

**Encouraging Women and Underrepresented Groups in STEM Careers
Through Agricultural Education and Role Model Workshops**

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Abstract

Women often need encouragement to select STEM educational programs, earn degrees in these fields, and pursue careers within the STEM workforce. This study examined the impact of role model workshops and a summer program for high school students on STEM interest. Many students reported a shift in their perspectives on STEM careers, expressing increased confidence in their ability to pursue careers in these fields. Results from the summer program indicated a generally positive trend in students' attitudes toward science after their summer camp experience. Additionally, the findings shed light on the significant influence of both parental and teacher support on students' perceptions of science and education.

Keywords: STEM, role model workshops, attitudes toward STEM

Resumen

Las mujeres a menudo necesitan aumentar el interés en programas educativos STEM, obtener títulos en estos campos o seguir carreras dentro de la fuerza laboral. Este estudio examinó el impacto en el interés hacia STEM a través de talleres de modelos a seguir y un campamento de verano para estudiantes de escuela secundaria. Una gran cantidad de los participantes presentaron un cambio en sus perspectivas sobre las carreras STEM y expresaron una mayor confianza en su capacidad para seguir carreras en estos campos. Los resultados del programa de verano indicaron

una tendencia generalmente positiva en las actitudes de los estudiantes hacia las ciencias después de su experiencia en el campamento de verano. Además, los hallazgos arrojan luz sobre la influencia significativa del apoyo tanto de los padres como de los maestros en la percepción de los estudiantes sobre la ciencia y la educación.

Palabras clave: STEM, talleres de modelos a seguir, actitudes hacia STEM

Introduction

Guiding students toward careers in science, technology, engineering, and mathematics (STEM) is essential for meeting the future demands of the U.S. workforce (Sadler et al., 2012). STEM fields are critical for developing solutions to global crises, particularly the challenges of food security exacerbated by climate change's impact on agriculture. The National Research Council (NRC) and the President's Committee of Advisors on Science and Technology (PCAST) emphasize the urgency of this issue and propose strategies to address the growing need for STEM professionals. However, women continue to be significantly underrepresented in these fields. In 2015, women accounted for only 28% of the STEM workforce despite making up 50% of the overall college-educated workforce (National Science Foundation, 2018). Research shows that having role models can substantially enhance retention rates in STEM (Baker & Leary, 2020). Role models can inspire and help reduce self-stereotyping among marginalized groups (Schmidt & Galindo, 2018). According to Smith and Doe (2021), specific interventions have decreased stereotypical images of STEM workers and increased enrollment of high-achieving 12th-grade girls in male-dominated STEM programs. Exposing female students to successful and admirable women can help break this cycle, significantly improving female representation in traditionally male-dominated fields of study (Lin et al., 2016).

Agriculture is an essential STEM field career and deserves significant consideration.

According to the U.S. Department of Agriculture, the agricultural sector of Puerto Rico—a U.S. territory—is comparatively small, making up only a fraction of 1 percent of the island's gross domestic product (GDP) in 2021. In the past, Puerto Rico's agricultural industry had more economic significance, surpassing 40 percent of the island's GDP in the mid-1930s. Even with incentives to increase production, agriculture generally provides a small share of farm household income, and few Puerto Rican households entirely rely on farming (Marrero & Gonzalez, 2019). According to the Milken Institute School of Public Health, about 40% of Puerto Ricans in general, and 56% of Puerto Rican children specifically, are estimated to be food insecure. This is a much higher rate than that of any U.S. state. The U.S. has an average food insecurity rate of just 10.4%.

According to Riegle-Crumb (2006), high school is a critical period for students to explore and develop an interest in STEM disciplines. In response, various educational programs focused on STEM have been designed to enhance K-12 students' knowledge, skills, and motivation in these fields (Stubbs et al., 2016). Our initiative comprises two key interventions: (1) role model workshops and (2) a summer camp program specifically tailored for high school students. We target women from the rural, economically disadvantaged eastern region of Puerto Rico. The role model workshops serve a dual purpose: to enrich students' academic preparation through diverse topics presented by each speaker and to provide inspirational role models. Speakers share pivotal experiences that shaped their educational and scientific careers, including personal and academic challenges they overcame. The Summer Program's development and design were based on Castleman, Page, and Schooley's (2014) work. Overall, this project seeks to enhance academic preparation, develop leadership and professional skills, and provide guidance from female role

models. The long-term goal is to increase representation and support for women and underrepresented minorities in STEM fields, particularly agriculture.

Methods

Sample

The role model workshops included 43 students from a public high school in Puerto Rico, selected from two ninth-grade groups. Only 16% of the participants expressed interest in a science career. All were low-income and Hispanic, with 53% identifying as female and 47% as male. Regarding post-high school aspirations, 16% aimed for a certificate, 11% for an associate degree, 34% for a bachelor's degree, and very few for master's (0.02%) or doctoral degrees (0.09%).

Summer Program

The summer program application was emailed to science teachers and posted on the campus webpage, requiring applicants to provide demographic information such as household income, current grade level, GPA, and anticipated career interests. The enrolled students consisted of 22 students from ninth to eleventh grades, with 81% of them being female and 19% male, and all identifying as Hispanic and low-income. Of the students, 68% came from public schools and 32% from private schools. Students' interest in STEM careers was 30%.

Instruments

All program activities, including the role model workshops and summer camp daily activities, were assessed via an evaluation sheet. The evaluation sheet features a scale of "I like" and "I do

not like" and sections for students to share their comments. In addition, to evaluate the impact of the Summer Program on students' interest in pursuing a STEM career, we used a revised version of the STEM Career Interest Survey (STEM-CIS), which we adapted from the original developed by Kier et al. (2014). The STEM Career Interest Survey was applied as a pretest before and posttest after the program. Finally, at the end of the summer camp, the students completed an evaluation using a satisfaction survey that employed a Likert scale with options including "Strongly Agree," "Agree," "Disagree," and "Strongly Disagree."

Procedure

As previously stated, the program included a series of role model seminars and a summer program focused on agriculture, both directed to high school students. Workshops included lectures and active learning activities (Table 1). In the first year, workshops featured women speakers who shared their personal experiences, including their challenges, job satisfaction, and the opportunities available in STEM fields for young people. In the second year, the seminars covered agriculture, global warming, and allotment gardening.

Table 1

Workshops and Speakers

Workshops	Speakers	Active Learning Activity
Motivate and empower future women scientists	Offered by a woman scientist	Drew the perception of scientist before the workshop.
Enhancing my self-esteem	Offered by a psychologist	Looked in a mirror and described what they saw.
Motivate and empower future women scientists	Offered by a psychologist	Talked in groups about the positive characteristics they had.
Women in science	Offered by a woman scientist	Selected the prominent woman in science from the presentation who impressed them the most and explained why.

Workshops	Speakers	Active Learning Activity
Scientific Communication	Offered by a woman scientist	Developed a short communication to explain a scientist's results.
Climate change and Agriculture	Offered by a woman scientist	Presented different solutions to deal with the effects of global warming.
Compost	Offered by a woman scientist	Selected the best materials for a good compost from a worksheet.
Resilience and stress	Offered by a woman psychologist	Presented the stress triggers and how they managed them.
Importance of nutrition	Offered by a woman teacher	Selected from a list the best foods for good nutrition.

During the Summer Program, students engaged in hands-on activities such as developing an allotment garden, researching the nutritional value of food, and participating in various agriculture-related projects, as illustrated in Table 2. Students were guided by STEM faculty, psychologists, academic advisors, and undergraduate students. To reduce barriers to participation from underrepresented groups, the program was free for participants and provided lunch. At the end of each day, students completed assessments to evaluate their experiences. This daily evaluation process provided insights into the effectiveness of the day's activities and captured students' engagement and satisfaction. In addition to these daily evaluations, a comprehensive assessment of the camp experience was conducted to understand its overall impact. The STEM Career Interest Survey was administered before the program began to establish a baseline of participants' scientific interest and knowledge and gauge the program's further impact on students' interest and knowledge in science. The survey was also conducted at the end of the three-week program to identify student interest and knowledge changes.

Table 2*Summer Camp Activities*

Topic	Activity
Who am I? Who are you?	Offered tools for young people to increase their self-esteem. Conducted an activity for them to recognize their qualities.
Laboratory Safety Rules	Established science lab safety rules to offer participants real security situations through an experiment.
Vital Functions and Energy Production	Analyzed how energy production supported vital functions and the body's overall energy balance.
Macronutrients Experiment	Explored the primary functions of carbohydrates, proteins, and fats in the body and how they contributed to energy production and overall health through a laboratory experiment.
Nutrition in Living Organisms	Explained the different modes of nutrition (e.g., autotrophic, heterotrophic) across various species, including plants, animals, and microorganisms, through a laboratory experiment.
Digestion and Health	Examined various digestive disorders and their impact on nutrition and health, including strategies to manage and improve digestive health through diet and lifestyle changes, through a laboratory experiment.
Campus Tour and Allotment Gardening Management Orientation	Provided a comprehensive tour of key campus areas, including the allotment gardens, to help participants navigate the space and understand the resources available for gardening and campus life.
Seedbed Creation Workshop	Learned the essential steps in preparing a seedbed, including soil selection, seed planting techniques, and environmental considerations for optimal growth, and created their own seedbed.
Theory of Absorption Spectrophotometry	Explored the fundamental concepts behind absorption spectrophotometry, including the interaction of light with matter, the Beer-Lambert law, and how absorbance was measured.
Self-Management	Provided participants with a clear understanding of what self-management is and why it was important.
Preparing a Home Garden	Provided participants with fundamental knowledge about home gardening and introduced basic concepts, including soil types, plant selection, and garden design.
Maintaining of the Allotment Garden Plants	Discussed soil testing, improving soil quality with compost and organic matter, and methods for maintaining soil fertility and structure. Visited the greenhouse daily to perform maintenance.
Planting a Home Garden	Introduced the basics of garden planning, including choosing the right location, designing the layout, and selecting plants suited to the garden's conditions.
Preparing Sofrito and Its Importance in Puerto Rican Cuisine	Discussed methods for freezing or refrigerating sofrito and how to maintain its flavor and quality over time. Investigated how sofrito recipes differed by region or individual preferences, including ingredient substitutions and variations in proportions.

Topic	Activity
Composting and Its Importance in a Home Garden	Explained what composting is, including the decomposition process and the types of materials used to create compost. Created their own compost apparatus.
Women in Science	Motivated and empowered women to see science as an opportunity for study.
Absorption Spectrophotometry Data Interpretation	Taught how to identify and interpret peaks, determine their positions, and understand their significance in relation to the sample's composition and concentration.
Is College for Me?	Facilitated discussions and activities that encouraged participants to reflect on their career aspirations, interests, and long-term objectives, and how a university degree might support these goals.
What are my Goals?	Used activities and prompts to help students reflect on their interests, values, and future aspirations to set meaningful goals.
Field Trip to a Producer	Provided participants with a comprehensive understanding of the cultivation techniques used at the site.

Results and Discussion

The study used quantitative and qualitative data to identify effective strategies for motivating women in STEM. Most students rated their role model workshop experience positively (Table 3); critical written feedback revealed that many felt their perspectives on STEM careers shifted, boosting their confidence in pursuing these fields.

Table 3

Role Model Workshops Evaluation

Workshop	I like (%)	I don't like (%)
Motivate and Empower Future Women Scientists (Focus on Chemistry)	94%	6%
Enhancing my Self-Esteem	94%	6%
Motivate and Empower Future Women Scientists (Psychologically)	92%	8%
Women in Science	100%	0%
Scientific Communication	90%	10%
Climatic Change and Agriculture	100%	0

Workshop	I like (%)	I don't like (%)
Compost	92%	8%
Resilience and Stress	96%	4%
Importance of Nutrition	81%	19%

Some Student Comments:

- *The workshops helped me to improve my confidence and to pursue a dream.*
- *I learned to value myself and not to follow other people's comments.*
- *They taught us that women can do it too*

Summer Camp Activities

The summer program results, detailed in the following tables, indicate that most students provided positive feedback on the evaluation scale. This suggests a robust overall satisfaction with their experiences throughout the camp (Table 4). In the overall evaluation, it is noteworthy that 100% of the participants rated each criterion as either "strongly agree" or "agree."

Table 4

Summer Program Evaluation

Camp Day	I like (%)	I don't like (%)
Day 1	95%	5%
Day 2	95%	5%
Day 3	90%	0%
Day 4	100%	0%
Day 5	100%	0%
Day 6	94%	0%
Day 7	96%	0%
Day 8	91%	0%
Day 10	88%	10%

Note: Percentage discrepancies are due to some students not completing the evaluation.

Summer Program Students Comments:

- *It is an excellent camp, it made me realize that I love planting, and I really like it! And I will start allotment gardening in my house!*
- *I really liked the camp and would like to return.*
- *I loved the dynamics and the different topics that were discussed. In short, I can say that it was very well organized.*

STEM Career Interest Survey (STEM-CIS)

The interest in science test was administered in Spanish on the first day of summer camp as a baseline to assess students' science perception. A follow-up test was given on the final day to measure any changes. We also asked the students to assess their parents' and teachers' perceptions of school and science, but this portion was not included in the post-assessment, as the summer camp did not directly impact parents or teachers. Table 5 shows average pre- and post-assessment scores on STEM interests, including enjoyment, perceived usefulness, and understanding of science concepts.

Table 5

STEM Career Interest Survey (STEM-CIS)

	Strongly agree		Agree		Disagree		Not sure	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
I enjoy science.	23%	0%	55%	80%	9%	0%	14%	20%
Science is useful in my daily life.	18%	13%	68%	73%	5%	0%	9%	13%
Scientists often lack social skills.	0%	0%	9%	0%	73%	80%	18%	20%
Working on scientific research makes me feel nervous or disturbed.	0%	0%	0%	7%	82%	80%	18%	13%
Science challenges me to use my intellect.	18%	20%	73%	60%	5%	0%	5%	20%
The scientific education I have received will be useful to me in the future.	18%	27%	59%	67%	14%	0%	9%	7%
Scientists often work with colleagues as part of the team.	14%	33%	73%	53%	0%	0%	9%	13%
I'm good at science.	14%	0%	41%	47%	27%	13%	18%	40%
Advances in science and mathematics are largely responsible for the quality of life in Puerto Rico.	27%	40%	68%	47%	5%	0%	0%	13%

	Strongly agree		Agree		Disagree		Not sure	
I usually understand what we are doing in science class.	27%	13%	59%	73%	5%	0%	9%	13%

There was a notable increase in positive responses about enjoying science after the camp, with 80% of students agreeing in the post-test compared to 55% in the pre-test. This indicates that the camp had a significant impact on students' enjoyment of science. Similarly, the percentage of students who agreed that science is useful in daily life increased from 68% in the pre-test to 73% in the post-test, demonstrating an improved understanding of the practical applications of science.

Another important change was in students' perceptions of scientists' social skills. Those who disagreed with the statement that "scientists often lack social skills" rose from 73% to 80%, suggesting that the camp helped to challenge stereotypes about scientists being socially disconnected and improved students' perceptions of the profession. The perceived future usefulness of scientific education also showed a positive shift, increasing from 59% in the pre-test to 67% in the post-test. This suggests that students felt more confident about the relevance and applicability of their science education to their future careers and life choices.

Interestingly, when it came to teamwork in science, the percentage of students who agreed that "scientists often work with colleagues as part of the team" decreased from 73% to 53%. This drop could indicate a shift in how students perceive collaboration in scientific fields, potentially reflecting a more individualized view of science work or a decreased emphasis on teamwork in the camp activities.

In terms of self-perception, there was an improvement in how students viewed their scientific abilities. The percentage of students agreeing that they are good at science rose from

41% in the pre-test to 47% in the post-test, suggesting a boost in students' confidence in their scientific skills following the camp. The results were mixed when discussing the impact of science on the quality of life in Puerto Rico. While 40% of students strongly agreed post-camp and 47% agreed, the data suggests that students have a more nuanced view of science's role in societal development. This indicates that the camp may have encouraged critical thinking about the broader implications of science in the real world. Finally, there was an increase in students' understanding of what was being taught in science class, with the percentage of students who felt they understood the material rising from 59% to 73%. This suggests that the camp helped improve students' comprehension and engagement with science content.

Additionally, we asked students to assess their parents' and teachers' perceptions of school and science (see Tables 6 and 7). Notably, 91% of students believe their fathers expect them to complete university, with 41% strongly agreeing and 50% agreeing. This suggests that most students feel a strong expectation from their fathers regarding higher education.

In terms of academic support, 77% of students reported that their fathers frequently help with schoolwork, with 72% agreeing and 5% strongly agreeing. However, 23% were unsure whether their fathers offer academic help, highlighting a potential gap in perceived support. Regarding the recognition of academic achievements, 72% of students feel they are rewarded for good grades, with 58% agreeing and 14% strongly agreeing. However, 23% were unsure whether they receive such recognition, which points to inconsistencies in how academic success is celebrated within families. When it comes to the availability of fathers for academic support, 23% of students were unsure if their fathers have time to assist, while 46% believe their fathers are too busy to help.

This indicates that students may perceive their fathers as having significant external responsibilities, limiting their involvement in academic activities.

In terms of support for success in the sciences, only 9% of students feel their fathers expect them to excel in this area, while 36% disagree with this statement. Alarming, 55% agree that their fathers hope for them to succeed in the sciences, which reveals a notable difference in expectations. Regarding the importance of science, 69% of students recognize its value, with 14% strongly agreeing and 55% agreeing, while 26% remain unsure. This highlights a fairly positive perception of science, though some uncertainty persists.

As for career aspirations in STEM fields, only 27% of students feel their fathers want them to pursue careers in science, mathematics, technology, agriculture, or engineering. A significant 63% of students were unsure, which suggests a disconnect between fathers' aspirations and the students' perceptions of these aspirations. This points to a need for more open dialogue about career paths and goals within families.

Table 6

Students' Perception of Their Parents' Expectations

	STRONGLY AGREE	AGREE	DISAGREE	NOT SURE
They expect me to finish university.	41%	50%	0%	9%
They often help me with my academic work.	5%	72%	0%	23%
They reward me for getting good grades.	14%	58%	5%	23%
They are very busy and don't have much time to help with my tasks.	9%	36%	9%	46%
They hope I succeed in the sciences.	9%	55%	36%	0%
They think that science is a very important subject.	14%	55%	5%	26%

	STRONGLY AGREE	AGREE	DISAGREE	NOT SURE
They would like me to have a career in science, mathematics, technology, agriculture and engineering.	23%	5%	9%	63%
My parents make sure I do my assignments.	27%	64%	9%	0%
They ask me what I'm doing at school.	18%	72%	5%	5%

Finally, we asked students for their perceptions of their science teachers and courses (see Table 7). A significant 82% of students feel that their teachers push them to excel, reflecting a strong commitment to fostering academic growth. Similarly, 78% of students believe their teachers encourage them to explore science further, which can spark a lasting interest in the subject. Regarding engagement, 86% agree that classes are interesting, and 73% recognize their teachers' enthusiasm for science, creating an inviting classroom atmosphere. Furthermore, 76% of students appreciate that important real-world topics are discussed, effectively linking classroom learning to practical applications and enhancing the overall learning experience.

Importantly, no students found science topics boring, which suggests effective teacher engagement. However, perceptions of classroom resources are mixed; while 55% of students agree that the classroom has interesting equipment, many remain unsure about its effective use, indicating a potential area for improvement. In conclusion, while students view their teachers positively, enhancing classroom resources could further enrich the learning experience and deepen engagement in science.

Table 7

*Students' Perceptions of Their Science Teachers and Courses**Students Perception on Their Teachers*

	Strongly agree	Agree	Disagree	Not sure
They push me to be better at the subject.	23%	59%	0%	18%
They encourage me to learn more about science.	23%	55%	0%	22%
They make science class interesting.	19%	67%	0%	14%
They are enthusiastic about science.	18%	55%	0%	27%
They discuss science topics that are important in the real world.	24%	52%	0%	24%
Science class topics are boring.	0%	0%	33%	67%
My science classroom has interesting equipment.	5%	55%	0%	40%
They do not use the science classroom equipment.	23%	59%	0%	18%
They push me to be better at the subject.	23%	55%	0%	22%

Conclusions

This study offers crucial insights for parents, educators, administrators, and curriculum developers, aiming to foster new STEM opportunities. These insights are not just informative, but they also have the potential to significantly impact the future of STEM education. Ultimately, this could encourage greater participation of girls in STEM subjects and inspire them to consider careers in these fields.

Evaluation results from the role model workshops suggest that exposing high school girls to these experiences significantly enhances their self-esteem, confidence, and motivation to pursue careers in STEM fields. Participants reported feeling more empowered and inspired to explore STEM-related opportunities, which indicates that such programs can effectively encourage greater female representation in these areas. The summer program experience significantly improved students' attitudes toward science. Overall, the camp positively influenced

students' perceptions of science, but some complexities warrant additional investigation.

Strengthening these areas may empower students to pursue their interests and excel in their educational journeys.

This study highlights significant insights into parental and teacher influences on students' perceptions of science and education. Overall, while there are positive indicators of support from parents and teachers, enhancing engagement and communication about academic and career aspirations could empower students to thrive in their educational journeys.

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