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Girls In STEM

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GIRLS IN STEM

by

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Carrie Leopold
July 20, 2021

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To my children Nicholas, Amy, Isaac, Lydia, and Stacy.

You can do anything you put your mind to!

I love you!

ABSTRACT

The recruitment and retention of women in STEM have historically been a struggle. Several causes, such as social factors, stereotypes, and classroom environments, all play a role (Blackburn, 2017). Recruitment efforts are often focused on middle school students. Nevertheless, research shows that children as young as kindergarten already have a preconceived notion about math (Ceci et al., 2014), such as it is too difficult or girls are not 'smart enough' to be successful. By the time some of these girls enter middle school, it can be challenging to change their mindset. Therefore, we need to focus not only on the causes of the under-representation of women in STEM careers but also solutions to recruitment and retention of women in these careers. Although there are many reasons for pursuing STEM, such as building compassion, empathy, and developing different perspectives (Zeidlet et al., 2016), this body of research focuses mainly on STEM careers.

The first paper in this body of work addresses the effectiveness of intervention programs within schools determined by an increase in female's interest in taking math courses, math GPA scores, and self-efficacy. The second paper describes the GUESS (Girls Understanding and Exploring STEM Stuff) project and measures this specific intervention program's effectiveness on females' interest in STEM. The final paper looks at the GUESS project as a model and measures the effectiveness of this model in a nontraditional setting, welding.

Introduction and Statement of Problem

The recruitment and retention of women in STEM have historically been a struggle. Several causes, such as social factors, poor advising, and classroom environments, play a role (Blackburn, 2017). Recruitment efforts are often focused on middle school students. However, research shows that children as young as kindergarten already have a preconceived notion about math (Ceci et al., 2014). They may feel it is too complicated, or girls are not 'smart enough' to succeed. By the time some of these girls enter middle school, it can be challenging to change their mindset. Therefore, we need to focus not only on the causes of the under-representation of women in STEM careers but also solutions to recruitment and retention of women in these careers. Although there are many reasons for pursuing STEM, such as building compassion, empathy, and developing different perspectives (Zeidlet et al, 2016), this body of research focuses mainly on STEM careers.

The Underrepresentation of Women in STEM Careers:

The underrepresentation of women in nontraditional careers in STEM (Science, Technology, Math, and Engineering) is a well-known and documented societal problem. According to the National Girls Collaborative Project (Foster, 2011), women make up approximately 53% of biological scientists, 31% of physicians, 33% of chemists, and only 29% of geoscientists. Women also account for only 10% of civil engineers, 8% of electrical engineers, and 10% of aerospace engineers (Foster, 2011). In addition, only 6% of the workforce in the welding industry consists of women (WITC, 2012). Although the reasons for this are still in debate, some conclude it is driven by family values (Bhanot and Jovanovic, 2005), gendered socialization (Reinking and Martin, 2018), stereotypes, or a "chilly climate," which includes lack of encouragement, diminishing remarks, and even sexual harassment (Rolin, 2008).

Purpose of Research

The purpose of this research is to identify the effectiveness of intervention programs on females' interest in pursuing a STEM career or a nontraditional career. The first paper explores the effectiveness of having an intervention program in the school; the second paper explores a model of an intervention program (the GUESS model) for teen girls at a community college. Finally, the third paper explores the effectiveness of the GUESS (Girls Understanding and Exploring STEM Stuff) model in a different setting (welding instead of a general science) to measure the effectiveness of the GUESS model as an intervention program for a nontraditional technical education field. Together, the three papers represent a body of research that dives more deeply into the issues surrounding gender inequities in STEM fields and a possible solution to increasing the number of females represented in these nontraditional careers. There are many reasons that researchers have explored why this phenomenon is happening, but few with answers to the question of what we do about it. Currently, there are many missed opportunities for fantastic career options for women, and having these fields impacted by the different thinking that women bring to various problems. These three papers together focus on a possible solution or recruitment model - within a school setting and outside of a traditional school setting.

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Research Paper #1

Effectiveness of Intervention Programs in Schools on Females' Interest in Pursuing a STEM Career

Target Journal: International Journal of STEM Education

Introduction

According to the National Science Foundation, 41% of college freshmen men planned to major in a science or engineering field. In comparison, just 30% of their female peers planned to major in a science or engineering field (National Science Foundation's Women, Minorities, and Persons with Disabilities in Science and Engineering Report, 2012). However, there is an even more significant gap when transferring the earned degrees to the actual workplace. For example, in 2019, only 13% of engineers were women (Rincon, 2019). Therefore, many researchers ask the question, why is there such a gap? Several theories help explain this question, including gendered socialization, stereotypes, and peer groups; however, few explore solutions to this problem. In this study, we take a deeper look into the reasons why there is a gender gap and then measure the effectiveness of intervention programs within the school setting on interest in taking a math course, math GPA scores, and self-efficacy, all of which are indicators of the effectiveness of such intervention programs.

According to Wong and Wong (2019), interest is defined as “students’ affective state of being engaged in mathematics learning whereby students enjoy the learning process". Interest and learning are significantly correlated, as demonstrated by a study of 511 secondary students by Kpolovie, Joe and Okoto (2014). When students enjoy what they are learning, they are much more likely to do well. A student's interest in learning a subject such as math is a predictor of future course achievement and success (Heinze et al., 2005).

Literature Review

Gendered Socialization

We have all heard the saying 'boys will be boys,' or 'little girls are made of sugar and spice'. Gendered socialization is the theory that boys are girls are brought up differently based on their gender. Gender roles such as beliefs and attitudes are encouraged or expected from parents or society depending on a person's gender. These socialization practices show up early or even from birth (Reinking and Martin, 2018).

Social role theory describes the pressure that a female or male feels to act within a given social role and the discomfort they may feel when they do not follow the norm. However, social role theory also acknowledges that these roles are flexible and that as more women move into a nontraditional role, they will become more comfortable (Diekman & Goodfriend, 2006). Social cognitive career theory (SCCT), as explained by Lent, Brown & Hackett (1994), describes career development as one's "personal inputs". These inputs start with an individual's personal experiences and the environment, as well as gender and ethnicity. Parental advice and media messages, along with other learning opportunities, build a person's self-efficacy or the extent to which an individual believes they can achieve a goal. Social roles intersect with career goals when women feel they are expected to play out a particular role in society, and that role does not match up to a particular career goal. However, encouragement (for example, through mentoring or other intervention programs) can influence career goals. (Lent, Brown & Hackett, 1994).

Despite women making up almost half of the U.S. workforce, only 27% of women make up the STEM workforce. This has increased dramatically over the past 50 years (up from 8%), but women are choosing the social and biological sciences over computer science or engineering. Even though 48% of women make up the social sciences, social science only accounts for 3% of STEM fields, whereas computer and engineering occupations make up 80% of the job market (Martinex and Christnach, 2021).

The idea of gender roles relates directly to the STEM gender gap. Dasgupta and Stout (2014) found in their research that women are leaving the STEM field of study before they enter a STEM career because they are bombarded by negative stereotypes as well as socialized ideas that they are subpar, particularly in their math abilities. Males tend to be brought up being told they are naturally intelligent, whereas females are not (Cherya, Master & Melzoff, 2015). This is why providing experiences for girls that boost their confidence can profoundly impact their career choices (Allison & Cossette, 2007. In a study by Brown et al. (2016), it was determined that self-efficacy significantly predicted the perseverance to continue in STEM.

Children also grow up with gendered socialization within their family unit. Parents influence their children and motivation for pursuing STEM classes and interests (Partridge, Brustand, Stellino, 2008). Parents influence their children through activities they pursue, the toys they purchase, and the experiences they have together.

Stereotypes

Stereotypes about STEM fields can steer girls away from pursuing a career in one of those areas. For example, Cheryan, Master & Melzoff (2015) propose that the stereotypes surrounding a culture within a particular field, such as social isolation, the type of people within that culture, or perceived values of a particular field, can steer students away from a career. Social isolation, for example, is directly related to gender socialization theory in that females are generally brought up to be collaborative, caring, and socially interactive humans.

In a study by Selimbegovic, Karabegovic, Blazev, and Burusic (2019), they argue that there is an additional factor to take into consideration. Gender stereotype endorsement is how girls internalize said stereotype and can make women more vulnerable to stereotype threat. Stereotypes have been traditionally defined as task-oriented, but stereotype endorsement is task-oriented and competence beliefs. In an expectancy-value model used by Pnante, de la Sablonniere, Aronson, and Theoret (2013), they were able to show the relationship between stereotype endorsement and school achievement. When girls identify as someone who is not 'good at math', they score lower on math achievement exams. Intervention programs give girls the opportunity to overcome stereotypes and start self-identifying as a math or other STEM person. The math achievement scores in this study could be an indicator for stereotype endorsement, which could be holding back girls.

Peer Groups

Students often rely on their peers to help them decide what is acceptable or not acceptable within their culture of friends. Children (especially pubescent ones) want to feel accepted and liked by their peers. This can often lead to students making choices based on wanting to be a part of a group instead of what that student is genuinely interested in or even values. Children being accepted or rejected as part of a group is one of the most pivotal experiences students have during their school years (You, 2011). For example, if a group of peers believes a STEM class to be "cool", then students within that group are much more likely to pursue STEM classes. If, on the other hand, the group deems a STEM class to be "uncool", then that group of students is far less likely to pursue that class or a STEM track altogether (You, 2011).

Purpose of Study

For this study, a comparison between schools that have offered an intervention program for female youth to explore STEM fields will be compared to schools that did not. An intervention program could be any opportunity the school provides for girls to participate in learning about STEM careers, facilitating peer interactions around STEM topics, or combating stereotypes around women in STEM.

Method

Participants and Instrument

The data for this study came from the HSLS: 09 – High School Longitudinal Study of 2009 and from the National Center for Education Statistics (NCES) (Bozick & Ingels, 2008). In the fall of 2009, NCES launched the High School Longitudinal Study of 2009, which follows a cohort of more than 25,000 9th graders in the base year through their high school, postsecondary, and early career experiences, focusing on college decision-making and on math learning based on a new algebra assessment. Data are collected from students, administrators, math and science teachers, school counselors, parents, and administrative records. This study is under IRB approval by the University of North Dakota.

Design

We will compare female students (both white and nonwhite) who attended a school with an intervention program to female students (both white and nonwhite) who attended a school without an intervention program to measure the effectiveness of the intervention program on interest and math scores. Females with interest and/or have higher math scores have a higher likelihood of pursuing a STEM career. Analyzing the interest and math scores of both female students who attend schools with an intervention program and comparing those who attended a school without an intervention program in place will give us a glimpse into the effectiveness of the said program.

Research Question 1:

What is the effectiveness of a STEM intervention program in schools on high school females' interest in taking a math course?

Hypothesis:

A STEM intervention program will have a positive impact on females' interest in taking a math course.

Variables:

Independent Variables:

1. Label: School has a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
2. Label: School does not have a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
3. Label: X1 Student's sex
   Name: X1SEX

Dependent Variable:

1. Label: X2 Scale of student's interest in fall 2009 math course
   Name: X2MTHINT

Research Question 2:

What is the effectiveness of an intervention program in schools on high schools females of color interest in taking a math course?

Hypothesis:

A STEM intervention program will have a positive impact on females of color interest in taking a math course.

Variables:

Independent Variables:

1. Label: School has a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
2. Label: School does not have a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
3. Label: X1 Student's sex
   Name: X1SEX
4. Label: X1 Student's race/ethnicity-composite
   Name: X1RACE

Dependent Variable:

1. Label: X2 Scale of student's interest in fall 2009 math course
   Name: X2MTHINT

Research Question 3:

What is the effectiveness of an intervention program in schools on high school female's math GPA scores?

Hypothesis:

A STEM intervention program will have a positive impact on females' math GPA scores.

Variables:

Independent Variables:

1. Label: School has a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM

2. Label: School does not have a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
3. Label: X1 Student's sex
   Name: X1SEX

Dependent Variable:

1. Label: X3 GPA: mathematics
   Name: X3TGPAMAT

Research Question 4:

What is the effectiveness of an intervention program in schools on high schools females of color math GPA scores?

Hypothesis:

A STEM intervention program will have a positive impact on females of color math GPA scores.

Variables:

Independent Variables:

1. Label: School has a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
2. Label: School does not have a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
3. Label: X1 Student's sex
   Name: X1SEX
4. Label: X1 Student's race/ethnicity-composite
   Name: X1RACE

Dependent Variables:

1. Label: X3 GPA: mathematics
   Name: X3TGPAMAT

Research Question 5:

What is the effectiveness of an intervention program in schools on high school females' self-efficacy regarding math?

Hypothesis:

A STEM intervention program will have a positive impact on females' self-efficacy regarding math.

Variables:

Independent Variables:

1. Label: School has a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
2. Label: School does not have a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
3. Label: X1 Student's sex
   Name: X1SEX

Dependent Variable:

1. Label: X2 Scale of student's mathematics self-efficacy
   Name: X2MTHEFF

Research Question 6:

What is the effectiveness of an intervention program in schools on high schools females of color self-efficacy regarding math?

Hypothesis:

A STEM intervention program will have a positive impact on females of color self-efficacy regarding math.

Variables:

Independent Variables:

1. Label: School has a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
2. Label: School does not have a program to encourage underrepresented students in STEM
   Name: C2ENCSTEM
3. Label: X1 Student's sex
   Name: X1SEX
4. Label: X1 Student's race/ethnicity-composite
   Name: X1RACE

Dependent Variable:

1. Label: X2 Scale of student's mathematics self-efficacy
   Name: X2MTHEFF

Results:

The data for these research questions were pulled from the High School Longitudinal Study of 2009, which followed 25,000 students from across the nation through high school. Each of the variables looked at a subset of the 25,000 specific to the variables of the question. For example, there were 3457 females in the database with scores regarding interest in math courses, whereas 4198 females in the database had data specific to math GPA scores.

For the mean scores, the percent difference was calculated by adding the means together and dividing each x and y by the total. The formulas x/(x+y)*100 and y/(x+y)*100 were used to calculate the percentage, and then different was then calculated to determine the percent increase or change.

The box plots show the min, first and third quartiles, the median, and the max. The numbers are listed below the box plot for the median and first and third quartiles.

Research Question 1:

What is the effectiveness of an intervention program in schools on high school females' interest in taking a math course?

Table 1 shows the number of females, the t-test, degrees of freedom, p-value, confidence interval, and mean for the variables STEM intervention program and interest in taking a math course. These were derived from data from the HSLS: 09 – High School Longitudinal Study of 2009 database, and 3457 females were sampled. The p-value is high, >.05; however, the mean of x and y (schools with a STEM intervention program and schools without) is significant. Female students reported an 86% higher interest in taking a math class after attending a STEM intervention program at their school. This means there is no statistical significance, but there is practical significance.

Table 1

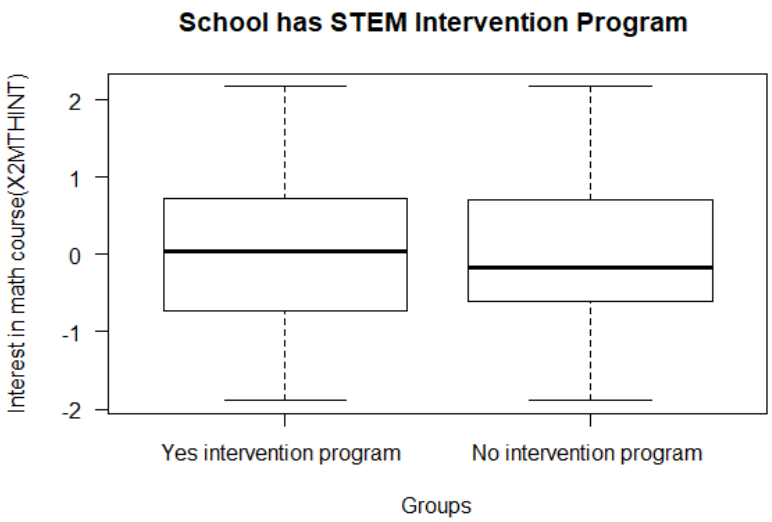
T-Test, confidence interval, and mean of interest in math course (n=3457)

# Females	3457		
Welch Two Sample t-test	t = 0.61805	df = 7169.1	p-value = 0.5366
95 percent confidence interval:	-0.03191676	0.06130954	
mean of x	0.0137460226		
mean of y	-0.0009503696		

Table 2 shows a box plot. It demonstrates an increase in females' interest in taking a math class based on the median interest scores. The quartiles and median scores are shown below the table.

Table 2

Box Plot of female's interest in math course



Intervention program - Q1: -0.73; Median: 0.04; Q3: 0.73

No Intervention program - Q1: -0.6; Median: -0.17; Q3: 0.71

Research Question 2:

What is the effectiveness of an intervention program in schools on high schools females of color interest in taking a math course?

Table 3 shows the breakdown of females of color sampled. There were 1617 sampled from seven different races.

Table 3

Females of color (n=1617)

# Females of color	1617		
Hispanic	524	Asian	340
Hispanic, no race specified	67	Amer. Indian/Alaska Native	27
Black/African-American	356	More than one race	291
Other	12		

Table 4 shows the results of the t-test, degrees of freedom, p-value, confidence interval and mean. This data is statistically significant with a p-value <0.05. The mean shows a 48% higher interest in taking a math course after participating in a STEM intervention program.

Table 4

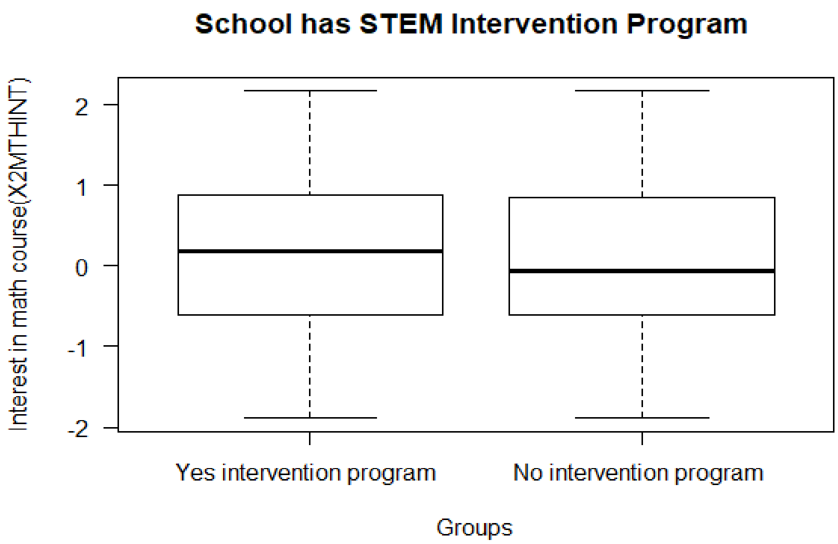
T-test, confidence interval and mean of females of color interest in taking math course

Welch Two Sample t-test	T= 2.4536	df = 2976.4	p-value = 0.0142
95 percent confidence interval:	0.01807534	0.16191388	
mean of x	0.1370439		
mean of y	0.0470493		

Table 5 shows a box plot. It demonstrates an increase in females of color interest in taking a math class based on the median interest scores. The median and first and third quartiles are listed below.

Table 5

Box Plot, females of color interest in taking math course



Intervention program - Q1: -0.6; Median: 0.19; Q3: 0.88

No Intervention program - Q1: -0.6; Median: -0.06; Q3: 0.84

Research Question 3:

What is the effectiveness of an intervention program in schools on high school female's math GPA scores?

Table 6 shows that there is a slight increase (2%) in math GPA reported by the mean of x and y. The p-value shows this test is statistically significant. However, a 2% increase is not practically significant.

Table 6

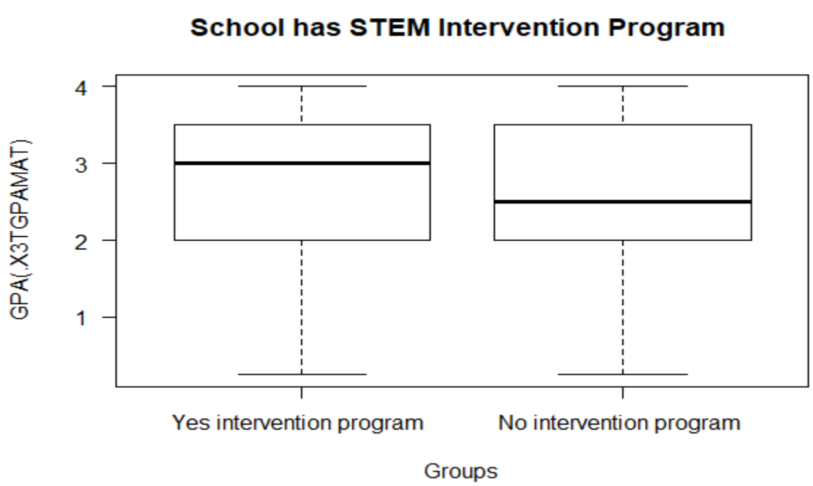
T-Test, degrees of freedom, p-value, mean (n=4198)

# Females	4198		
Welch Two Sample t-test	t = 5.6297	df = 8715.3	p-value <.001
95 percent confidence interval:	0.07196357	0.14885022	
mean of x	2.655964		
mean of y	2.545557		

Table 7 shows a box plot of the scores of math GPA. It shows a slight increase in median scores between females who participated in a STEM intervention program and those who did not. The median and first and third quartiles are listed below. This data is statically significant, but the change is not practically significant.

Table 7

Box Plot females math GPA scores



Intervention program - Q1: 2.0; Median: 3.0; Q3: 3.5

No Intervention program - Q1: 2.0 Median: 2.5; Q3: 3.5

Research Question 4:

What is the effectiveness of an intervention program in schools on high schools females of color math GPA scores?

Table 8 shows the total number of females sampled as well as the breakdown by race. There was 1975 total from 7 different races.

Table 8

Females of color (n=1975)

# Females of color	1975		
Hispanic	663	Asian	388
Hispanic, no race specified	86	Amer. Indian/Alaska Native	26
Black/African-American	448	More than one race	349
Other	15		

Table 9 shows a statistically significant t-test, degrees of freedom, and a p-value < 0.05. It also shows a slight decrease in the reported mean. The girls who did *not* participate in a STEM intervention program reported having a slightly higher (2%) math GPA. Although this is statistically significant data, it is not practically significant.

Table 9

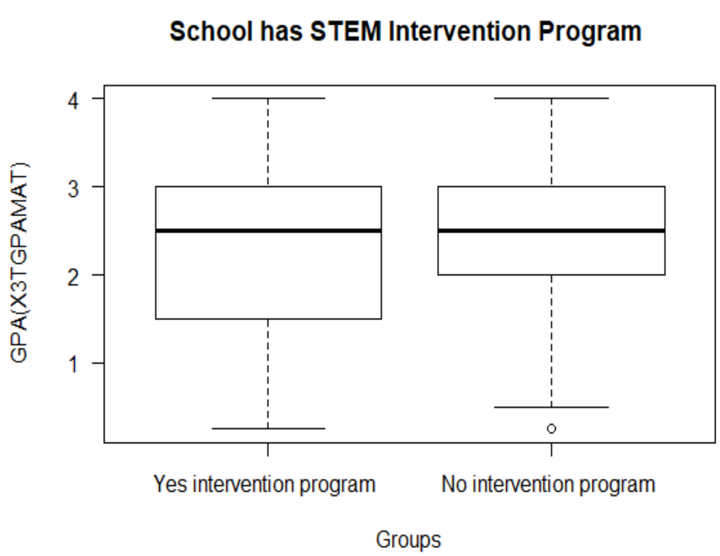
T-Test, df, p-value, mean females of color math GPA scores

Welch Two Sample t-test	t = -2.9419	df = 3626.9	p-value = 0.003283
95 percent confidence interval:	-0.1507255	-0.0301689	
mean of x	2.402025		
mean of y	2.492472		

Table 10 shows a box plot with median math GPA scores. The median and first and third quartiles are listed below. Although this data is statistically significant, there is no practical difference.

Table 10

Box Plot females of color and math GPA scores



Intervention program - Q1: 1.5 Median: 2.5; Q3: 3.0

No Intervention program - Q1: 2.0 Median: 2.5; Q3: 3.0

Research Question 5:

What is the effectiveness of a STEM intervention program in schools on high school females' self-efficacy regarding math?

Table 11 shows the number of females in the sample, t-test, degrees of freedom, and p-value, which is not statistically significant. The mean is slightly different but not practically significant, showing no actual effectiveness of a STEM intervention program in schools on female's self-efficacy.

Table 11

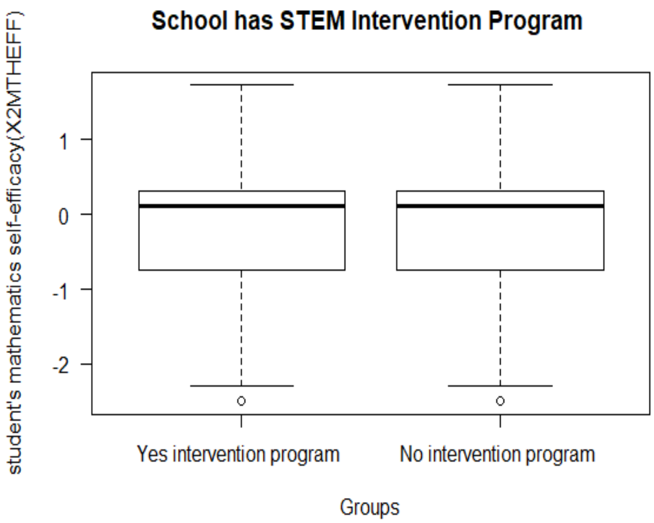
T-test, df, p-value, mean females self-efficacy (n=1975)

# Females	1975		
Welch Two Sample t-test	t = -1.3436	df = 8248.3	p-value = 0.179
95 percent confidence interval:	-0.073	0.014	
mean of x	-0.095		
mean of y	-0.065		

Table 12 shows a box plot of female's self-efficacy in math. The medians and first and third quartiles are listed below. There is no statistical or practical significance.

Table 12

Box Plot of female's self-efficacy



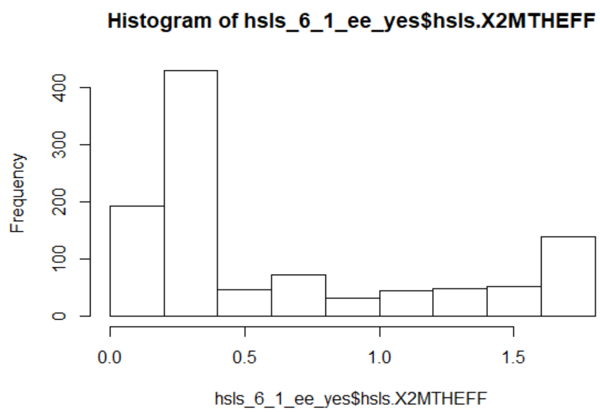
Intervention program - Q1: -0.74; Median: 0.11; Q3: 0.32

No Intervention program - Q1: -0.74; Median: 0.11; Q3: 0.32

Table 13 shows a positively skewed histogram of self-efficacy regarding female students who participated in a STEM intervention program. Although these results are small, they do show it helps some girls. Although the two previous tables show no statistical or practical significance, this histogram warrants some attention.

Table 13

Histogram of female student's self-efficacy



Research Question 6:

What is the effectiveness of a STEM intervention program in schools on high schools females of color self-efficacy regarding math?

Table 14 shows the number of female students in this sample and the various races included in this sample.

Table 14

Females of color (n=1056)

# Females of color	1056		
Hispanic	326	Asian	229
Hispanic, no race specified	40	Amer. Indian/Alaska Native	26
Black/African-American	253	More than one race	186
Other	8		

Table 15 shows the t-test, degrees of freedom, and statistically significant p-value (<.05), as well as the mean for female students of color who participated and did not participate in a STEM intervention program and their self-efficacy. This data shows a 100% increase in females of color self-efficacy in math after participating in a STEM intervention program. Self-efficacy is a measurement of confidence and a key indicator of future direction.

Table 15

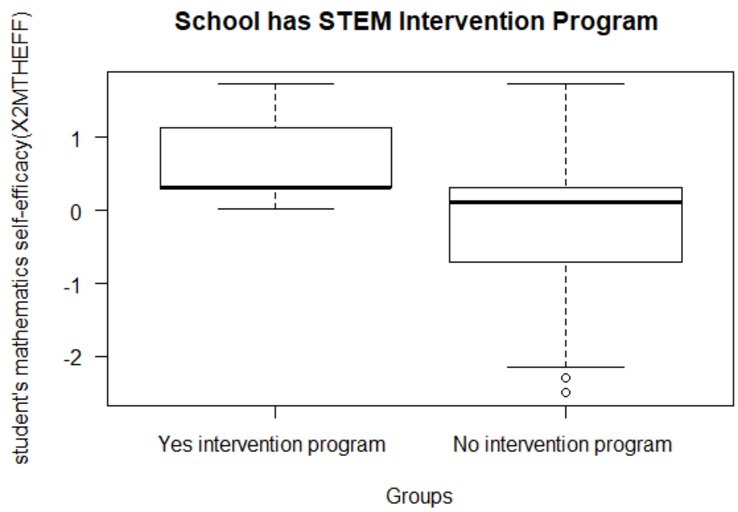
T-test, df, p-value, mean females of color self-efficacy

Welch Two Sample t-test	t = 22.669	df = 2661	p-value < .001
95 percent confidence interval:	0.621	0.739	
mean of x	0.659		
mean of y	-0.022		

Table 16 shows a box plot of self-efficacy medians and first and third quartiles (listed below). These results are statistically and practically significant.

Table 16

Box Plot females of color self-efficacy



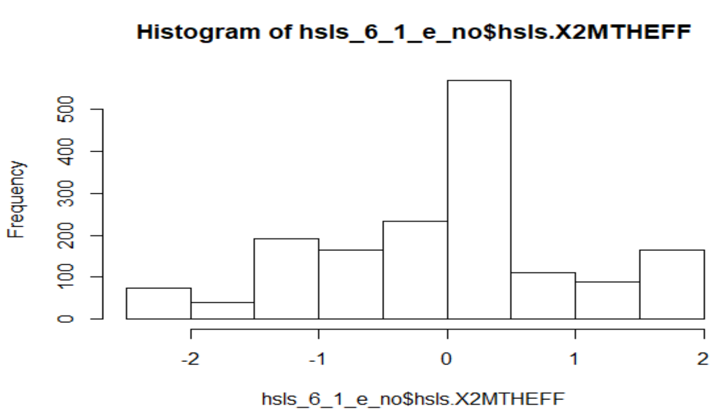
Intervention program - Q1: 0.32; Median: 0.32; Q3: 1.14

No Intervention program - Q1: -0.7; Median: 0.11; Q3: 0.32

Table 17 shows a histogram of females of color self-efficacy in math after attending a STEM intervention program. It is more evenly distributed than table 13.

Table 17

Histogram of females of color self-efficacy



Discussion:

The underrepresentation of women in STEM has been a long-standing problem. Many researchers have tried to answer the question of why this phenomenon exists. This paper took a deeper look into the reasons why such as gendered socialization, stereotypes, and peer groups. However, we also dove into the long-standing question of 'what do we do about it?

The research questions addressed the effectiveness of a STEM intervention program in schools on female students. We measured the effectiveness based on female student interest in taking a math class, math GPA, and self-efficacy. We also broke down the data to look at the effect on females of color.

For females who participated in a STEM intervention program, our hypothesis was there would be a positive impact on female student's interest in taking a math course, math GPA, and self-efficacy. Interest in taking a math course (Kpolovie et al., 2014), as well as self-efficacy in math (Brown et al., 2016), are crucial to motivating female students to explore mathematics. STEM intervention programs can overcome stereotypes and help female students to begin to identify as a STEM or math person.

The results of this study show some positive impacts of STEM intervention programs in schools on females. For interest, the results showed were not statistically significant. However, there was an 86% higher interest rate reported by means scores. Although the data is not statistically significant, it is practically significant. There is a positive impact reported in mean sores. When the data is broken down to look at females of color interest in taking a math course after participating in a STEM intervention program at their school, the data is statistically significant. There was also a 48% higher interest rate in those who participated in the intervention program over those who did not.

The results of the math GPA scores were statistically significant for both all females as well as females of color. However, the results showed no practical significance. There was a 2% increase in the mean score of females and a decrease in 2% when looking at females of color.

The results of the self-efficacy in math for females were not statistically significant and did not have any practical significance either. However, the histogram did show a positive skew. This may mean there the intervention program is helping some females. Overall, it may not have any practical significance.

The results of the self-efficacy in math for females of color were statistically significant and showed a 10% increase in the mean of females of color who participated in a STEM intervention program over those who didn't. The histogram showed a more evenly distributed distribution.

Overall, these results show that having a STEM intervention program within a school does have a positive impact on female students. Interest in taking a math course increases, and self-efficacy also shows a positive impact. Self-efficacy and interest are two significant factors in predicting future success in pursuing a STEM career (Blotnicky et al., 2018).

Conclusion:

STEM intervention programs in schools show promising results in increasing females' interest in taking a math course as well as female student's self-efficacy in math. These two attributes are vital in predicting future STEM participation. Although the self-efficacy construct was not statistically significant, there was a positive skew to the histogram. This shows there may be some benefit to some female participants. For women of color, this can be a turning point for their career choice. Schools with an intervention program showed a 10% increase in mean scores, and they were statistically significant! This is moving the needle in a positive way. With so few women in some STEM areas (engineering, for example), schools can implement an intervention program to help change the trajectory of women in these careers as well as their lives.

Implications for Practice:

This study shows the importance of STEM intervention programs in schools. With so many fantastic career opportunities for women, conquering stereotypes and helping these young women see themselves as scientists or mathematicians (or other STEM career areas) is vital to shaping America's workforce. This research shows a positive impact on female students participating in a STEM intervention program at their school. This is an opportunity for these young ladies to have an experience that conquers stereotypes, uses peer groups, and offers a chance at building confidence. Even if some of the participants do not go on to pursue a STEM career, they will still have impacted beliefs that can carry on for generations.

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Research Paper #2

Published: ATEA Journal

Leopold, C. J., & LeMire, S. D. (2014). A Model of Outreach to Increase Female Enrollment in Technical Education. *American Technical Education Association Journal. Fall/Winter, 41(*2*)*

The STEM Workforce Challenge

The United States is falling behind other developed nations in creating a technically skilled workforce for the 21st Century. In 2010, the National Academies ranked the United States 27th among developed nations in the number of college graduates with a degree in science or engineering. This has resulted in a shortage of qualified American scientists and engineers (Augustine, 2010). This discouraging trend derives from sluggish American student rankings in science and math. In a comparison study of 65 countries, the United States ranked 19rd in science and 24th in math (Fleischman, Hopstock, Pelczar, & Shelley, 2010). Improved student education in STEM (science, technology, engineering, and math) is crucial for developing and maintaining a technologically trained workforce.

Literature Review

The Underrepresentation of Women in STEM Careers

The underrepresentation of women in nontraditional careers in STEM (Science, Technology, Math, and Engineering) is a well-known and documented societal problem. According to the National Girls Collaborative Project (Foster, 2011), women make up approximately 53% of biological scientists, 31% of physicians, 33% of chemists, and only 29% of geoscientists. They also account for only 10% of civil engineers, 8% of electrical engineers, and 10% aerospace engineers (Foster, 2011). Only 6% of the workforce of the welding industry is women (WITC, 2012). Although the reasons for this is still in debate, some conclude it stems from family values (Bhanot and Jovanovic, 2005), to a “chilly climate” which includes lack of encouragement, diminishing remarks, and even sexual harassment (Rolin, 2008).

The Challenge of Promoting STEM to Students in Rural Areas

The National Research Center on Rural Education Support (NRCRES) identifies a number of issues that limit the ability to make progress in rural education, including retention of qualified teachers, student achievement and dropout rates, availability of and access to opportunities for advanced placement courses, and improvement in teacher quality through professional development (Meese & Farmer, 2012). Furthermore, NRCRES reports that more than 40% of all American schools are in rural areas and 30% of all students attend rural schools (Meese & Farmer 2012). In fact, a recent journal indicates that South Dakota and North Dakota rank first and third in the nation when calculating the number of schools located in rural communities, with 76.9% and 72.1%, respectively (Rural Policy Matter, 2010).

According to the Rural Development Research Report, there are also disparities across educational levels attained between metro (urban/suburban) and rural communities. There is an 11.5% gap between the number of adults that have obtained a college degree or have attended some college from urban/suburban versus rural communities (National Center for Educational Statistics, 2011). These statistics are even direr for the Native American students in these districts. Only 11% of Native Americans earn a college degree, compared to the total population, where the figure is 24 percent (Native American Public Telecommunications, 2006).

Theoretical Context for GUESS Project

Constructivist Theory of Learning: A central theme of constructivist theory is that students acquire knowledge through active learning rather than passive learning. Students are active participants, and the role of the teacher is of a facilitator rather than a lecturer. Students become engaged in their experience as well as have a feeling of ownership of their learning. Students learn to transform information, construct hypotheses and make decisions (Bruner, n.d.).

In classic Piagetian constructivist theory, students must be actively engaged in their learning in order to "restructure their cognitive maps" (Richardson, 1997). Most constructivists would agree that individuals create their own understandings based on prior knowledge. Traditional education does not promote interactions between prior knowledge and new knowledge, let alone the conversations needed for a deeper understanding. In order for students to reach this higher level of understanding, they need to be actively engaged in restructuring their prior knowledge. In a traditional classroom, the teacher may do this by encouraging an environment in which students undergo some cognitive dissonance which hopefully leads to some restructuring of their thoughts. This has often been translated to hands-on activities to engage students and challenge the concepts which make students begin to question and think deeply into a particular phenomenon. It has been recently thought that constructivists have allowed for social theories to come into play, suggesting that student's social interactions through collaborative projects can provide a source of cognitive dissonance, which provides students the opportunity to reconstruct their knowledge (Richardson, 1997).

Project-Based Learning: Project-based learning (PBL) goes beyond just hands-on activities. It is a way of bringing true meaning and relevance to student learning. According to Larmer and Mergendoller (2010), projects need to fulfill two criteria in order to be meaningful. First, students need to feel that their project is personally meaningful and the project has an educational purpose. They recommend seven essential elements for meaningful projects: A need to know (why they need to learn this material), a driving question (gives a student a sense of challenge), student voice and choice, 21st-century skills (collaborating, communicating, time and task organization), inquiry and innovation (as students answered questions, they raised other questions), feedback and revision (promotes high-quality products and that first attempts don't result in high quality), a publicly presented product (adds real-life meaning). Hands-on activities can be introduced to the classroom, and students may do a project with a poster, but it is really the process of getting to that poster, the project as a whole, which brings real meaning to learning (Larmer & Mergendoller, 2010).

Strategies for Recruiting Girls into STEM Careers: There are known strategies in order to engage girls in STEM. In fact, according to Allison and Cossette (2007) they outline elements of interventions that prove to be effective for boys as well as girls. They include creating a positive environment, building self-confidence, offering hands-on workshops, creating cooperative groups, applying practical applications of what they are learning, offering role models, family support, and mentoring.

Additionally, according to SciGirls (2010), there are seven common strategies that work, all of which support the current GUESS model. The SciGirls Seven strategies include: girls need to work collaboratively; girls are motivated by meaningful projects; girls are motivated by a hands-on, open-ended approach to learning; confidence increases with positive feedback; confidence increases when the girls are challenged to critically think through problems; and girls benefit from role models and mentors (SciGirls, 2010).

Research shows that girls often turn away from STEM education and careers in middle school, and that providing collaborative, hands-on learning experiences with an emphasis on practical applications and social good engages interest in STEM (Campbell, Jolly, Hoey & Perlman, 2002; Davis & Rosser, 1996). Programs that successfully engage girls often have standard features: hands-on experiences, real-world based problems, "girls-only" time, and professionals from the field are involved (GSA, 2008).

Strategies for Building Confidence: Self-efficacy consists of two components, confidence and the readiness to choose a career (Lent, Lopez, & Bieschke, 1991). Confidence can be referred to as the strength of certainty of one's beliefs (Bogue, 2007) while Lent, Lopez and Bieschke describe the readiness to choose a career stems from the beliefs in one's own abilities to be able to act on an action required to reach a specific goal. Confidence is critical in recruiting women into STEM fields. According to Allison and Cossette (2007), girls' confidence has to build before they will try something new where boys will try something new to build their confidence.

Purpose of Study

Based on proven practices such as the SciGirls Seven (SciGirls, 2010), NDSCS developed the GUESS model. The GUESS model includes: getting out of school and spending a "day at the lab", the girls are chosen by the schools, run by women mentors, large group activity to start the day, small groups, pink shirts give at the beginning which offers a feeling of togetherness and empowerment, social lunch, hands-on-projects, female-friendly activities, targets the 8th and 9th grade girls, and the local school instructor is present during the program

The GUESS project adapted parts of the SciGirls approach as the GUESS model was developed to address some of the concerns regarding women entering a STEM career. GUESS focuses on girls in the 8thand 9th grade and exposes them to the emerging technologies of STEM fields such as nanoscience, engineering, space science, welding, computer science, and nontraditional areas within the biomedical field through hands-on activities.

The goal of the GUESS project is to expose the girls to emerging technologies so participants gain a greater understanding and appreciation for careers in STEM fields. Many of the girls come to this experience with attitudes that science and math are 'hard' and often have a misconception of what a career looks like.

GUESS Project Model:

Schools are selected to participate, and each school in turn identifies the girls who will be invited to attend. This unique selection process results in participants who are traditionally known as 'high flyers', who may be at risk but display potential, and who have demonstrated an interest in STEM courses. The project addresses three priority groups identified as underrepresented by the National Science Foundation: rural, Native American and female.

The GUESS project is designed for girls to attend a 'day at the lab' facilitated by women professional mentors during their regular school day hours. Hosting the day during regular school hours rather than a traditional after school program offers the girls a feeling of importance and makes participation very appealing. When the girls arrive for their 'day at the lab,' they experience a very social and welcoming environment. The girls are greeted by the women mentors, and the day begins with a large group opening activity designed to break down any barriers and get conversations started early on. This is also an opportunity to discuss the negative aspect of attending a "science day." Many of the girls acquire the nicknames of geek or nerd from their peers and teachers because they have chosen to attend, but throughout the day the girls embrace such nicknames instilling confidence and the self-perception of 'smart.' By having this open conversation at the beginning, these issues are addressed and the girls develop a sense of pride in attending the day.

Lab activities are constructed where girls are divided into groups of four and begin rotating through the lab stations, which are all based on a particular focus such as nanotechnology or space science. During lunch, the girls are able to ask questions about STEM careers and about how to juggle careers and families. This offers insightful opportunities to talk one-on-one or in small groups about these issues. The lab activities continue after lunch, and the day ends with another large group activity and a question-and-answer session to provide any necessary information to the girls regarding their experience and future opportunities.

Knowing the growing need for women in this workforce, we decided to survey the female participants before and after they attended the GUESS day to measure the impact of this intervention program.

Research Question:

What impact does the GUESS project have on female participants?

Hypothesis:

The GUESS project has a positive impact on female participants, measured through an increase in knowledge, confidence, attitude, interest, perception of women engineers and career expectations and interests.

Methods

Participants

The study used a convenience sample of female participants from schools around North Dakota. 42 surveys were given out and 42 collected. 100% of the participants were female. 100% of them were 8^{th} or 9^{th} grade.

Instrument

The instrument was developed by the researchers for the study and consisted of 35 items. Level 2 constructs were created to align with specific goals of the GUESS project question, what impact does the GUESS project have on female participants. The constructs assessed an increase in knowledge, confidence, attitude, interest, perception of women engineers and career expectations and interests. Participants were asked to rate their agreement on a 6-point Likert scale with 6 = strongly agree, 5 = agree, 4 = slightly agree (all some form of agreement), 3 = slightly disagree, 2 = disagree, and 1 = strongly disagree (all some form of disagreement).

Procedure

The researcher gave a presurvey before girls participated in the GUESS day and a post-survey at the end of the GUESS day. They were told participation was voluntary and no compensation was given.

Results

Table 1 shows demographically 100% of the participants were females and 100% were 8th or 9th grade, which is the target group for this project.

Table 2 shows descriptive background information on participants. Over 90% of the participants state they enjoy their science class, over 50% consider themselves to be a 'geek', over 60% stated they have family members that enjoy science 'stuff', over 80% stated they have friends that enjoy science 'stuff', and there was in a positive increase of 23% of knowledge gained about career opportunities in STEM.

Table 3 shows the percent form of agreement for the pre and post surveys as well as the mean and standard deviation.

Table 4 shows a comparison between confidence, enjoyment, ability to succeed, perceptions of women engineers, expectations of job treatment, and confidence in their future education. Reliabilities were good.

Table 5 shows a comparison pre and post surveys with a paired-samples t-test. The p-value was less than .05 indicating there was a statistical significance between the pre and post survey.

Table 1

Demographic Information

Demographic Category	Overall Sample Count (n = 42)	%
Sex		
Male	0	0.0
Female	42	100.0
Grade		
8	16	38.1
9	24	57.1

Table 2

Knowledge / Perceptions

Survey Questions	% Yes	
	Pre	Post
Descriptive		
Q1. I enjoy my science class.	97.6	92.9
Q2. I consider myself a “geek”.	57.1	54.8
Q3. I have family that enjoys science 'stuff.	65.9	59.5
Q4. I have friends that enjoy sciency 'stuff.	85.7	88.1
Q5. I know about career opportunities in STEM (science, technology, engineering, math).	65.9	88.1

Table 3:

Constructs: Understanding of STEM, Confidence in science, Enjoyment, Ability to Succeed, Perceptions of Women in Engineering, Expectations, Confidence in Completion. % Some for of Agreement, Mean, and Standard Deviation (strongly disagree = 1, strongly agree = 6)

	Pretest			Posttest		
Survey Questions	% Some Form of Agreement	*M*	*SD*	% Some Form of Agreement	*M*	*SD*

Understanding of STEM						
Q6. I understand what STEM is.	70.7	4.2	1.3	95.2	5.4	.8
Q7. I understand what careers are available in STEM.	55.0	3.55	1.2	92.9	5.3	1.0
Q8. A career in STEM could give me the lifestyle I want.	72.5	4.2	1.2	92.9	5.2	1.0
Confidence in Science						
Q9. I feel confident in my science class.	100.0	5.3	.7	100.0	5.5	.6
Q10. I feel confident 'doing' science.	97.6	5.2	.9	100.0	5.4	.7
Q11. I feel confident doing hands-on science activities.	92.9	5.3	1.0	100.0	5.5	.7
Q12. I feel confident in my ability to succeed in science.	95.0	5.2	.9	95.2	5.4	.9
Q13. I feel confident in participating in science activities outside of school (ex. After school science club)	80.5	4.6	1.3	90.5	5.1	1.1
Enjoyment						
Q14. I think attending the GUESS day will be fun.	100.0	5.4	.7	100.0	5.9	.4
Q15. I think attending the GUESS day will be interesting.	100.0	5.5	.7	100.0	5.9	.4
Q16.I think I will enjoy attending the GUESS day.	100.0	5.5	.6	100.0	5.9	.4
Q17.I think I would attend the GUESS day again.	97.6	5.4	.8	100.0	5.9	.5

Ability to Succeed						
Q18. I can succeed in a science program.	90.5	5.0	.9	97.6	5.4	.7
Q19. I can succeed in a science program while NOT having to give up participation in my outside interests (extra-curricular activities)	90.0	4.7	1.0	92.9	5.1	1.0
Q20. I will succeed in my science course.	92.9	5.1	.9	97.6	5.4	.7
Q21. I will succeed in other STEM (science, technology, engineering, math) courses.	89.7	4.7	.9	97.6	5.4	.7
Perception of Women Engineers						
Q22. Women should become engineers because women should have equal rights.	100.0	5.3	.8	97.6	5.5	.9
Q23. Women should become engineers because it provides a feeling of independence.	95.1	5.0	.9	95.1	5.5	.9
Q24. Women should become engineers because it provides a feeling of empowerment.	90.2	5.0	1.0	95.2	5.5	1.1
Q25. Someone like me can succeed in an engineering career.	87.8	4.9	1.1	97.6	5.4	.7
Expectations						
Q26. A degree or certificate in engineering would allow me to obtain a lifestyle I want.	82.1	4.5	1.0	95.2	5.4	.8
Q27. A degree/certificate in engineering would allow me to obtain a well-paying job.	95.1	5.0	.9	100.0	5.6	.5
Q28. I expect to be treated fairly on the job. That is, I expect to be given the same opportunities for pay raises and promotions as my fellow workers if I enter	100.0	5.5	.7	97.6	5.6	.7

engineering.						
Q29. I expect to feel “part of the group” on the job if I enter an engineering career.	92.9	5.3	1.0	97.6	5.6	.7
Q30. A degree/certificate in engineering would allow me to get a job where I can use my talents and creativity.	83.3	4.9	1.3	95.2	5.6	.8
Q31.A degree/certificate in engineering would allow me to obtain a job that I like.	85.0	4.6	1.1	97.6	5.4	.8
Confidence in Completion						
Q32. I feel confident that I will be enrolled in an engineering program in the next 5 years.	63.2	4.0	1.2	94.7	5.1	1.0
Q33. I feel confident that I will complete an engineering program.	74.4	4.3	1.2	97.5	5.2	.9
Q34. I feel confident I will complete a STEM (science, technology, engineering, and math) program.	79.5	4.6	1.3	100.0	5.3	.8
Q35. I feel confident that I will complete a degree in college.	97.6	5.7	.7	100.0	5.8	.6

Table 4 shows three constructs and their reliability measures. The table also shows the correlation between each of the constructs. With the exception of a few of the relationships, The statistical correlations are low. This value would indicate both conceptual and statistical independence of the constructs measured.

Table 4

Correlation of Subscale Constructs and Measures of Internal Consistency for Presurvey Data

Construct Number	Subscale Constructs	C1.	C2.	C3.	C4.	C5.	C6.	C7.	α
C1.	Understanding of STEM q6,q7,q8		.35	.45	.58	.50	.50	.27	.72
C2.	Confidence in Science q9,q10,q11,q12,q13	.35		.58	.69	.66	.71	.64	.89
C3.	Enjoyment q14,q15,q16,q17	.45	.58		.65	.53	.56	.46	.93
C4.	Ability to Succeed q18,q19,q20,q21	.58	.69	.65		.56	.61	.50	.82
C5.	Perception of Women Engineers q22,q23,q24,q25	.50	.66	.53	.56		.83	.51	.80
C6.	Expectations q26,q27,q28,q29,q30,q31	.50	.70	.56	.61	.83		.67	.87
C7.	Confidence in Completion	.26	.64	.46	.50	.51	.67		.79

	q32,q33,q34								

Question 35 deleted.

Table 5

Comparison Between Pre and Post Surveys

(strongly disagree = 1, strongly agree = 6)

Subscale Constructs	Meaning	Pre *M*	Post *M*	Diff *M*	*t*	*df*	*p*
Understandin g of STEM	Student perception of having an understanding of STEM	3.98	5.31	-1.33	-9.08	40	.000
Confidence in Science	Student perception of confidence level in Science	5.12	5.41	-.29	-3.39	41	.002
Enjoyment	Student perception of enjoyment while attending GUESS	5.46	5.88	-.41	-4.71	41	.000
Ability to Succeed	Student perception of her ability to succeed in an engineering career	4.87	5.32	-.45	-4.31	41	.000
Perception of Women	Student perception of women in Engineering	5.02	5.46	-.45	-5.31	41	.000

Engineers							
Expectations	Student perception of her expectation of job treatment	4.95	5.50	-.55	-5.65	41	.000
Confidence in Completion	Student perception of confidence in completion of a college degree	4.70	5.31	-.62	-5.52	40	.000

* $p > .05$ = No statistical significance.

Discussion

The research question being asked is "What impact does the GUESS project have on female participants?" and the hypothesis is that the GUESS project has a positive impact on female participants measured through an increase in knowledge, confidence, attitude, interest, perceptions of women engineers and career expectations and interests.

Surveys were given to the female participants before and after they participated in the GUESS project 'day at the lab' experience. Overall, there was a consistent increase across all of the constructs. The girls who attended this intervention program had a marked increase in their confidence level, which is key to their future success. With confidence being defined as the strength of certainty of one's beliefs (Bogue, 2007) and the readiness to choose a career stems from the beliefs in one's own ability (Lent, Lopez and Bieschke), increasing the girls' confidence level is critical to recruiting these young women into STEM careers. According to Allison and Cossett (2007), girls' confidence has to build before they will try something new which is what the GUESS project provides. The data shown above marks a much needed increase in the girls' confidence levels, which will result in them pursuing STEM careers.

For the enjoyment measure, we saw a ceiling effect. The girls came in believing they would have a great day, and the post-survey showed they believe they did.

The ability to succeed construct is based around the female participants perceptions of their ability to succeed in an engineering career. There was an increase in this perception due to the GUESS project.

The participants also showed an increase in their perceptions about women engineers. The girls believe that by women becoming engineers, they will gain a feeling of independence, empowerment and have equal rights. Most of them also saw themselves as being able to succeed in an engineering career.

The female students showed an increase in their confidence of completion of a college degree after attending the GUESS project. This is a key factor to ensuring the girls will continue onto a path within a nontraditional career field.

Conclusion

The main purpose of this study was to find out what impact the GUESS project has on female participants. The hypothesis is that the GUESS project has a positive impact on female participants, measured through an increase in knowledge, confidence, attitude, interest, perception of women engineers and career expectations and interests.

When looking through the data collected, there was an increase measured in every construct with p values indicating that statistically, the GUESS project does have a positive impact on female participants.

Implication for Practice

By increasing knowledge of STEM careers, building confidence levels, increasing attitudes, interest and perception of women engineers, as well as increasing career expectations and interests in STEM, the GUESS project is showing promise to increasing women entering STEM fields, especially engineering. With a shortage of workforce and high paying jobs available, it is critical that a higher number of women enter these STEM fields. By continuing the GUESS program, we will be able to create a tipping point for other STEM careers such as engineering.

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Research Paper #3

Guess Again: Engaging and Inspiring Girls in Nontraditional Careers

A Model for Motivating Girls to Consider Welding Careers

Potential Submission: ATEA Journal Fall 2021

Introduction:

The underrepresentation of women in nontraditional careers is a growing problem. There are many hypotheses regarding the reasons why. Knowing there is a need in technology fields, defining the problem and designing a proper intervention are critical. The GUESS (Girls Understanding and Exploring Stem Stuff) was designed to improve the interest of eighth and ninth-grade girls from North Dakota in STEM (Leopold and Lemire, 2014). Because of the positive results in increasing female students' interest and confidence in STEM fields, we wanted to test the model in a different content area. By including a technical field, in this case, welding, we want to expand the definition of STEM.

Traditionally, welding is taught through CTE (Career and Technical Education). CTE and STEM intersect because of the project-based learning focus found in both. CTE classes such as automotive repair, HVAC, building and trades as well as welding have a hands-on focus on how they are taught, while STEM also uses project-based hands-on education as a way for students to learn. Some may even refer to CTE as STEM because of the teaching practices. STEM, however, typically refers to people seeking a bachelor's degree or higher, while CTE focuses on associate's degrees, certificate programs, and other training such as apprenticeships. 21% of current welders hold an associate's or diploma degree, 29% hold a high school diploma, and 46% hold a different degree. Only 4% hold a bachelor's degree (Zippia, 2021). Defining STEM and CTE are essential factors because of the difference the degree's sought out. Some may focus solely on a degree emphasis, while others will focus on hands-on learning.

The average age of welders is mid-fifties, and many are close to retirement. Opportunities in the field are rapidly growing, and nearly 100% of new welding graduates are finding jobs. A federal stimulus plan during the Obama administration provided $285 billion toward infrastructure repair and a focus on emerging technologies such as alternative energy. These growing markets combined with automation and advancement in materials all contribute to the demand for skilled technicians (Shook, 2009). According to the U.S. Bureau of Labor Statistics, projected employment opportunities for welders are expected to increase by 3% between 2019 – 2029, and in 2019, there were 438,900 jobs available (Bureau of Labor Statistics, 2021). These are jobs that are available to women right out of high school or with a small amount of training or additional education. According to indeed.com, the average pay for welders in North Dakota ranges from $20-$50/hour, and pipefitters can earn up to $150,000/year. For women who earn on average $783/week compared to a man's $1051/week (74.5% less) in North Dakota, a welding career could offer an opportunity for a boost in earnings (U.S. Bureau of Labor Statistics, 2019).

The GUESS (Girls Understanding and Exploring STEM Stuff) model can be readily replicated across content fields, such as welding and other higher-paying and nontraditional areas in North Dakota as well as across the nation to help address the needs of various industries. This study demonstrates the results of the GUESS model pilot project after 20 girls attended a GUESS experience and show the follow-up with girls in a welding course eight months after they attended the GUESS experience.

Literature Review

The underrepresentation of women in nontraditional careers such as STEM (Science, Technology, Math, and Engineering) and CTE is a well-known and documented societal problem. Welding Technology is a large area of concern. According to the National Girls Collaborative Project (NGCP), women make up approximately 53% of biological scientists, 31% of physicians, 33% of chemists, and only 29% of geoscientists. They also account for only 10% of civil engineers, 8% of electrical engineers, and 10% of aerospace engineers (Foster, 2012). Only 5% workforce of the Welding industry is women (American Welding Society, 2021). Although the reasons for this are still in debate, some conclude it stems from family values (Bhanot and Jovanovic, 2005), to a “chilly climate” which includes lack of encouragement, diminishing remarks, and even sexual harassment (Rolin, 2008). However, with increased social support, women report having a more positive perception of their work climate (Rincon and George-Jackson, 2016).

Career and Technical Education has become popular in U.S. schools. CTE offers "both academic content and technical skills in current or emerging professions, and builds pathways connecting education and the workforce" (Kim and Flack, 2021). Much of the research in CTE focuses on access but little focuses on equity. CTE is historically known for vocational education or trade schools and focused on low-income or 'difficult to teach students. However, in the 1990's a shift in focus to broader career paths instead of specific training in one field emerged. This shift in focus included an emphasis on females as well as opportunities for all students (Kim and Flack, 2021). By 2015, the U.S. Department of Education deemed CTE as a part of a well-rounded education for students (U. S. Department of Education, 2015).

Welding, being a nontraditional career field for women, is often thought about in terms of a man wearing a helmet working in a dirty environment. However, there are many other areas of the welding industry. Common misconceptions such as all welders work under a helmet, welding is dirty, and women don't like sparks are common in this field (American Welding Society, 2021).

Workshops can be used to motivate career paths:

Several 'intervention programs' are currently set up around the nation to target girls' interest in STEM as well as other areas. By having camps or programs outside of the current school setting, such as an after-school program, young women will often choose to participate because the activities are not graded and pressure-free. These types of programs are less threatening to girls and can move beyond the anxieties the girls may feel in a traditional classroom (especially with boys present) which promotes participation (Frost and Wiest, 2007).

Confidence:

Self-efficacy consists of two components, confidence and the readiness to choose a career (Lent, Lopez, and Bieschke, 1991). Confidence can be referred to as the strength of certainty of one's beliefs (AWE, 2005), while Lent, Lopez, and Bieschke describe the readiness to choose a career stems from the beliefs in one's abilities to be able to act on an action required to reach a specific goal.

Confidence is critical in recruiting women into STEM fields. According to Allison and Cossette (2007), girls' confidence has to build before they will try something new, where boys will try something new to build their confidence.

Strategies:

In order to engage girls in STEM, there are known strategies. Allison and Cossette (2007) outline elements of interventions, which prove to be effective for boys as well as girls. They include creating a positive environment, building self-confidence, hands-on workshops, cooperative groups, practical applications of what they are learning, role models, family support, and mentoring.

According to *SciGirls (2010)*, there are seven common strategies that work, all of which support the GUESS model. The SciGirls Seven include, girls need: collaborative work, meaningful projects, hands-on, open-ended approach to learning, positive feedback, opportunities to think critically through problems, and role models and mentors.

Purpose of Study

The purpose of this study is to evaluate the implementation of the GUESS project model, which can be used to motivate girls to pursue nontraditional careers. We show the results of the intervention program in relation to improving girl's confidence, which is key in considering a nontraditional career.

Elements of the GUESS project model:

Based on proven practices such as the SciGirls Seven, we developed the GUESS model. This includes: getting out of school and participating in the GUESS experience. The girls are chosen by the schools. The program is run by women mentors and included a large group activity in starting the day and small groups. Matchings shirts are given at the beginning of the day, which offered a feeling of togetherness and empowerment, social lunch, hands-on projects, female-friendly activities, targets 8^{th} and 9^{th}-grade girls, and the local school instructor is present during the program.

The GUESS Again (welding) event description:

When the girls first arrived, they were given a pink camouflaged t-shirt to signify unity. This was a way to show the girls they all belonged at the event and to promote a feeling of empowerment. After the girls had changed and were ready to begin, we showed them a wheelchair that the current welding students at NDSCS were working on. The wheelchair was being built for a female with a disability and her trainer to run in the local marathon. By showing the girls a real-life problem and the critical need for women in the field (engineering design for a female in a wheelchair would be different than for a male), the girls were intrigued, and their nurturing role was sought out.

The first hands-on activity of the day was tensile testing. The girls were grouped and given a small bag of 'stuff' and told to make a hammock or bridge between two points. Each group was given a different bonding agent, and a contest was formed to see who could build the strongest bridge. This provided a group activity that connected the girls with each other as well as created a bond with their mentors for the day. It also set the stage for the expectations of having fun, learning, and having a safe environment in which to explore.

The girls were then split up and rotated through different stations of wire-feed welding (making at-joint), annealing process (spoon jewelry), soldering (wheel of fortune game), automated robotics (block stacking), and characterization of welds (scanning electron microscopy). The girls were taken to Pizza Hut for lunch which provided an opportunity for the girls to socialize and ask informal questions to their mentors about career choices and available options.

The local welding instructor also attended the 'day at the lab' experience with the girls. Often girls don't know who the welding instructor is or where the welding class is located. By having the welding instructor as not only a chaperone but as an active participant, this allowed the girls to build a relationship with the instructor, thus increasing the confidence of the safe learning environment established at their local school.

Methods

Participants

The targeted school for this study was a rural school in northeastern North Dakota. To help increase interest in participation in this study, we went to the school for a day and did a soldering activity with the 9th grade Physical Science students (boys and girls). The girls were then invited to sign up to participate in the ‘day at the lab’ activity. We had 20 girls participate in the GUESS Again day. This work was approved by the Sanford Research Institutional Review Board.

Instrument

For the initial 'day at the lab' experience, the girls were given a pre/post assessment of open-ended questions that addressed attitude, confidence, welding content knowledge, knowledge of gender in science and technology, career pathways, perceptions of women in welding, and excitement around attending a 'girls only' event.

A follow-up was done eight months later with the girls who entered into the welding course at their school. The instrument used was made up of open-ended questions as well as seven constructs, including knowledge, confidence, attitude, self-efficacy, gender stereotypes, and welding career expectations I and II.

Design:

Research Question 1:

What impact does the GUESS project have on female participants in a welding setting?

Hypothesis:

The GUESS project has a positive impact on female participants, measured through an increase in knowledge, confidence, attitude, interest, perception of women welders, and career expectations and interests.

Results

Results of the pre/post surveys of the GUESS Again day:

Table 1 shows the percent increase of change in attitude, confidence, and welding content knowledge. These were derived from pre/post surveys given to the girls. When we visited the girls' school for recruitment into this program, we conducted a soldering activity and talked about welding. Because of this, 100% of the girls were demonstrating some knowledge of what welding was prior to their attending the GUESS Again program day.

Table 1

Percent increase between Pre/Post results from GUESS Again project day (n=20)

Category	% increase
Change in Attitude	95
Change in confidence	90
Welding content knowledge	0*

*Welding content knowledge was at 100%. This is likely due to the participants having some knowledge of what welding was from the soldering activity day of recruitment.

Table 2 shows perceptions of what the girls believe is a ratio of males to females working in STEM careers. Seventy-six percent of the girls overall believe it is not a male-dominated field but that it is shared equally between males and females. All 100% of the participants felt it was important for women to study welding, and all 100% felt that there would be a negative impact if boys were present during this program. Ninety-five percent felt they would pursue taking some kind of technology course the following year in school. Fortyfive percent claim they are considering a welding career, while 70% are considering a STEM career.

Table 2

Pre/Post results from GUESS Again project day (n=20)

Category	% Overall
Perceptions of male/female ratio of employees in science and technology	76
Importance of women studying welding	100
Student perceptions of negative experience if boys present	100
Chances of taking a technology course the following year	95
Considering a career in Welding	45
Considering a career in STEM	70

Results of follow-up survey eight months later, N=4

Table 3 shows the results of knowledge, confidence, attitude, self-efficacy, gender stereotypes, and two constructs of welding career expectations.

% form of agreement, Mean, and Standard Deviation (strongly disagree = 1, strongly agree = 6)

Table 3

Knowledge, confidence, attitude, self-efficacy, gender stereotypes, career expectations

Survey Questions	% Some Form of Agreement	*M*	*SD*
Knowledge			
Q7. Helped me understand welding better.	100	5.0	1.00
Q8. Helped prepare me for taking a welding class.	100	5.3	0.6
Q9. Gave me a basic understanding of what welding is.	100	5.3	0.6
Confidence			
Q10. Increased my confidence level in welding.	100	5.3	0.6
Q11. Increased my confidence level in registering for welding class.	100	5.3	0.6
Q12. Gave me the confidence to take a cte course.	100	5.0	0.0
Q13. Made me more confident in my ability to succeed in welding.	100	5.3	0.6
Q14. Increased my confidence to participate in welding projects or activities.	100	5.3	0.6
Attitude			
Q15. I thought attending the GUESS welding day was fun.	100	6.0	0.0
Q16. I thought attending the GUESS welding day was interesting.	100	6.0	0.0
Q17. I enjoyed attending the GUESS welding day.	100	6.0	0.0
Q18. I would attend the GUESS welding day again.	100	6.0	0.0
Self-efficacy			
Q19. I can succeed in a welding program.	100	5.5	0.6
Q20. I can succeed in a welding program while NOT having to give up participation in my outside interests (extra-curricular activities)	100	5.5	0.6

Q21. I will succeed in my welding course.	100	5.5	0.6
Q22. I will succeed in other cte courses.	100	5.7	0.6
Gender Stereotypes			
Q23. Women should become welders because women should have equal rights.	100	5.5	0.6
Q24. Women should become welders because it provides a feeling of independence.	100	5.8	0.6
Q25. Women should become welders because it provides a feeling of empowerment.	100	5.5	0.6
Welding career expectations I			
Q26. Someone like me can succeed in a welding career.	100	5.5	0.6
Q27. A degree or certificate in welding will allow me to obtain a lifestyle I want.	75	5.0	1.4
Q28. A degree/certificate in welding will allow me to obtain a well-paying job.	100	5.5	0.6
Q29. I expect to be treated fairly on the job. That is, I expect to be given the same opportunities for pay raises and promotions as my fellow workers if I enter welding.	100	5.8	0.5
Q30. I expect to feel "part of the group" on the job if I enter a welding career.	100	5.5	0.6
Q31. A degree/certificate in welding will allow me to get a job where I can use my talents and creativity.	100	5.5	0.6
Q32. A degree/certificate in welding will allow me to obtain a job that I like.	100	5.5	0.6
Welding career expectations II			
Q33. I feel confident that I will be enrolled in a welding program in the next 5 years.	75	4.8	1.5
Q34. I feel confident that I will complete a welding program.	100	5.3	1.0

Q35. I feel confident that I will complete a degree in college.	100	5.8	0.5

Table 4 shows measures of internal consistency and reliability. All the Cronbach alpha numbers are acceptable.

Table 4

Measure of internal consistency and reliability

Number	Subscale Constructs	C1	C2.	C4.	C5.	C6.	C7.	α
	Knowledge (7-9)		.98					.92
C1.								
C2.	Confidence (10-14)	.97						.92
C4.	Self-efficacy (19-22)	.50	.69					.97
C5.	Gender Stereotypes (23-25)	.28	.50	.97				.89
C6.	Welding career expectations I (26-32)	.28	.50	.89	.93			.93
C7.	Welding career expectations II (33-35)	.28	.50	.96	.99	.97		.76

Discussion

The underrepresentation of women in welding has been a long-standing problem. There is a workforce shortage and an untapped population of workers. According to the American

Welding Society, there are expected to be over 400,000 welding jobs in the United States by 2025, and only 5% of the current welding jobs are held by females (AWS, 2021). The GUESS project is an intervention program that is showing promising results to entice women to enter this field.

We piloted this study with 20 girls attending the GUESS Again 'day the lab' intervention program and did a follow-up eight months later with four females who were enrolled in a welding program at their school.

Discussion of the GUESS Again day experience:

The results showed a positive increase in the girls' readiness and confidence levels toward welding. They also showed that over 75% of the girls believe that women and men are employed equally in STEM fields of employment, and all of the girls who participated believe that it is important for women to experience welding. Every participant believed the GUESS experience would have been negatively impacted if boys were present. Ninety-five percent of them left the day planning to take a technology course the following year, and 45% said they would consider a career in welding. Seventy percent said they would consider a STEM career. This data shows that the GUESS experience made an impact on how the girls perceive the welding field, and they feel like they can have a place in it.

The goal of the GUESS project as a model is to build self-efficacy, including confidence and awareness through hands-on, collaborative activities in a safe and social setting. The results listed above clearly increase these goals. However, the question remains, to what extent is the impact of this project long after the day?

Discussion of the GUESS Again follow-up:

After the girls had their GUESS experience and returned to school, 30% of the participants visited the counselor's office to change their schedule to register for a welding course. The follow-up showed that 20% of the participants were active in a welding course that fall. The remaining 10% were unable to register for a welding class due to scheduling challenges.

According to Kirkpatrick's levels for evaluation model, students were evaluated on four different levels. The beginning or reaction step is how well the participants enjoyed the activities. The second step is how much information the participants learned. The third step has to do with behavior, such as were the girls were able to apply what they learned or there was a change in course because of this intervention. The final stage is the result, such as the tangible results of this activity (Kurt, 2016).

When looking at the results of the GUESS follow-up survey, which was conducted eight months later, the girls all agree they gained an increase in knowledge, confidence, attitude, self-efficacy, gender stereotypes, and welding career expectations for themselves. These constructs directly reflect the goals of the GUESS project model and are in line with Kirkpatrick's evaluation model. The really exciting part is the final stage of Kirkpatrick's model, the result is that there were four girls enrolled in the high school welding program!

Conclusion

The GUESS project model shows promising results not only in all STEM areas and specifically in welding. This is a user-friendly model that follows principles and best practices from research. The results have been tremendous, and girls are now entering the welding courses at their local school. Feeding the pipeline is the first step to getting a female workforce employed in the industry.

Implication for Practice

This study demonstrates a successful model for an intervention program that increases women in welding careers. With over 400,000 jobs available, there is a shortage of workers in welding and an untapped workforce that can fill the needs of this industry. The GUESS project model can be easily replicated in other areas and used to motivate girls and women to consider a viable but largely unexplored career path and help meet the needs of the welding industry nationally.

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