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Using STEM Camps to Improve Female Interest in Technology Careers

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Abstract

Science, technology, engineering, and math (STEM) fields have been traditionally entered by men, often establishing women as underrepresented in many of these fields. This research study focuses on participants at a STEM camp for middle- and high-school girls designed to introduce them to technology. The camp was held 4 times over 3 years, with many of the participants from rural areas, underrepresented by race and economic status. Sixty camp attendees completed pre- and post-camp surveys and are referred to as the intervention group. A control group of 200 middle- and high-school girls who did not attend the camp also took the survey. This paper focuses on a subset of the survey results that sought to determine the impact on camp participants in the areas of technology self-efficacy and technology career interest as it related to management information systems (MIS). Analysis of the data collected found a significant difference in MIS self-efficacy between the intervention group and control group but no significant difference in choices of MIS-related careers. Results also include recommended improvements to STEM camp design.

Key words: STEM, technology STEM camp, STEM fields, technology gender gap, management information systems



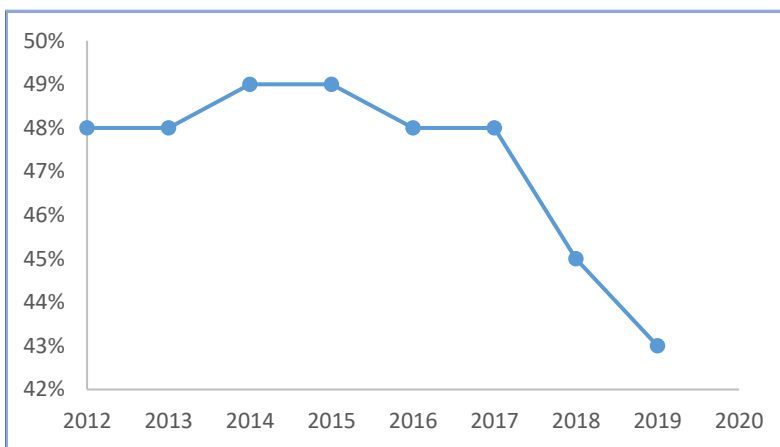
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Introduction

Traditionally, science, technology, engineering, and math (STEM) fields have been entered by men. As of 2018, women earn 53 percent of STEM college degrees but only 22 and 18 percent, respectively, in engineering and computer science (Fry et al., 2021). As recently as April 2021, the Pew Research Center reported that women remain underrepresented in job clusters of physical sciences, computing, and engineering. The Pew report also stated that “while women now earn a majority of all undergraduate and advanced degrees, they remain a small share of degree earners in fields like engineering and computer science—areas where they are significantly underrepresented in the work force” (Fry et al., 2021, p.2).

Reports by the National ACT Condition of College and Career Readiness (CCCR) indicate stagnation followed by a decline in interest in STEM fields among high school students of both sexes in the United States for several years (ACT, Inc., 2013). The pattern, in terms of percentages as shown in Figure 1, is an alarming issue due to the increasing need for technical skills across many industries (ACT, Inc., 2014a, 2014b, 2015, 2016, 2018a, 2018b, 2019). The ACT report on the state of STEM Education showed additional results which reinforce the need for improvements.

Figure 1. High School Student STEM Interest From ACT CCCR Reports



In order to investigate and possibly alleviate this trend, researchers from East Carolina University (ECU) in Greenville, North Carolina undertook a multi-year project consisting of STEM interventions in the form of summer camps for middle- and high-school girls designed to introduce them to technology. The camp was held four times over 3 years starting in 2017, with many of the participants from rural areas and underrepresented by race and economic status.

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Sixty camp attendees completed pre- and post-camp surveys and are referred to as the intervention group within this research paper. A control group of 200 middle- and high-school girls who did not attend the camp also took the survey.

There were three goals in this project, each focused on enhancing STEM initiatives in Eastern North Carolina (ENC). The first goal was to advance technology education in ENC counties where this type of educational experience seemed to be lacking. Many of these counties are considered rural with low economic rankings. This can cause the residents of these areas to be underrepresented and underserved in technology fields due to their economic status, race, and/or gender. They are also underserved in their access to technology as evidenced by many recent efforts to improve broadband internet connection in these types of locations. The second goal had a more long-term aim to address the critical need for females to enter career paths in underrepresented technology-related fields. The final goal was to pique their interest in attending college by hosting the camp on a college campus and introduce these youths to technology-related college degrees.

Summer camps have traditionally been a way to get students engaged in areas that they may not otherwise experience. The concept presented in this paper provided a chance for middle- and high-school females to experience the excitement in STEM-related fields during the summer, learning from other female practitioners along with creating an interest in and a pathway through college into STEM professions. The research results presented herein focus on a subset of the data collected from camp surveys and as related specifically to management information systems (MIS).

As a college curriculum, MIS combines business with technology courses and these types of careers help businesses find technical solutions to problems, some of which are societal. Dr. Libeskind-Hadas indicated "female students tended to think more about their careers in terms of social relevance and how their work could help the world" (Xia, 2017, p. 2). The importance of this research is to identify value for youth attending technology camps, and insights on best practices and improvements to help make the experience more effective.

Literature Review

A 2016 study, *Cracking the Gender Code*, on females in technology fields (Accenture & Girls Who Code, 2016) stated that, "the number of women in the US computing workforce will drop from 24% to 22% by 2025 if tech leaders and others don't intervene" (DeNisco, 2016, p.1). The report also found increasing the number of females in computer science careers cannot be

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accomplished by exposure alone (Accenture & Girls Who Code, 2016) and stressed the urgency of these issues stating, "that means we need to act urgently if we are to reverse today's alarming trends" (Accenture & Girls who Code, 2016, p.3). A 2017 report states "It's difficult to admit, but the United States is a STEM-deficient nation" (ACT, Inc., 2018-b, p.3). One of the primary findings shows stagnation in interest and achievement in STEM fields in the United States for the past 8 years (ACT, Inc, 2018-b).

Literature also indicates "introduction to STEM" interventions are an essential tool to attract, increase interest, and bring awareness to related careers for youth. Active hands-on learning and laboratory experience help enhance interest in STEM majors (President's Council of Advisors on Science and Technology, 2012). More specifically, researchers have found hands-on learning and early introduction can help females develop more confidence with technology by increasing their computer experiences (He & Freeman, 2010). STEM-based literature finds several programs for students have been initiated to increase access and exposure to hands-on learning. Research by Whittington and Garst (2018) indicated self-efficacy was one of the three skills reported most frequently as having been impacted by camp participation.

There is an additional need for exposure for underserved and underrepresented minorities and students. A PEW research report noted that "Black and Hispanic adults are underrepresented among STEM college graduates compared with their share in the population, and a smaller share are earning degrees in a STEM field than in other degree programs" (Fry et al., 2021, p.6). As of 2018, African American students earn only 7% of STEM bachelor's degrees and Hispanic students only 12%, both lower than the overall 15% of all college graduates (Fry et al., 2021).

Finding #5 in the ACT (2018-a) CCCR report defines underserved populations using a three-pronged definition: (a) those with lack of access to high-quality educational and career planning resources, (b) those who are a minority and first-generation college student, and/or (c) those coming from a low-income family. This finding indicates that these types of students were at a huge disadvantage stating, "Underserved learners lag far behind their peers in the area of STEM preparedness" (p.11). Finding #6 states that the proportion of students taking the ACT-test students expressing an interest in STEM was about the same across genders, with 47% of female and 50% of male graduates showing interest. The problem appears to be in the ability of female students to pursue these careers: "We continue to see females fall behind males in STEM-related attainment" (ACT, 2018-a, p.13).

On-Campus STEM-Camp Design and Development

Cracking the Gender Code (Xia, 2017) served as a roadmap for putting the research into practice by suggesting the need to spark the interest of girls in junior high school, then sustaining that interest through high school and into college. The three-stage approach is to (a) deepen girls' hands-on computing experience, (b) change girls' perceptions of computing, and (c) support parents and teachers in understanding the wider role of computing. Table 1 summarizes details of some related camps, each open to both males and females, using pre and post surveys. A consistent theme shows the camps generally improve the interest level of the participants in STEM and should be designed to provide hands-on activities and an environment to reinforce learning through practice (Ucguil & Cagiltay, 2014). Note that only two organizations were identified that host events specifically for girls, [Girls Who Code](#) and [Black Girls Code](#), neither of which had relevant published data for this research.

Table 1. Comparison of STEM Camp Studies

Camp host	Duration	Grades	Campers	Results	Research focus
UNC Charlotte (Binns et al., 2016)	4-week summer camp	High school	67	Positive impact	Student attitudes and interest in career areas before and after a summer camp
Texas A&M University (Naizer et al., 2014)	2-week summer camp	Middle school	66	Positive impact	Measure participants' interest in, aptitude for, and enjoyment of STEM and other academic areas.
University of Oklahoma (Dubriwny et al., 2016)	Longitudinal study	Middle school	158	Partially positive impact	Correlations between self- efficacy, attitudes toward STEM, perceived impact, and skill attainment.
Colorado State University (Dillivan & Dillivan, 2014)	3-day summer camp	Middle school	14	Positive impact	Inquiry-based activities vs. non-inquiry-based activities.

The STEM camp and associated research at ECU was developed as an engaged scholarship outreach project for young females. The original community partner was the local public-school administrator in Pitt County for STEM programs. The value of the community partners included their insights on how to recruit the participants and the type of activities students might be

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interested in. They also helped us understand prior STEM experiences offered to the campers. Most importantly, community partners helped with planning by meeting with the researchers monthly for the 6 months prior and participating in and/or observing camp activities. A memorandum of understanding (MOU) was created to guide the relationship and research expectations.

Two middle schools and two high schools were selected out of a total of six middle schools and six high schools in the county. The camp was free because cost would be a barrier to most students. Recruitment involved one of the researchers and school STEM coordinators, who helped recruit students and assisted them with applying. The type of student recruited was guided by the expression, "reach for the middle," by including students who otherwise might be overlooked; that is, not top students and not low, at-risk students.

Camp Overview

The camp has been held four times since 2017, each run by the researchers and assisted by university students who helped with each of the sessions. Camp sessions were held in a dedicated computer lab at the university with a planned curriculum that included hands-on activities. Camp participants were led through step-by-step development of websites using *Webstarts* software (WebStarts, n.d.). Students were also taught to code using the ALICE 3D coding language (Carnegie Mellon University, n.d.). Other sessions focused on collaborating in teams to develop and present a project. Students were placed in small groups where they used their new knowledge to design and create a final project: a website or an Alice skit on a topic of their choosing. A closing ceremony included final project presentations given by the campers and judged by female volunteers who worked in the technology industry. At the conclusion of each camp, a lessons-learned session was held with camp staff to determine any necessary adjustments to the camp.

Camp 1 – November 2017

The first camp was non-residential, held in November 2017 on two Fridays and a Saturday, for Pitt County school students with funding from a small grant. It was hosted by three MIS department faculty and three student assistants. Participants were accompanied by their school's STEM coordinator. At the closing ceremony, camp participants presented their completed group projects to friends and family. Grant funding was used to purchase the Qualtrics survey panel after this first camp.

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Camp 2 – July 2018

The second camp was held in 2018 from July 15-20 as a residential summer camp in conjunction with university faculty in the Department of Technology Systems. Funding was from a large grant given by a local utility company. Participants were transported by their families (some as far as 3 hours away) to the university dorms on the Sunday before the camp began and picked up on Friday afternoon after attending the closing ceremony. Recruitment for students was expanded through new community partners in six surrounding ENC counties: Beaufort, Greene, Jones, Lenoir, Pitt, and Robeson. The biggest change was the addition of a middle-school teacher from each of the six counties to be included in activities alongside their students. All students and teachers stayed in dorm rooms. Activities were upgraded to build and program a robot using a Raspberry Pi kit (which they took home), watch a 3D-printing demonstration, and take a field trip to tour a major networking company. Website development and Alice 3D coding sessions were still included.

Camps 3 and 4 – July 2019

The third and fourth camps were held in 2019 with two different groups of participants at two 1-week non-residential summer sessions from July 8-12 and July 22-26. These were hosted by the MIS department and included only students as participants. A new community partner, the head of programming for the Boys and Girls club in this region, was brought in to help and an MOU was created for this partnership. The change in the community partner was due to issues related to recruiting students from public schools in the summer, logistics, and funding for transportation.

The core curriculum again included website development and Alice 3D coding. "Project Management for Kids" to help students plan their projects was taught by a professional project management trainer who volunteered his time. New collaborations with other university departments provided hands-on sessions through a geographic information system (GIS) demonstration at the geography department along with an augmented reality sand table demonstration at the geology department. Both activities showed students that technology can be used in many industries. The 3D printing demonstration and campus tour were still included. A new field trip was introduced, a visit to the University Operations facility where several female employees talked about their careers; topics ranged from networking to coding. A change to final presentations had students present their topic in a poster session. This method was much preferred by all and allowed the judges to view each poster, interact one-on-one with students, ask questions about their project, and provide written critiques.

Method

Instrument

All camps used survey questionnaires as the research vehicle. The researchers created pre and post surveys using the Student Attitudes Toward STEM (S-STEM) survey from the Friday Institute as a guide (Friday Institute for Educational Innovation, 2012). Survey questions asked about the students' self-efficacy in computer science, MIS, and 21st century learning (i.e., collaboration with a diverse population.) Other questions inquired about their interest in various STEM fields as future majors or careers, as well as their plans for taking STEM courses in high school.

For all camps, the pre-camp survey was administered electronically on the first day before any training was given. The post-camp survey was administered electronically on the morning of the last day before the final presentations. A second survey was created for participants' parent or guardian to determine their attitude towards being supportive if their child pursued a STEM career. Unfortunately, a low response rate resulted in insufficient data to analyze. Evaluation surveys were used to get feedback on the sessions but were not used every year, so comparisons were not possible.

Sample

Camp participants were all females in Grades 6, 7, 8 and 9 from rural areas with underserved/ underrepresented populations in seven ENC counties: Beaufort, Greene, Jones, Lenoir, Martin, Pitt, and Robeson. The participants formed a racially diverse group. The economic condition of these counties is indicated in Table 2 by their tier designation ranking: 1, 2, or 3, where Tier 1 is the most distressed and Tier 3 the least distressed (North Carolina Department of Commerce, 2019). Demographic data for each county is also included in Table 2 (U.S. Census Bureau, 2010; North Carolina Department of Commerce, 2019). The ENC sample population demonstrated a much higher percentage of White students than U.S. averages along with a lower percentage living in poverty. The high school graduation rate and number of diplomas was comparable.

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Table 2. 2010 Participating County Demographics

County	Tier	Black	White	Hispanic	In poverty	High school graduation rate	Median income	No high school diploma	Attended some college	Bachelor's degree or higher
Beaufort	1	26%	69%	7%	24.8%	79%	\$41,431	15.4%	40.4%	3.1%
Greene	1	36%	52%	15%	26.5%	87%	\$39,738	24.9%	38.2%	3.2%
Jones	1	31%	64%	4%	23.0%	81%	\$38,873	18.5%	48.2%	2.5%
Lenoir	1	41%	54%	7%	29.2%	78%	\$39,341	19.7%	34.8%	2.6%
Martin	1	4%	90%	6%	30.5%	76%	\$35,561	16.3%	41.0%	2.9%
Pitt	2	34%	59%	6%	23.5%	78%	\$45,918	11.2%	58.5%	9.7%
Robeson	1	24%		8%	37.8%	76%	\$34,439	23.6%	32.1%	3.5%
NC Average		22%	71%	9%	24.8%	87%	\$50,595	15.4%		

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The participant count for the ECU camps was 18 in 2017, 17 in 2018, 15 in Week 1 of 2019, and 16 in Week 2 of 2019 for a total of 60 students and six teachers. A Qualtrics survey panel of 200 parent–daughter pairs (females in grades 7 through 12) who did not attend the camp was purchased in February 2017. This was the control group, and they were given the same student and parent surveys as the intervention group.

Results

Multiple linear regression analyses were conducted to determine if there were differences between the control and intervention groups in self-efficacy and career choice while controlling for age, which ranged from 10 to 15 years old. The dependent variables were the mean of four questions about the comfort level (self-efficacy) of the respondents with their abilities in MIS-related work and the mean of five questions about MIS career choices of the respondents.

The research combined all data collected for each of the four camps into a single “intervention group” for analysis. Analysis focused on a subset of survey questions: a series of statements related to MIS rated on a 5-point Likert scale by campers. The statements mainly related to two outcomes: (a) self-efficacy with MIS-related abilities and (b) interest in MIS-related careers.

The multiple linear regression results in Table 3 show that, in general, the independent variables of group (intervention and control) and age jointly predicted self-efficacy, $F(2,26) = 3.83$, $p = .02$. The adjusted R^2 was 0.02, which indicates that about 2% variance of self-efficacy is explained by group and age. There was a significant difference between the two groups in self-efficacy as shown in Table 3 while controlling age ($b = 0.28$, $p = .02$). The students in the intervention group had higher self-efficacy than those in the control group. The mean for self-efficacy was 3.34 ($SE < 0.01$) for the control group and 3.62 ($SE < 0.01$) for the intervention group. The multiple linear regression results for careers in Table 3 show that, in general, group and age jointly did not significantly predict future careers, $F(2,26) = 0.042$, $p = 0.959$. The analysis produced an adjusted R^2 of -0.00, which indicates that less than 1% variance of potential careers in MIS is explained by group and age. There was not a significant difference between the two groups in careers as shown in Table 3 while controlling age ($b = -0.04$, $p = .774$). The students in the intervention group did not exhibit more potential career choices in MIS than those in the control group. Means for self-efficacy were 3.34 ($SE < .01$) for the control group and 3.62 ($SE < .01$) for the intervention group.

Examples of some self-efficacy and career questions from the survey are shown in Table 4, with means calculated for pre-camp, post-camp, and the control group. The MIS self-efficacy mean

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participants after participating in the camp was better than that of control group survey respondents by 0.36 (sure of myself) and 0.65 (know I can do well). While not statistically significant, it did move the frame of reference from neutral to closer to "Agree." The intervention's impact on MIS careers was virtually unchanged and essentially equivalent to the control group. This was most likely due to the age of the participants and little exposure to professional career options up to this point. The researchers believe longer term student reflection is needed but the intervention will at least have served as a baseline data point for future experience and career consideration.

Table 3. Linear Regression MIS Self-Efficacy and Careers Between Groups (Controlling for Age)

Measures	Self-efficacy					Career				
	<i>b</i>	<i>SE</i>	β	<i>p</i>	95% CI	<i>b</i>	<i>SE</i>	β	<i>p</i>	95% CI
Age	0.005	0.033	0.011	.874	-0.060	-0.007	0.043	-0.013	.862	-0.091
Control vs. intervention or group	0.282	0.116	0.175	.016	0.053	-0.043	0.150	-0.021	.774	-0.339
	$R^2 = 0.02$					$R^2 < .01$				

Table 4. Student Attitudes Toward MIS Self-Efficacy and Careers Pre-Camp, Post-Camp, and Control

	Pre-camp		Post-camp		Change ^a	Control		Difference ^b
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>M</i>	<i>SD</i>	<i>M</i>
MIS self-efficacy								
I am sure of myself when I do MIS.	3.52	0.90	3.90	0.92	0.38	3.54	0.99	0.36
I know I can do well in MIS.	3.86	0.81	4.10	0.83	0.24	3.45	1.03	0.65
MIS careers								
I would consider a career in MIS.	3.60	0.95	3.54	1.16	(0.06)	3.54	1.03	0.00
I will need MIS for my future work.	3.55	0.79	3.45	1.08	(0.10)	3.57	0.96	(0.12)

Note. Statements were rated on a 5-point Likert scale: 1 (*Strongly disagree*) to 5 (*Strongly agree*).

^a Post-camp mean minus pre-camp mean.

^b Difference between the intervention group's post-camp mean and the control group mean.

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Evaluation surveys were helpful in determining which sessions the campers enjoyed the most. The favorites in order of preference were Webstarts (web development), Alice coding, 3D printing, data center tour, sand table and the GIS demonstration.

Discussion

The results from the linear regression analysis show MIS self-efficacy of participants after participating in the camp was higher than that of control group survey respondents.

Researchers believe this is due in part to the activities students experienced during the camp.

Although not identical, these results are similar to those of the Fab Lab Tulsa longitudinal study in which survey results showed an increase in self-efficacy from pre- to post-program, giving support to the possibility that participating in a STEM camp can improve technology-related self-efficacy (Dubriwny et al., 2016).

Camp staff observations showed some participants were surprised by what they were able to accomplish. Students were genuinely excited when creating their websites. While creating the 3D animations, staff were delighted by how quickly many students learned. Several groups were not satisfied with the basics taught in camp and asked how to create more advanced movements in the animation. Final group projects were remarkable as noted by invited judges and provided additional proof of the knowledge gained during the camp.

Qualitative data from the session evaluations include the following student comments:

- "I like how at first it was a real challenge but now it actually seems easy."
- "I wish we had more time to play around with the different things with our websites."
- "It was really fun making the website and getting to experiment with different things."
- "My favorite thing to do in the workshop was to do the animation and to dress up my people the way I wanted and a different way from their hair and their skin color and the most important was to be able to learn something new."
- "We were able to work in groups and come up with ideas together."
- "My favorite thing was to see how the butterfly printed in the 3D printer. My second favorite thing was to use the 3D pens."

The results from the post-camp linear regression analysis showed interest in MIS careers was not significantly different from that of control group survey respondents. It showed the possibility that participants did not want to work in technology-related fields or could not see

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themselves working in technology related fields. This result mirrored the Fab Lab Tulsa study that did not find a statistically significant change in attitude after their camp (Dubriwny et al., 2016). This suggested several possibilities, including that a single camp is not sufficient to impact interest and further study is needed. Additionally, the results seem to indicate there was not strong agreement in the intervention group or the control group that this type of work would be important in their future. This was unexpected but does tie back to the findings in the *Cracking the Gender Code* report that suggested the key to improvement was in sustaining commitment to spark interest throughout high school (Accenture & Girls Who Code, 2016).

A planned modification for the 2022 camp and beyond will incorporate additional demographic data in a new survey to delve deeper into this and begin data collection to allow pattern-centered analysis in the future. Further, a second post-camp survey at least 1 week after the conclusion of the STEM camp but before they leave their summer camp with our partnering organization(s) will be added.

In conclusion, the purpose of this research was to identify the value for female youth attending a technology camp and is based on four technology STEM camps for girls held during 2017 to 2019. The focus was on technology self-efficacy and technology career interest generated through camps for middle and high school girls. Overall, the project met its goals for the participants and the enthusiasm of the campers supported the value of hands-on activities. Further, the results established a methodology for future camps. While the results validate there is value in a STEM camp for youth participants, it demonstrates future research is needed to understand what types of continuous reinforcement or intervention is needed. The researchers are excited that the end of pandemic restrictions will allow follow up. This will involve repeating the camp, adjusting where needed, and analyzing additional survey data.

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