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Influence of Robotics on Women in STEM

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Problem Statement

This research study will address the underrepresentation of women in areas of science, technology, engineering, and mathematics (STEM). It will also attempt to identify a correlation between Robotics and STEM paths in college. From a young age, girls are believed to have a lower aptitude for science and math than boys. Because of this, girls might be taught differently or have gender-related beliefs in their abilities. Accordingly, these stereotypes affect young women to not pursue science and math further; therefore, there is a significant gap between men and women in STEM majors in college and an even greater one in the career field.

Negative perceptions of girls' abilities adversely affect their chosen careers. To combat this, more resources and innovative programming are being developed to bridge the gap and help young women develop greater interest in STEM areas. One program that promotes STEM is robotics intervention. For example, FIRST (For the Inspiration and Recognition of Science and Technology) Robotics is a program founded to encourage students to pursue careers in STEM. An example of a FIRST Robotics team and the primary resource for this research is the Firebirds Robotics Team at Mount Saint Joseph Academy.

The goal of this research is to study the data of former participants on the Firebirds team to show the influence of an after-school intervention for young women in areas of STEM.

Rationale

This problem is important to the evolvement of society and the equality of women and men. The disproportionate number of women in STEM career fields leads to a male dominance within the fields. Many young girls are not interested in the fields of STEM for several reasons. One consideration is that they do not see many women in these fields and believe it cannot be achieved. Another, if more STEM-focused programs were developed for girls, they would realize their potential and revisit misperceptions. Therefore, it is important to study the relationship between robotics and girls' achievement to further advance the research in what will influence female students and increase female representation in STEM fields. This in turn could relate to other STEM interventions that might increase the competency and confidence of young women.

Problem Question

Is there a correlation between girls on the Robotics Team and their achievement of GPA and SAT scores, and their College Major in fields of science, technology, engineering, and mathematics (STEM)?

Hypothesis

Hypothesis 1: At the onset of this research, I believe that there will be a positive correlation between girls on the Robotics Team and high GPA and SAT scores. Since the Mount Saint Joseph Academy is a prestigious all-girls school, some in the control group would have similarly high scores, which is a limitation in the

study. However, being on the Team would gain skills beneficial for the mathematics portion of the SAT (SAT-M) and other STEM classes, which would boost their GPA.

Hypothesis 2: I believe that I will find a majority of graduates (formerly on the Robotics Team) that have chosen College Majors in areas of STEM because of their knowledge and skills attained while being on the Team.

Foundations of Mount Saint Joseph Academy Robotics Team [1]

Always striving for excellence, the Mount St. Joseph Academy is at the forefront of academic rigor and provides opportunities for their female students. For this research study, I was aware of at least one opportunity—the Firebirds Robotics Team—while interviewing Bob Foell. Precipitated by the first all-girls robotics team at Girls High, Principal Sister Karen Dietrich encouraged Foell to explore FIRST Robotics and what it entailed. After talking to many people, he surmounted that it would involve a lot of time and effort. However, Sister Dietrich persisted and in 2000, the robotics team was founded and is now the longest standing all-girls FIRST Robotics Team in the world.

Since he was the chair of the science department, Foell became one of the initial leading forces on the robotics team. With others, he advertised the team to the school and announced it during classes. Out of the one hundred students that came to the general meeting, only ten persevered and initiated the team called M.I.N.T. meaning Mounties Interested in New Technology. The name was changed to the FIRST Firebirds 433 as the

[1] Bob Foell, "Foundations of Mount Saint Joseph Academy Robotics Team", (2 March 2015). All quotes not footnoted will reference this.

website describes, "After a mishap in which our robot caught fire during one of our first matches, our team rose from the ashes and renamed ourselves the Firebirds."[2]

The team rose from the ashes but it was hard getting there. The five thousand dollar starting price was funded partly by the Pew Research Center who has an agreement with FIRST to help start-up teams for one year. In the beginning, the team had to work hard to receive funding, get a support system, and basically survive. With nowhere else to work, the team started in the basement of the convent next to the high school. Conditions were harsh during that time: it was dark and damp, it was dangerous, and it was hard to haul equipment up and down the narrow steps. The mentors of the team, usually parents or teachers, convinced the school to allow them to have a new workspace. Although it is still in a basement, the area is now in the new part of the school building with better lighting, more open space, and easier access.

When the team first started, Foell did not imagine the extensive dedication or the altruistic behavior it garnered. Without much knowledge on the program, he believed it was just a science project sort of activity. He soon realized that was far from the truth. This was "an opportunity for kids to work with engineers." Because of its altruistic philosophy, the competition meant that the teams were there to compete and win, but also work together to get better. The older veteran teams held workshops for the rookie teams and help them whenever necessary. In the first year, the other teams were very helpful and generous and wanted to see the Firebirds succeed. Consequently, when they finally got their first point, the whole arena erupted in applause.

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[2] FIRST Firebirds 433, *FIRST Firebirds 433*, (2014).

Many benefits come from this collaborative but competitive institution. Teams help each other to allow for a more intensive event. Once the team realized the approach that "failures are learning opportunities", they accomplished more feats and had fun meanwhile. The program not only gets material resources that a team needs, but it also facilitates human contacts to work as mentors for the students. In this way, the Firebirds were able to build alliances with businesses and enlarge their team members. With a sponsor from Aetna, the team was able to build an interactive robot for children to learn about the heart with its pulsing lights. Taken from a business model, the team ran in accordance to various departments, which includes: finance, technical operations, and public relations.

With its eclectic members, the Firebirds are able to spread their talents throughout each department. The team is not only science and engineer oriented students; additionally, there are members who are writers, filmmakers, artists, and more. These differences do not separate them. It identifies what needs to be done and enables cooperation of the same team moving towards the same goal. From its rocky beginnings, the Firebirds have become a well-respected team receiving the Chairman's Award in the Philadelphia region for five years in a row.

The mentors promote self-confidence and team spirit, which supports the growth of confident, compassionate, and courageous young women. The team also "prepares students for college and professional careers in STEM."[3] Since they are established as a successful team, the Firebirds have dedicated service to outreach programs like Summer of Inspiration, Rock that Bot-ty. Moreover, the team partners with the Boys and Girls

[3] Ibid.

Club and the Girl Scouts to run workshops in the summer and at conventions, respectively. They provide FIRST LEGO League (FLL) mentoring in five different elementary schools in Camden, New Jersey. Most impressively, the Firebirds started the first FIRST team in Ghana. They help in whatever way possible, usually by sending used parts and tools to them.[4]

Although Foell is now retired from teaching at the Mount Saint Joseph Academy, he is now working as a referee during robotics competitions. Recalling the beginning year, he did not believe it would develop so well. Foell says, the "FIRST organization is a stroke of genius." The organization and philosophy behind it really challenges and brings out the best in kids. The last comment he made was that it is not about robotics; it is about "building better people one robot at a time."

Literature Review

Women are underrepresented in fields of science, technology, engineering, and math (STEM) when it comes to school courses, degrees, and careers. Not all researchers argue for the same reasons; therefore, the disparity emanates from a variety of explanations. Although not all are proven, the underrepresentation is shown through biological differences, pedagogy of the curriculum favoring men, and absence of women role models. Society's perceptions of women in STEM also influences women's own beliefs about their abilities in those areas. However, programs like robotics show that girls have true potential in areas of STEM. Focusing on an all-girls robotics team, the

[4] Ibid. This paragraph was from the FIRST Firebirds 433 website.

study acknowledges the capability young women have in STEM through their scores and career paths.

Perceptions of Teachers and Parents

Perceptions of girls' intelligence in STEM courses are identified with how people treat girls in regards to STEM classes. Ceci, Williams, and Barnett (2009) cited studies of teacher-student interactions. Here, teachers gave more attention to boys while teachers gave girls less criticism and instruction. In another study of high school mathematics classes, "teachers provided boys with more formal and informal reward and support, and a good affective environment in which to learn, and male students answered more open as well as direct questions, process questions, and callouts, even though there were no differences in student-initiated interactions."[5] Both male and female teachers have negative perceptions of girls in STEM, which is detrimental for a student's self-efficacy belief.

For some, more important influencers are the students' parents, especially their mother. In addition to less attention from the teacher, girls receive low standards from parents. When determining their self-worth in areas of STEM, young women refer more to their mothers' perceptions than to class grades. This is harmful to girls that have a talent in STEM, but do not achieve it because of other people's false perceptions. However, focusing on students in the top percentage shows that parental perceptions did not show a significant relation to differences in their own perceptions of ability in STEM

[5] Stephen J. Ceci, Wendy M. Williams, and Susan M. Barnett, "Women's Underrepresentation in Science: Sociocultural and Biological Considerations," (*Psychological Bulletin* 135.2: 2009), 228.

classes. Overall, stereotypical responses from underrepresentation stem from the 18th century belief that "girls' brightness, construed as inferiority, and boys' dullness construed as potential."[6]

Self-Perception of Women

Viewing self-efficacy beliefs of men and women, Zeldin, Britner, and Pajares (2006) compared many different studies that showed a counterintuitive occurrence. Even though women make up the majority of the college student population in science, technology, and mathematics classes, they earn fewer degrees in these fields than men. Motivated by perceptions of their ability, women have stopped pursuing these careers because of certain experiences. The experiences are authentic mastery experiences, vicarious experiences, social persuasions, and physiological emotions. In each situation, negative reinforcement are enforced for women in STEM, including: recurring failures, less likely to have models, disparaging messages about their competency, influential emotional indexes such as anxiety.

Biological Differences

Such physiological emotions are reasons why some believe biological differences impact the disparity of women in STEM fields. Instead of focusing on previous tests like the brain size of women compared to men, IQ tests and multiple intelligence tests are now used to study the underrepresentation of women in STEM. Studying this leaky

[6] Jo Boaler and Tesha Sengupta-Irving, "Gender Equity and Mathematics Education," *Encyclopedia of Diversity in Education,* (Thousand Oaks, CA: SAGE Publications, Inc., 2012), 975.

gender pipeline, Blickenstaff (2005) determines that multiple intelligence tests are detrimental since they result in the belief that men are stronger in spatial and mathematical abilities, while women are stronger in verbal abilities. However, most research does not show results backing these seemingly true facts. In other studies that were referenced, no substantial difference in verbal ability was shown with only small differences in mathematical and spatial ability. The significant variances though "could explain a two to one ratio of males to women in engineering, but not the 20 to one ratio that is observed" in other science courses.[7] Although there are intelligence differences between men and women, they are insignificant in describing the disproportionality of women in STEM areas.

Curriculum Pedagogy

The differences between male and female in STEM classes are minimal, but they do occur. Some researchers suggested that this could be resolved by changing the curriculum to gear it towards women's strengths. Boaler and Sengupta-Irving (2012) indicate problem solving and spatial ability as the factors where gender differences occur. Traditional methods of teaching with rote memorization and practice problems are not beneficial to students, especially girls. Other research is referenced "showing that when students are more actively engaged in mathematical classrooms… they achieve at higher levels, they enjoy mathematics more, and gender inequalities in achievement and

[7] Jacob Clark Blickenstaff, "Women and Science Careers: Leaky Pipeline or Gender Filter?" *Gender and Education* 17.4 (Bellingham, WA: Western Washington University, 2005) 372-373.

participation are reduced or even eliminated."[8] Researching about women in science careers, Blickenstaff notes that the curriculum could also help women more if less material was covered but in greater depth.[9]

As previously mentioned, teachers need to provide attention to all students, not only young men. Remarked in the study by Blickenstaff (2005), "teachers in the UK marked it higher if it appeared to come from a male student than if it came from a female student."[10] A science teacher's pedagogy also tends to account for students switching out of the course. This can be through withdrawn and unapproachable instructors or grading systems that focused on competitiveness rather than collaborative improvement. Additionally, many course materials are biased with few pictures of young women in STEM textbooks. Also, Blickenstaff states that when women are shown in the books, they are viewed as bystanders looking on at the men performing the science experiments.[11] When text materials show a bias toward women, women feel inadequate and do not acknowledge women who have high-established careers as scientists, technician, engineer, or mathematician.

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[8] Jo Boaler and Tesha Sengupta-Irving, "Gender Equity and Mathematics Education," *Encyclopedia of Diversity in Education,* (Thousand Oaks, CA: SAGE Publications, Inc., 2012), 974.
[9] Jacob Clark Blickenstaff, "Women and Science Careers: Leaky Pipeline or Gender Filter?", *Gender and Education* 17.4., (Bellingham, WA: Western Washington University, 2005), 378.
[10] Ibid 378.
[11] Jacob Clark Blickenstaff, "Women and Science Careers: Leaky Pipeline or Gender Filter?", *Gender and Education* 17.4., (Bellingham, WA: Western Washington University, 2005), 377.

Environmental Factors

Since the classroom is segregated in teaching men, women become more discouraged and drop out of STEM courses. There is a lack of women in these careers ensuing from the rates of attrition that occur each year. In the United States alone, women in mathematics represent 45% of undergraduate degrees, 24% of PhD's, and only 17% of tenured faculty.[12] Many suggestions are made as to why women are so underrepresented. One is a cyclical argument: female students are discouraged in classrooms of majority male STEM professors. Since they are discouraged, women in the fields drop out; consequently, when they drop out, there are less women faculty teaching STEM courses. Then there are higher rates of attrition because there is less women faculty.

Mentioned in the section on perceptions, girls conform to rigid stereotypes and expectations that society holds. Blickenstaff (2005) expresses this anticipation where women will have to primarily become caretakers for their family. Focusing on the last piece of STEM, "Mathematics is not seen as an appropriate domain for females. Therefore, achievement by a female in the mathematical domain results in her fulfilling her sex role identity adequately."[13]

In fact, becoming the nurturer role affects women's ability to stay in their STEM careers. In the research of Ceci, Williams, and Barnett (2009), another important reason women stop climbing the ladder in STEM is having a home life as well as a work life.

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[12] Jo Boaler and Tesha Sengupta-Irving, "Gender Equity and Mathematics Education," *Encyclopedia of Diversity in Education,* (Thousand Oaks, CA: SAGE Publications, Inc., 2012), 973.

[13] Jacob Clark Blickenstaff, "Women and Science Careers: Leaky Pipeline or Gender Filter?", *Gender and Education* 17.4., (Bellingham, WA: Western Washington University, 2005), 381.

Being in STEM-intensive fields requires a lot of time, which makes commitment harder. Especially when children are involved, women prefer to be at home doing housework and taking care of their young ones.

Afterschool STEM Programs

Noticing the gender gap, the Afterschool Alliance (2011) published an article describing various programs to help students learn about STEM. These afterschool settings provide enrichment for those underrepresented in STEM, whom are women and minorities. Combining positive academic and behavioral environments, the programs yield high-quality results including the following:

1. Improve attitudes in STEM fields and careers.
2. Increased STEM knowledge and skills.
3. Higher likelihood of graduation and pursuing a STEM career.[14]

Improving attitudes led to enrollment in STEM courses in school, increased self-confidence in classes and projects, and attitude changes about potential careers in areas of STEM. While students learned general knowledge and skills, they also gained an awareness of teamwork, communication, and analytical thinking. The advances in overall knowledge led to higher test scores for participants in comparison to those who did not participate.

The program most relevant to this research is For Inspiration and Recognition of Science and Technology (FIRST). This program comprises many students, 41% of whom are girls, which is almost half of the organization. In this program, student teams have six weeks to plan, design, and build a robot to compete in various competitions.

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[14] Afterschool Alliance, *STEM Learning in Afterschool: An Analysis of Impact and Outcomes,* (September 2011), 2.

Researchers at Brandeis University conducted a retrospective study of FIRST alumni. From this study came proven results of an increased understanding of technology and science in everyday life. Not only did 80% of participants report increased self-confidence, but also "86 percent reported an increased interest in science and technology generally and 69 percent had an increased interest in STEM careers."[15] Moreover, "92 percent of respondents stated that they 'want to learn more about science and technology' as a result of their participation in FLL," a subgroup of FIRST.

Robotics to Increase Achievement

While learning skills of teamwork and communication, robotics programs also teach students about skills in science, technology, engineering, and mathematics fields. More recently robots have been used in studying human emotion and consciousness, which brings aspects of science into it. From the Viterbi School of Engineering at the University of California, PhD student Ross Mead describes his robotic interaction labs, "My focus is on making robots that understand and use body language in social interactions with people."[16] In these labs and other robot inventions, technology and engineering is used while engaging mathematical computational skills.

By excluding rote memorization and promoting creative ways to solve problems, working with robots creates an interest in STEM; furthermore, it does not feel like work and is entertaining for those who are involved. Studying robotics achievement for kindergarteners, Sullivan and Bers (2013) found that "both boys and girls were able to successfully complete the TangibleK curriculum, although as the lesson became

[15] Ibid 3.
[16] Ross Mead, *The Sum of Its Parts,* Pollinator Productions, 2014, Documentary.

increasingly difficult, both boys' and girls' scores generally decreased."[17] Overall they found no significant difference between boys and girls.

Instead of merely learning skills, students in robotics generate imagination and "can understand abstract concepts and gain a more functional level of understanding."[18] Barker and Ansorge (2007) also determined that women would be motivated to learn STEM skills with robots instead of the traditional curriculum pedagogy. The study focused on an after-school 4-H experiential science program that incorporated robotics intervention. This program revealed tremendous results showing "the overall effect size for the intervention was calculated at .943, which indicates a large effect from the robotics program."[19] Although not dividing scores of women and men, the research proves that this robotics program increases scores, by 128% for youth 9 to 11 years old. Therefore, robotic intervention is helpful in increasing achievement scores and teaching STEM skills, problem-solving skills, and teamwork skills.

Research Limitations

My study of high school students in robotics looks to show increases in scores and emphasis on STEM majors in college. If there are results showing high scores or STEM majors in college, then the assumption will be that robotics influenced it. However, since the Mount St. Joseph Academy provides an academically rigorous setting, young women

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[17] Amanda Sullivan, and Marina Umaschi Bers, "Gender Differences in Kindergarteners' Robotics and Programming Achievement," (*International Journal of Technology and Design Education* 23.3, 2013) 697.
[18] Bradley S. Barker, and John Ansorge, "Robotics as Means to Increase Achievement Scores in an Informal Learning Environment," (*Journal of Research on Technology in Education* 39.3, 2007) 230.
[19] Ibid 237.

in both the control and experimental groups will favor high scores and majors in STEM. Counteracting this, the data between both groups is averaged for more accurate results.

Some limitations occurred in the surveys of the alumni. The GPA scores were bounded at 4.0, yet the actual weighted GPA may have been larger. Therefore, this question was omitted from the analysis.

Another limiting question was Question 9: Part 6: "I often thought men had more math and science ability than women." Those surveyed were asked if they completely disagreed or agreed, with varying options in between. Although they may not agree with the statement, they may have viewed this stereotypic behavior played out in society.

In Question 7, the survey asked, "Was your graduating degree in STEM fields?" Since most have not yet graduated, it does not incorporate the alumni those respondents. Also they had the option of picking more than one area in STEM so it is not clearly distinguished how many people had a graduating degree in STEM fields.

Future Research

By studying the influencing effects of robotics for women in STEM, many other areas for research became evident. A further study for an all-male robotics team would determine if robotics plays a role in high scores and STEM majors for men. Then the next obvious step would be to do a comparative study of a co-educational robotics team.

Another recommendation for further research is to include the pattern of multiple regressions. Themes that have emerged from the research involve support from parents, teachers, and peers and additional updated information of perceptions of women in STEM.

Methodology

The main data collection for this study came from two surveys. One was specified to the experimental group or the alumni who were on the Firebirds Robotics Team. The other survey was indicated for the control group or those not on the team. As emails get lost and change throughout time, about one hundred out of the roughly five hundred emails sent were rejected. Out of the Mount Saint Joseph Academy graduation population from 2010-2014, there were 104 total responses to the surveys, which is roughly a 25% responding rate. Of the responders, 28 were robotics and 76 were non-robotics. The differing population size made it imperative for averages to be used instead of any other statistical analysis.

The survey for both groups had most of the same questions, except number ten and eleven that were solely for the experimental group. The questions for both the control and experimental group consisted of the following:

1. What year did you graduate Mount Saint Joseph Academy?
2. What was your final GPA? (Round to the nearest tenth)
3. What was your SAT score?
4. What was your total SAT score?
5. What was your initial Major in College?
6. If you changed your Major, what did you change it to?
7. If you changed your Major, why did you change it?
8. Was your graduating degree in STEM fields?
9. If you graduated or have a job already, what position and career field are they?
10. How did you feel in each instance BEFORE joining Firebirds Robotics?
11. How did you feel in each instance AFTER joining Firebirds Robotics?

Although numbers three and four may appear the same, number three asked to distinguish their SAT scores for each separate section. Besides the first range, the scale

was out of 50 points, e.g. SAT Mathematics score 200-250, 260-300, 310-350, … , 710-750, or 760-800. Then, number four asked alumni to simply state their total SAT score.

Data Analysis

Since the GPA scores were constricted by the upper bound of 4.0, many respondents were not able to type in their correct average. Also mentioned in the limitations, the data of the SAT and GPA scores of both robotics and non-robotics are very similar to each other from the nature of the high academic setting. However, the surveys delineated some significant differences.

QUESTION THREE. There were some outliers in the control group that brought down the average; nonetheless, there are important figures to note. Between the SAT Writing scores of 200 through 500, the control group answered 2.66% of the time while the experimental group answered 0.00% of the time. The SAT Critical Reading scores from 200-550 showed 14.48% for the control group and 0.00% for the experimental. Similarly, from the SAT Mathematics scores of 200-450, the control group answered 3.96% on the time while the experimental group was at 0.00%.

With the smallest range of 0.00% answering for the experimental group, SAT-M can be seen as the most difficult of the sections for both groups. However, in a 260 point difference, the experimental group did not answer with the lower part of the scale and the control group did, which could be an indicator of robotics influencing math testing scores.

The higher side of the scale from the range 610 to 800 showed small differences for the experimental and control groups respectively. Responses for SAT-W showed a small variation of *6.62%* with each group at 89.28% and 82.66%. The SAT-CR responses were more variant with 89.29% and 74.99% for the groups, which showed a *14.30%* disparity. With the most significant difference, the answers for SAT-M were at 85.71% and 67.10% that consisted an *18.61%* variance. Since the experimental group was higher in all three sections, higher SAT skill in writing, reading, and mathematics may be reflective of being on robotics. Table 1 on the next page creates a more formal analysis of the SAT ranges for each section.

QUESTION FOUR. From the 76 responses in the control group, only 59 answered with their SAT score since many did not remember their total score. The scores were scattered with the outlier being 1200 and the highest consisting of 2400. The average of these scores was 2051.69492 or about 2050.

All 26 in the experimental group answered this question. The outlier in this set was 1560 while the highest was 2380. Averaging the scores gave 2059.61538 or approximately 2060.

These results show a ten-point difference, which cannot account for a significant difference. The low outlier could be the reason why the score was lower. In this situation, the variation was not noteworthy, which robotics cannot claim influence.

SAT Writing Score	200-300	310-350	360-400	410-450	460-500	510-550	560-600	610-650	660-700	710-750	760-800
Robotics	0.00%	0.00%	0.00%	0.00%	0.00%	7.14%	3.57%	10.71%	14.29%	35.71%	28.57%
Non-Robotics	0.00%	0.00%	1.33%	0.00%	1.33%	5.33%	9.33%	21.33%	25.33%	14.67%	21.33%

Table 1A. Data from the survey of the experimental and control groups for SAT Writing Scores.

SAT Critical Reading Score	200-300	310-350	360-400	410-450	460-500	510-550	560-600	610-650	660-700	710-750	760-800
Robotics	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.71%	14.29%	25.00%	21.43%	28.57%
Non-Robotics	0.00%	0.00%	1.32%	1.32%	3.95%	7.89%	10.53%	21.05%	23.68%	15.79%	14.47%

Table 1B. Data from the survey of the experimental and control groups for SAT Critical Reading Scores.

SAT Math Score	200-300	310-350	360-400	410-450	460-500	510-550	560-600	610-650	660-700	710-750	760-800
Robotics	0.00%	0.00%	0.00%	0.00%	7.14%	7.14%	0.00%	21.43%	32.14%	25.00%	7.14%
Non-Robotics	0.00%	1.32%	1.32%	1.32%	1.32%	11.84%	15.79%	28.95%	21.05%	7.89%	9.21%

Table 1C. Data from the survey of the experimental and control groups for SAT Mathematics Scores.

QUESTIONS FIVE AND SIX. These questions refer to their initial college major and the one they changed to, if any. To analyze these questions, I tallied up each major and split them into categories of STEM, Business, Liberal Arts, Nursing, and Undeclared. A problem occurred when responses included dual majors in two different classifications. If one major was related to STEM, I automatically placed it into that section. If the majors were unrelated to STEM, I placed it into whichever the first one happened to be, e.g. Business and History would be put into Business. This is due to an assumption that students put the major most valuable to them first.

Many changes were made from the initial to final majors, as is expected for college students deciding on careers. Changes within a classification were not counted in this study; conversely, changes from one major to another were put into the tallying process. The percentages in the analysis of these questions are shown in Table 2. The majority of all alumni in both groups chose STEM majors for both initial and final major, with a minimal attrition rate of 5.769%.

Initially, 17 in the experimental group declared a major in STEM but only 15 continued in a STEM major. The decrease of two people did not dramatically affect the percentage of majors in STEM for this group. With a final major in STEM, the percent of the experimental group was 53.57142% while the percent of the control group was 38.15789%. This 15.41353% difference is notable to the influence of robotics on STEM.

Classifications of Majors	Robotics	Robotics	Non-Robotics	Non-Robotics
	Initial Major	Final Major	Initial Major	Final Major
STEM	𝍸 𝍸 𝍸 || 17	𝍸 𝍸 𝍸 15 **54%**	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 ||| 33	𝍸 𝍸 𝍸 𝍸 𝍸 |||| 29 **38%**
Business	|||| 4	𝍸 ||| 8 **29%**	𝍸 𝍸 || 12	𝍸 𝍸 𝍸 | 16 **21%**
Liberal Arts	𝍸 | 6	𝍸 5 **18%**	𝍸 𝍸 𝍸 𝍸 || 22	𝍸 𝍸 𝍸 𝍸 𝍸 || 27 **36%**
Nursing	0	0 **0%**	𝍸 5	|||| 4 **5%**
Undeclared	| 1	0 **0%**	|||| 4	0 **0%**

Table 2. Differences in Initial and Final Majors of the experimental (robotics) and control (non-robotics) groups.

QUESTION SEVEN. Both groups portrayed curriculum bias as reasons why they left STEM majors. Entering into school with an Electrical Engineering degree, one respondent in the experimental group switched to Psychology saying, "I struggled with the 'hard science' prerequisites." In the control group, one woman "was not well-prepared for my chemistry classes, and felt that I didn't enjoy the lab work as much as I thought I might" and changed her Biology major to one in Spanish and Economics.

Another in the control group switched from Neuroscience to Psychology because "I decided I didn't like all the Biology that went with neuroscience and decided to focus

on Psychology to eventually maybe go into cognitive psychology and psycholinguistics." Similarly, one person "realized Biology was not for me… high school Biology wasn't the same…misleading" and so went to Geology. Although still a STEM major, Geology was not as difficult as Biology since she was not prepared. Still one more responded that she was not interested in Biology and consequently changed to Health Science.

Switching from Chemistry to Accounting, a young woman in the experimental group chose to use her leadership and interpersonal skills that she learned from being the Firebirds president. This more analytical, faster-paced topic broadened the area in her mind more that the perhaps limited or narrow view of science. These examples could refer to curriculum bias, differences in the brain, or stereotypic threats from college classrooms.

Many suggested that they did not like or were not prepared for the "hard science" classes like Biology, Engineering, and Chemistry. Arguably, this could reference to these curriculums not focusing on engaging lessons or in-depth instructions, which are proven areas where women succeed. Being in these courses where men dominate can falsify their perceptions of women in STEM leading them to believe that women are not able to complete high-level STEM classes. It is possible that coming from an all-girls school may not have prepared the students to be involved in higher-level STEM courses with young men. Also, not having many female STEM professors would not provide them with models to look up to, which can dissuade them from pursuing STEM fields.

QUESTIONS TEN AND ELEVEN. Although not part of the problem question, determining perceptions of the robotics team before and after joining provides important information. These questions were just for the experimental group to answer. For each question, there were seven different parts. They answered to each part by clicking on a scale from completely disagree to completely agree with three ranges in between. From the 25 responders to the questions, about 20% often heard about women in STEM before robotics compared to the 64% who heard more about it after joining.

The next two parts of each question dealt with their feelings towards women in STEM—if it was negative or positive. Before joining the team, this group answered *completely disagree* 64% of the time in feeling negatively towards women in STEM; however, after robotics, the percentage that completely disagreed went up to 84% with a 20% increase. The positive feelings towards women in STEM also increased by 20% after being in robotics. Answering *completely agree*, the robotics alumni felt positively towards women in STEM 56% before joining and 76% after joining.

When answering *I often thought men had more math and science ability than women*, most participants disagreed. Before robotics, 44% completely disagreed while it was at 60% after robotics. This could show robotics as an influencer in their skills and in the perception they had. The following tables distinguish the differences in averages.

BEFORE Robotics	Completely Disagree		Indifferent		Completely Agree	Total
I often heard about women in STEM.	8.00% 2	24.00% 6	8.00% 2	40.00% 10	20.00% 5	25
I felt negatively towards women in STEM.	64.00% 16	16.00% 4	16.00% 4	0.00% 0	4.00% 1	25
I felt positively towards women in STEM.	0.00% 0	0.00% 0	32.00% 8	12.00% 3	56.00% 14	25
I always did well in math and science courses.	0.00% 0	20.00% 5	12.00% 3	20.00% 5	48.00% 12	25
I never did well in math and science courses.	60.00% 15	28.00% 7	0.00% 0	12.00% 3	0.00% 0	25
I often thought men had more math and science ability than women.	44.00% 11	20.00% 5	4.00% 1	28.00% 7	4.00% 1	25
I would join a co-ed robotics team.	8.33% 2	20.83% 5	20.83% 5	33.33% 8	16.67% 4	24

Table 2. Shows how alumni from the Firebirds Robotics Team felt before joining the team.

AFTER Robotics	Completely Disagree		Indifferent		Completely Agree	Total
I heard more about women in STEM.	0.00% 0	0.00% 0	8.00% 2	28.00% 7	64.00% 16	25
I felt negatively towards women in STEM.	84.00% 21	8.00% 2	4.00% 1	0.00% 0	4.00% 1	25
I felt positively towards women in STEM.	0.00% 0	0.00% 0	8.00% 2	16.00% 4	76.00% 19	25
I did better in math and science courses.	8.00% 2	20.00% 5	52.00% 13	12.00% 3	8.00% 2	25
I still thought men had more math and science ability than women.	60.00% 15	12.00% 3	20.00% 5	4.00% 1	4.00% 1	25
I would join a co-ed robotics team.	4.17% 1	12.50% 3	33.33% 8	29.17% 7	20.83% 5	24

Table 3. Shows how alumni from the Firebirds Robotics Team felt after joining the team.

Not all parts of questions ten and eleven were analyzed since there were no significant differences to delineate. Specifically, parts three, four, and seven from Table 3 and parts four and six from Table 4 were not included. Describing their academic achievement in mathematics and science courses, the majority of the group picked "indifferent" to doing better in the classes even after being on the robotics team. For the last part in each, the group answered more to be indifferent or agree with joining a co-ed robotics team.

Conclusion

The research conducted in this study indicates that robotics has an influence on women choosing STEM majors. The differences between the experimental and control groups were not as vast as anticipated. However, it should be noted that there were significant variations between robotics and non-robotics in their SAT scores and the College Majors that they chose. These differences suggest some correlation between robotics and high SAT scores and STEM Majors in College.

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