with lower scores representing their lower perceived ability in technology and higher scores representing higher perceived ability in their technological abilities. Because this scale had several desperate questions, Cronbach's alpha was calculated to examine its internal consistency. The alpha value is equal to 0.79, above the 0.7 which is considered to be acceptable, meaning the scale is internally consistent despite the questions being varied.

2.3.5 Science Self-efficacy

Science self-efficacy was a self-reported measure of participant's 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 participant's science self-efficacy, with lower scores representing less science self-efficacy and higher scores representing more science self-efficacy.

2.3.6 Condition

Condition was the experimental variable. The control group was "dummy" coded as 0 and the treatment group was "dummy" coded as 1 for later analysis. Due to the unequal distribution of missing data for the treatment and control group, the condition variable won't be added to models unless it is directly being tested.

2.4 Summary of Analysis

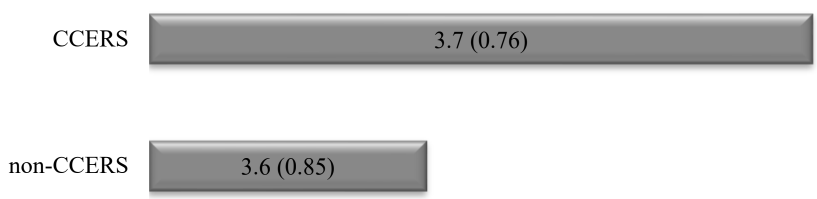
Researchers examined the data used missing data, normality of distribution and multicollinearity. For data that met all the assumptions, an independent samples t-test was used to examine if there were statistically significant differences between the CCERS (treatment) and comparison groups. For continuous data that did not meet the assumptions of equality of variance, Welch's t-test was used, and for categorical data, Fisher's exact test was used. The research team presented the means and standard deviations of the indices for each of the groups identified. Please note that sample size may vary in different sections because not every respondent answered every question (or a "N/A" option was chosen).

3. Results

3.1 Addressing the Original Research Questions

Research Question 1: Does participating in CCERS activities increase student's confidence in their technological abilities compared to non-CCERS students?

Respondents answered four questions on a Likert scale with ratings from 1=strongly disagree to 5=strongly agree regarding their confidence in their technological abilities. Cronbach's alpha was run to examine internal validity (.84), and then items were averaged to compute an index, with higher average scores representing higher confidence in their technological abilities. On average, the CCERS group expressed a higher confidence in their technological



abilities (n= 115, M=3.70, SD=0.76) then the non-CCERS group (n=85, M=3.60, SD=.85). See Figure 1.

Figure 1. Average Score of Respondents' Confidence in Their Technological Abilities by Condition

Research Question 2: Does participating in CCERS activities increase URG student's confidence in their technological abilities compared to non-CCERS URG students?

To assess how CCERS participation impacts URG respondents' confidence in their technological abilities, researchers examined respondents' responses to four questions. URG CCERS respondents, on average, had higher levels of confidence in their technological abilities than non-CCERS URG respondents.

3.1.1 URG Confidence in Technological Abilities

Respondents answered four questions on a Likert scale with ratings from 1=strongly disagree to 5=strongly agree regarding their confidence in their technological abilities. Cronbach's alpha was run to examine internal validity (.84), and then items were averaged to compute an index, with higher average scores representing higher confidence in their technological abilities. On average, the CCERS URG group expressed a higher confidence in their technological abilities (n= 86, =3.70, SD=0.76) then the URG non-CCERS respondents (n=61, M=3.60, SD=.85). See Figure 2.

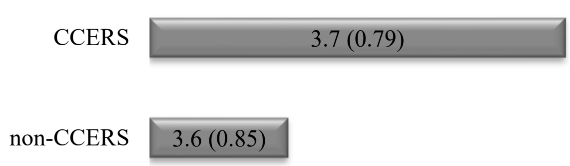


Figure 2. Average Score of URG Respondents' Confidence in Their Technological Abilities by Condition

3.2 Analysis of All Students

To further analyze participation in CCERS respondents, researchers created linear models to assess its impact with other key outcomes. Results are presented below.

3.2.1 Model Predicting Scientific Identity

A model was created to see if any variables were significantly related to scientific identity. The linear model was created with scientific identity as the dependent variable and engagement, condition, and grade as predictor variables.

Using bootstrap, the variance inflation factor (VIF) revealed that no variables in the pre-bootstrapped model posed a risk to multicollinearity (Note 1). Simple slope analysis revealed that respondents in 11th grade who participated in CCERS had the highest reported scientific identity (M= 3.28) when compared to any other grade across conditions (9th grade = 3.02, 10th grade = 3.07, 12th grade = 3.08).

3.2.2 Model Predicting Career Interest

A model was created to examine whether any variables were significantly related to career interest. The linear model was created with career interest as the dependent variable and engagement, condition, and grade as predictor variables. Utilizing bootstrap(Note 2), VIF revealed that no variables in the pre-bootstrapped model posed a risk to multicollinearity. Simple slope analysis revealed that students in 9th grade who participated in CCERS had the highest reported career interest (M= 3.58) when compared to any other grade across conditions (10th grade = 3.04, 11th grade = 3.00, 12th grade = 3.08).

3.2.3 Condition and Engagement

A model was created to test the relationship between condition and engagement. The model was then bootstrapped. Results indicated that respondents who participated in CCERS reported higher levels of engagement M= 3.54) than non-CCERS respondents (M=2.54). To examine which specific part of the engagement variable was being increased, a model was created where the variable was deconstructed, and used to predict condition in a binomial logistic regression. The model was then bootstrapped. Results indicated that CCERS participants were more likely to receive direct guidance on projects from a scientist and were more likely to read articles written by scientists. No other variables were related to condition.

Because volunteering is specific, measurable, and had a component of commitment and pursued engagement, a chi-square test for independence was conducted to see if volunteering was related to condition. The results indicated that there was no relationship between volunteering and condition

3.2.4 Exploratory Analysis of Underrepresented Groups (URG)

To test the generalizability of the models created above, a subset of the dataset containing only underrepresented groups was created. This subset of data used the same variables as the general dataset, and the same test was applied unless otherwise noted.

3.2.5 Model Predicting URG Scientific Identity

A model was created to see if any variables were significantly related to scientific identity. The linear model was created with scientific identity as the dependent variable and engagement and condition, and grade as predictor variables. Using the bootstrap method, VIF revealed that no variables in the pre-bootstrapped model posed a risk to multicollinearity. Analysis revealed that unlike the overall sample, there was no significant difference between the URG CCERS respondents and URG non-CCERS respondents. This pattern was consistent when underrepresented minority students and girls were analyzed separately.

3.2.6 Model Predicting URG Career Interest

A model was created to see if any variables were significantly related to URG career interest. The linear model was created with career interest as the dependent variable and engagement and condition, and grade as predictor variables. Using the bootstrap method, VIF revealed that no variables in the pre-bootstrapped model posed a risk to multicollinearity. Results indicated that there was no significant difference in career interest between URG CCERS respondents and URG Non-CCERS respondents. However, a further analysis of only female students revealed a significant difference for 9th grade girls, in which 9th grade girls (M=3.63) who participated in CCERS had higher reported levels of career interest than girls in any other grade or condition.

3.2.7 Model Predicting URG Engagement

A model was created to see if any variables were significantly related to engagement. The linear model was created with engagement as the dependent variable and scientific identity, condition and grade as predictor variables. Using, VIF revealed that no variables in the pre-bootstrapped model posed a risk to multicollinearity. Results indicated that participating in CCERS positively predicted engagement, however scientific identity and grade were non-significant.

3. Discussion

The findings of this study indicate that CCERS participant respondents have higher confidence in their technological abilities than non-CCERS respondents. Furthermore, students identifying as underrepresented and participating in the CCERS program have higher confidence in their technological abilities than students who identify as underrepresented and did not participate in the CCERS program. These results suggest that the Curriculum and Community Enterprise for Restoration Science has a positive impact on participants' confidence in their technological abilities, a key indicator in pursuing post-secondary STEM fields and future careers. Exploratory findings also provide support for the CCERS Model. In general, significantly higher reported levels of engagement, career interest, and scientific identity for students in the treatment condition compared to students in the control condition were observed.

Technological developments are continually evolving and the advancements in educational technology support student learning in complex, integrated STEM learning environments (Yang & Baldwin, 2020). The ability of students to possess the tools and skills to meet this evolution is vital in many career fields but is most essential in the fields collectively known as STEM. The integration of technology and STEM content in the CCERS Project presents a multidisciplinary, technology-enabled project-based learning (PBL) curriculum that integrates STEM, environmental restoration, and real-world issues of community action and social justice. With the aid of technology, students and teachers can create and solve a larger amount of problems (Beal & Cohen, 2012). The challenges that are presented with connecting the skills needed to master technology with integrated STEM learning must be addressed to adequately support student learning. It is clear that by integrating the STEM learning environment with technology-supported content and career awareness, such as is evident in the CCERS Project, students gain self-confidence in their ability to succeed. Self-esteem can serve as a motivator for academic engagement (Lim &Lee, 2017). Students' trajectory through the STEM pipeline – pre-K through career pathway – is impacted by several factors, such as instructional, motivational, and societal. Students' self-efficacy and interest in technology-based STEM matter can predict student participation in STEM-related careers (Han, Kelley & Knowles, 2021).

Empirical evidence gleaned from the work done in the Curriculum and Community Environmental Sciences Restoration project suggests that the project is successful in elevating all student self-efficacy in technology-based STEM education and more specifically, students identifying as underrepresented. Self-efficacy may be one of the more important variables for academic success, which is related to student engagement and persistence (Birney, et al). A limitation of this study is the ability to monitor student participants in their post-secondary educational and career pathways. Future studies in this area are suggested using the CCERS project as a model for increasing student motivation and self-efficacy. Building upon the confidence that has been instilled in the students through success with the CCERS STEM + Computer Science Project, increased social and community supports are encouraged to enhance academic engagement and maintain awareness of careers in the STEM disciplines.

Higher confidence in their technological abilities, as provided by the CCERS STEM + C Program, encourages communication and collaboration between the STEM instructors, scientists and students. This directly impacts the students' well-being and creates a non-threatening environment. Instructors and scientists are seen as mentors sharing content and skills in technology rather than the traditional top down instructional structure found in traditional settings. An increase in participating students' technological ability led to an increase in student self-efficacy. Enhanced self-efficacy contributes to student agency and the ability to develop ownership, purpose and engagement in STEM content. The findings of this study support the hypothesis that all students benefit from the technology enhanced CCERS STEM + Computer Science Program. Additional programs that incorporate the teaching methods and instructional tools used in this program are encouraged.

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Notes

Note 1. Multicollinearity – several interdependent variables in a model

Note 2. Bootstrap – Bootstrap is a method of deriving robust estimates of standard errors and confidence intervals for estimates such as the mean, median, proportion, odds ratio, correlation coefficient or regression coefficient. It may also be used for constructing hypothesis tests.

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