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BREAKING GENDER STEREOTYPES: HOW INTERACTING WITH STEM PROFESSIONALS CHANGED FEMALE STUDENTS' PERCEPTIONS

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Abstract. *Various studies have reported that students have limited, stereotypical perceptions of STEM fields. However, few studies have attempted to evaluate interventions undertaken with the aim of changing female student's perceptions of STEM professions. This research aimed to examine the changes in mental images among female students as a result of interacting with STEM professionals in a STEM camp. The Draw-a-Scientist Test was revised, and female students were asked to draw and describe STEM professionals at work before and after attending STEM camp. The participating students attended workshops and career talks given by STEM professionals. The findings showed that the perceptions of the participating female students regarding gender images of STEM professionals changed. After the STEM camp, it was also observed that knowledge about STEM professionals and the content of their work had increased. The studied intervention program for female students positively contributed to changes in the students' mental images of STEM professionals. Therefore, it is recommended that female students interact with professionals working in STEM fields to change their perceptions of those fields.*

Keywords: *female students, gender stereotypes, human images in STEM, role models, STEM*

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Introduction

As students gain experience as learners, many of them imagine their possible selves in terms of what they do and do not want to be in the future (Markus & Nurius, 1986). In spite of growing demands for a better understanding of science, technology, engineering, and mathematics (STEM) within communities (National Research Council [NRC], 2011) and more STEM-literate citizens (Zollman, 2012; Huang et al, 2022), there seems to be reluctance among students to participate in STEM fields (Stephenson et al., 2021). A large body of research has addressed ongoing concerns about gendered professional participation and the underrepresentation of women in STEM-related occupations, focusing on international statistics, the departure of women from STEM fields, and disinterest among female students in pursuing STEM careers (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2020; National Science Foundation [NSF], 2019). The underrepresentation of women in STEM fields is attributed in part to early gender socialization, such as the perpetuation of stereotypes, during a developmental stage in which academic identities and interests are emerging (Rogers et al., 2021). It is important to understand how the disintegration of the STEM identities of female students begins in order to stop the process and guide more female students toward successful STEM careers (Corrigan & Aikens, 2020). The forms of interaction of people in society both reflect and influence the formation of their identities, beliefs, values, and choices, which are affected by stereotypes that are transmitted explicitly and implicitly from childhood. This leads girls to believe that STEM subjects in general are for boys, which in turn affects girls' confidence and interest in studying STEM-related topics. Despite the significant concern surrounding the underrepresentation of female students in STEM classes at both grade schools and universities, it's worth noting that prior research on gender differences among students in classrooms that implement integrated STEM projects remains relatively limited compared to the broader body of research on gender differences in science education (Koul et al., 2021).

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Within this context, informal STEM education programs have become spaces where action and advocacy can take place in safe settings while students work with role models who resemble them and participate in STEM projects with professionals from these fields. Studies have shown that interventions such as science camps shape students' images of scientists (Leblebicioglu et al., 2020). Fostering a social environment where female students can identify with successful female role models in STEM can help change stereotypes about women in STEM. The aim of the present study is to examine the effects of a career-based STEM teaching model on female students' perceptions of STEM professions. After providing the theoretical background, the research findings from an experimental STEM education intervention program for female upper-secondary students are discussed to evaluate whether this model creates conditions for female students to develop positive images of STEM professions.

Literature Review

Gender Gap in STEM

As women constitute an average of 30% of research and development employees and only 18% of relevant task forces, they are underrepresented in these fields in many countries around the world (UNESCO, 2020). In the United States, 18.7% of all students earning a bachelor's degree in computer science are women, while this rate is 20.9% in engineering, 42.4% in mathematics and statistics, and 19.3% in physics (NSF, 2019). Female students often begin to question their sense of belonging in STEM fields, also known as STEM identity, during adolescence (Roberts & Hughes, 2019). Accordingly, there are significant decreases in the percentage of female students who choose to pursue STEM subjects or show interest in STEM professions, especially after starting upper-secondary (Chen et al., 2022). It has been shown that gender differences in STEM career interests are common among upper-secondary students (Mau et al., 2020). Hence, it is imperative to consistently explore strategies for nurturing and sustaining STEM aspirations among students, irrespective of their gender, throughout their educational journeys (Chen et al., 2022). The notion that STEM fields entail limited interpersonal interaction and the perpetuation of gender-biased stereotypes about STEM professionals in mainstream media can potentially hinder the development of a strong STEM identity, particularly among adolescent girls (Master & Meltzoff, 2020). Pilotti (2021) offered a nuanced perspective on the various forms of gender bias and recommended the implementation of tailored educational interventions aimed at enhancing the motivation and enrollment of women in STEM disciplines.

Images of STEM Professions

As the significance of scientific knowledge continues to gain prominence, nations are increasingly focusing their efforts on augmenting both the quantity and caliber of scientists who play a pivotal role in advancing our understanding of the world through scientific research (Karacam et al., 2021). The global competitiveness of countries is often suggested as a key outcome of developing a skilled STEM workforce (Bybee, 2013; Constan & Spicer 2015). Studies have shown that students have stereotypical images of scientists; for example, scientists are often portrayed as men wearing lab coats, with curly hair, beards, and glasses, working with test tubes in a laboratory (Ateş et al., 2020). It is not easy to change that stereotypical image of scientists because individuals, and especially women, are exposed to such stereotypes for years through the media, textbooks, and social media (Karacam et al., 2021). A close connection is perceived to exist between science and masculinity in our society today, historically informed by masculine conceptions of scientific professions (Archer et al., 2013). In the literature, there is growing interest in students' perceptions of scientists as a result of the recognition that stereotypical perceptions of scientists may influence students' attitudes toward science and their interest in science-related activities and careers (Emvalotis & Koutsianou, 2018). Finson (2002) emphasized that an individual's mental depiction of scientists holds significant sway over their inclination to pursue a career in scientific fields. This is because there exists a profound interconnection between one's mental imagery of scientists and their attitudes towards science, as well as their self-assurance in engaging in scientific pursuits.

Generally speaking, sufficient research has not yet been conducted on professions in the field of technology (Silver & Rushton, 2008). It has been stated that students tend to have positive attitudes toward technology coupled with a limited understanding of the field (Ankiewicz, 2019; Koch, 2013). For example, in a previous study conducted with secondary school students, a representative image of a technologist depicted a man with short hair wearing safety glasses and a welding mask (Jung & Kim, 2014). Technologists were described as working with cars, robots,

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and rockets and using wrenches, hammers, screwdrivers, and welding machines (Jung & Kim, 2014). It has also been reported that students confuse people who work with technology and engineers. To develop a rational and comprehensive perception of technologists, students must receive effective STEM education and acquire a deep understanding of the nature of each STEM component (Blom & Abrie, 2021).

Various studies have revealed that children tend to portray engineers as white, male, and self-employed people who do physical work on a large scale, such as repairing and building things (Chou & Chen, 2017). In a report issued by the National Academy of Engineering (NAE) (2008), it was observed that while many students held a generally favorable view of engineers, they expressed self-doubt about their own abilities, believing that they might not be intelligent enough to pursue a career in engineering. Furthermore, existing literature frequently highlights that students possess a restricted comprehension of engineering and the tasks performed by engineers (Kelly et al., 2017; Knight & Cunningham, 2004). Many students have misconceptions about engineers (Fralick et al., 2009), and recent studies indicate that even preservice teachers have stereotypical images of this profession (Kuvac & Koc, 2022). Hence, it is of utmost importance to dispel misconceptions surrounding STEM careers through the dissemination of precise information (Wyss et al., 2012) and the integration of additional STEM resources into the educational curriculum (DeJarnette, 2012). A significant number of K-12 students tend to associate engineers with occupations such as train drivers, auto mechanics, construction workers, or individuals operating large machinery (Capobianco et al., 2011). When students' drawings included identifiable gender representations, the figures were predominantly male. Furthermore, a higher percentage of male figures were present in students' drawings depicting engineers compared to those representing scientists (Fralick et al., 2009; Karatas et al., 2011).

Math images are important elements for students to solidify their knowledge about math and their math learning. Students' understanding of such concepts is molded by a range of activities and diverse life experiences, including those related to mathematics education (Osman et al., 2010). Rock and Shaw (2000) asserted that when students perceive mathematics as an unappealing subject through their perceptions of mathematics and mathematicians, the process of mathematics education becomes notably more arduous. Picker and Berry (2000) found that students' images of mathematicians reflected balding and messy men, and it is widely recognized that men are represented more than women in the fields of mathematics and science (Gjøvik et al., 2022). If the representations of STEM fields that children and young adults encounter negatively affect their STEM-related self-concepts and identity development, the effects may spill over to negatively influence their continued involvement and participation in these fields. Therefore, the portrayal of gender role stereotypes of scientists, technologists, engineers, and mathematicians in media representations may play a significant role in shaping gendered identities (Steinke et al., 2007). From this point of view, it is important for students to encounter professionals of both genders while forming their perceptions of STEM fields. Consequently, the favorable perception of STEM professionals and the understanding of STEM's implications for society among students are significantly correlated with their interest in pursuing STEM careers (Pan et al., 2022)

Role Models in STEM Education

Efforts aimed at increasing the involvement of historically marginalized groups in STEM frequently emphasize the importance of showcasing real-life STEM role models. This approach serves to confront and dismantle stereotypes while fostering a sense of connection with these fields (Van Camp et al., 2019). In this context, a role model is defined as someone who is more advanced in technology or engineering and has long-term interactions with a less advanced person who is making a decision (Guenaga et al., 2022). Effective informal STEM education initiatives create secure physical and psychological settings for girls, enabling the cultivation of positive social norms, encouraging supportive peer and role model interactions, and fostering a sense of belonging (Simpkins et al., 2017). Research conducted with adolescent girls demonstrated that their interest in STEM disciplines increased, and their self-perceptions regarding science and mathematics improved following their participation in a summer camp featuring authentic female role models (Hughes et al., 2013). Counteracting the ease with which stereotypes are transmitted and the ways in which they affect the performance of female students in STEM fields, female role models can serve as constant reminders that STEM fields are for everyone and may help motivate young women to pursue careers in STEM-related fields (Fernández-de la Peña et al., 2021). The advantages of such programs are remarkable, as scientists can serve as positive role models, and engagements with even brief outreach initiatives can yield enduring positive effects on students. This includes an increased interest in pursuing careers in the field of science (Kompella et al., 2020). For many students, gaining access to real-life STEM role models representing

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diverse backgrounds can be challenging in STEM learning environments (Steinke et al., 2022). Therefore, providing access to role models and opportunities to work with professionals in these fields can create opportunities to understand and change students' perceptions of STEM careers. Moreover, effective initiatives facilitate the development of STEM identities by integrating inclusive curricula and teaching methods with opportunities to interact with female role models (Prieto-Rodriguez et al., 2020).

Out-of-School Learning Environments

Teaching and learning about scientific research helps students better understand the nature of science and the work of scientists (Emvalotis & Koutsianou, 2018). Therefore, more systematic education and training interventions are needed to facilitate more accurate and realistic images of the work of scientists (Emvalotis & Koutsianou, 2018). Young people today can take advantage of a wide variety of opportunities to engage with STEM content and educational activities that will be unquestionably beneficial to them as future citizens (Zollman, 2012). It was also shown that out-of-school projects may have the potential to increase interest in science among young people and that female students are particularly interested in artistic and realistic educational activities (Walan, 2021). The number of girls and women pursuing STEM-related careers is slowly increasing thanks to extracurricular activities that take new approaches to introducing STEM to children of all ages (Fernández-de la Peña et al., 2021). Sadler et al. (2012) proposed that initiatives aimed at nurturing female students' enthusiasm for mathematics and science have the potential to concurrently enhance their interest in pursuing careers in STEM fields upon completing upper-secondary education. Exposing girls to various female role models in out-of-school learning environments expands the representation of women in these areas and allows students to imagine themselves in the place of those role models (Anderson & Cavallaro, 2002). A study conducted by González-Pérez et al. (2020) assessed the impact of a role-model intervention involving female volunteers working in STEM who visited schools to discuss their careers with female students. The results of the intervention were notably positive, with a significant increase in the girls' confidence in their ability to succeed in STEM fields, as well as an elevated likelihood of choosing a STEM career (González-Pérez et al., 2020). Such programs provide students with opportunities to engage in authentic real-world problem-solving activities that go beyond the content covered in textbooks (Baran et al., 2019). They expose students to STEM concepts and ideas in informal learning environments that may not be readily available within the formal school curriculum (Baran et al., 2019).

Theoretical Background

Social Cognitive Theory (SCT) is a psychological framework that explains human behavior and learning processes through the interaction of personal, behavioral and environmental factors (Bandura, 1986). This theory suggests that individuals acquire knowledge and skills by observing others, drawing on personal experiences and responding to environmental influences (Bandura, 1997). In the context of STEM education, SCT can be utilized to understand and improve students' engagement, motivation, and performance in these fields, particularly among female students who are underrepresented in the professions (Cheryan et al., 2017). SCT emphasizes the importance of role models and mentors in shaping students' attitudes, beliefs, and behaviors (Bandura, 1986). In the context of STEM education, exposure to diverse and successful STEM professionals, especially female role models, can help students develop positive perceptions of these fields, challenge stereotypes, and see STEM careers as viable options. Informal STEM education programs and out-of-school learning environments such as science camps provide students with opportunities to interact with and learn from STEM role models, providing a supportive learning environment that encourages students, especially girls, to pursue STEM subjects and careers (Dabney et al., 2012). According to SCT, the learning environment plays a crucial role in shaping students' experiences and outcomes (Bandura, 2001). In the context of STEM education, stereotypes about scientists, technologists, engineers, and mathematicians in media portrayals can negatively impact the formation of gendered identities and contribute to the underrepresentation of women in STEM fields (Cheryan et al., 2017). A supportive and inclusive environment that values diversity, collaboration, and innovation can promote student engagement and achievement (Simpkins et al., 2017). Socio-cognitive career theory examines the process by which students imagine their future occupations and the social influences on this process. However, this theory has generally not addressed important factors such as gender roles and gender norms. This research examines in more detail the gender-related factors that influence students' interest and engagement in STEM fields.

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Research Aim and Research Questions

Adolescence is commonly recognized as a crucial developmental stage for challenging and dispelling cultural stereotypes (Cvencek et al., 2015). It is also a crucial period in terms of students' understanding of STEM fields and their decisions about pursuing STEM careers (Lampley et al., 2022). Increasing the STEM experiences of adolescents and planning activities in partnership with professionals working in STEM fields are supportive elements in orienting students toward STEM fields. Stereotypical views of science and scientists can detrimentally affect the career prospects and opportunities of upper-secondary school students (Garriott et al., 2017). Conversely, engaging students in discussions about a range of STEM career possibilities can aid in the formation of their future aspirations (Constan & Spicer, 2015). A lack of positive role models may prevent students from achieving their career goals (Constan & Spicer, 2015), while the presence of role models and out-of-school learning programs may provide support for upper-secondary students' STEM career goals, positive perceptions of scientists, and general interest in the sciences (Barry et al., 2022). The present study was undertaken with the aim of overcoming gender stereotypes of STEM professionals held by female upper-secondary students by emphasizing diversity in STEM fields in an interdisciplinary way. Female upper-secondary students' perceptions of people working in STEM fields and the changes in those perceptions before and after attending a STEM camp were explored within the framework of the following research questions:
RQ1: How do female students' perceptions of scientists differ before and after STEM camp?
RQ2: How do female students' perceptions of technologists differ before and after STEM camp?
RQ3: How do female students' perceptions of engineers differ before and after STEM camp?
RQ4: How do female students' perceptions of mathematicians differ before and after STEM camp?

Research Methodology

This research was designed as a case study, an approach selected from among qualitative research methods. Case studies are used to understand people's lives and experiences, and they involve an in-depth and detailed examination of particular situations in the context of real phenomena or events (Bromley, 1986). In a phenomenological case study, the researcher seeks to gain insight into the subjective perspectives, thoughts, emotions, and interpretations of the participants involved in the case. The goal is to capture the essence of their experiences and provide a rich and detailed description of their lived reality (Han, 2015). The phenomenological case study allows participants to describe their experiences of attending the STEM camp and the impact of these experiences on their perceptions.

Research Process and Participants

The research was conducted with 25 female upper-secondary students over the course of 6 days. Five students (20%) were 16 years old, and 12 students (80%) were 17 years old. The research was funded by the TÜBİTAK (The Scientific and Technological Research Council of Türkiye), and ethical approval was obtained from the ethics committee of the researcher's university. Permission to conduct the research was also obtained from the local authorities of the Ministry of National Education (MoNE). Students voluntarily offered to participate in the project by filling out an application form online. Subsequently, 113 possible participants were selected by the researcher from among those applications. The applicants were then selected based on specific criteria. These criteria included factors such as age and previous STEM experiences. In this way, the results were intended to become more specific and meaningful, given that the group of participants represented in the research had a specific demographic. After the students volunteered to participate in the project, their families were also contacted for permission (N = 25). This research was conducted at a university in Turkey in September 2021.

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Table 1
STEM Camp Schedule

	First Day	Second Day	Third Day	Fourth Day	Fifth Day	Sixth Day
Morning Sessions	Pre-Test "Draw a STEMist"	Drama **(Male)**	Robotic Coding with Lego and mBot **(Male)**	Traditional Arts with STEM **(Male)**	STEM Activity: Are You Up For The Marshmallow Duel? **(Female)**	Music in STEM Education **(Female)**
	Drama **(Male)**	Socio-Scientific Issues and STEM Practices **(Male)**	Physics Applications with Arduino **(Female)**	Traditional Arts with STEM **(Male)**	Robotic Coding with Lego and mBot **(Male)**	Argumentation in STEM **(Male)**
Afternoon Sessions	Nature in Science and STEM Education **(Male)**	Science Activity: DNA and Genetic Code Design **(Male)**	Science Activity: DNA and Genetic Code Design **(Male)**	Traditional Arts with STEM **(Male)**	Socio-Scientific Issues and STEM Practices **(Male)**	Physics Applications with Arduino **(Female)**
	Career Talks: Nanotechnology **(Female)**	Career Talks: Computer Engineering and Artificial Intelligence Applications **(Female)**	Career Talks: Expectations of Business Life in the Future **(Female)**	Career Talks: Traditional Arts **(Female)**	Career Talks: Health Practices **(Female)**	Post-Test: "Draw a STEMist"

Table 1 shows the educational content of the STEM camp and the genders of the presenters. Seven male and four women took part in the educational training sessions. Each day of the camp focuses on different STEM topics and activities, complemented by career talks and pre-and post-tests to measure students' perceptions of STEM professionals. The camp provides students with the opportunity to experience STEM fields and also allows them to interact with STEM professionals.

Data Collection Tools

Children's drawings have long been an object of study for researchers in many fields (Longobardi et al., 2017). In this study, the Draw-a-Scientist Test (DAST-C) was used to determine students' perceptions of people working in STEM fields, and three alternative tests (Draw a technologist, draw an engineer, draw a mathematician) were used to describe professionals in other fields. The scientific environment portrayed, and the gender and physical characteristics of the represented scientists were used to evaluate the results of the classical DAST-C, and similar features were used in evaluating the three alternative tests. Thus, four separate forms were given to the students, and they were respectively asked to draw a scientist, a person working in the field of technology, a person working in the field of engineering, and a person working in the field of mathematics. Instructions on each form asked them to explain the drawing and the characteristics of the person they drew as it would have otherwise been difficult to evaluate their drawings. During the drawing process, students were provided colored pencils and paper, and one hour was allotted for the creation of the drawings at the beginning and the end of the STEM camp. Instructors were present in the classroom but did not provide any additional time or instructions to the students.

Data Analysis

The data analysis included quantification, which refers to the conversion of qualitative data into numerical values (Sandelowski et al., 2010). Quantification of qualitative data is a good tool in thinking about and interacting with data. A checklist was created for evaluating students' drawings in each of the STEM disciplines, drawing upon tools and methodologies outlined in existing literature (Meyer et al., 2019; Martins et al., 2021). For example, Martins et al. (2021) applied a checklist developed by students to evaluate their drawings of professionals working in STEM fields. Chambers (1983) and Finson et al. (1995) also evaluated participants' drawings using a scoring checklist of elements that serve as indicators in standard images of scientists. In the present study, the drawings

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and the participants' explanations of those drawings were analyzed by two science education experts according to the analytical framework proposed by Fralick et al. (2009). These experts evaluated the drawings according to a specific analytical framework and took note of their characteristics, such as content, gender representation and physical characteristics. A reliability formula (Reliability = Consensus / (Consensus + Disagreement)) was applied to their results and the agreement rate between the two experts was determined as 89.9% (Miles & Huberman, 1994). A descriptive analysis of the results was performed based on the recorded frequencies for each item of the checklist for students' drawings made before and after the STEM camp. According to the results of the Shapiro-Wilk normality test ($p < .05$), non-parametric tests were used because the data were not normally distributed. Percentages, frequencies, chi-square and Wilcoxon tests were applied to compare the pre-test and post-test drawings. In order to evaluate the items in the checklist, a scoring system was applied by giving a value of 1 (yes) or 0 (absent) and calculating (Chambers, 1983; Finson et al. 1995; Martins et al. 2021). The classification criteria created by Martins et al. (2021) were used to evaluate the dimensions of technology, engineering, and mathematics.

Research Results

Perceptions of Scientists Before and After STEM Camp

This sub-section presents an analysis of female students' perceptions of scientists before and after attending the STEM camp. The research question is defined as RQ1, and this section focuses on the participants' perceptions.

Table 2
Students' Drawings of Scientists

Dimensions	Items	Pre-test (N = 25)	Post-test (N = 25)	Chi-squared Test	
		f (%)	*f (%)*	χ^2	*p*
DAST-C Items	1. Lab coat	14 (56)	4 (16)	5.82	0.001*
	2. Eyeglasses	10 (40)	5 (20)	2.38	0.12
	3. Facial hair	6 (24)	2 (8)	2.38	0.12
	4. Symbols of research	10 (40)	11 (44)	0.82	0.77
	5. Symbols of knowledge	8 (32)	14 (56)	0.76	0.38
	6. Technology	10 (40)	11 (44)	0.82	0.77
	7. Relevant captions	1 (4)	3 (12)	1.08	0.29
	8. Male gender	12 (48)	3 (12)	7.71	0.001*
	9. Indications of danger	4 (16)	2 (8)	0.75	0.38
	10. Presence of light bulbs	4 (16)	2 (8)	0.75	0.38
	11. Mythical stereotypes	-	-	0.00	1.00
	12. Scientists doing work indoors	16 (64)	7 (4)	6.52	0.01*
	13. Middle-aged or elderly scientist	14 (56)	4 (16)	8.61	0.001*
	14. Crazy hair	6 (24)	5 (20)	0.11	0.73
	15. Bald head	3 (12)	1 (4)	1.08	0.29
Gender	16. Male	12 (48)	3 (12)	7.71	0.001*
	17. Female	1 (4)	12 (48)	12.58	0.001*
	18. Undetermined	12 (48)	7 (28)	2.12	0.14
	19. No person	-	3 (12)	3.19	0.07

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Dimensions	Items	Pre-test (N = 25)	Post-test (N = 25)	Chi-squared Test	
		f (%)	*f (%)*	χ^2	*p*
Expression	20. Smiling	1 (4)	5 (20)	3.03	0.08
	21. Frowning	8 (32)	2 (8)	4.50	0.03*
Field of specialization	22. Physics	12 (48)	16 (64)	1.29	0.25
	23. Chemistry	6 (24)	15 (60)	6.65	0.10
	24. Biology	7 (28)	12 (48)	1.38	0.23
	25. Omniscient	-	2 (8)	2.08	0.14
Workplace	26. Indoors	20 (80)	8 (32)	11.68	0.001*
	27. Outdoors	3 (12)	11 (44)	6.34	0.01*
	28. Undefined	2 (8)	6 (24)	2.38	0.12
Action	29. Making something/working with hands	8 (32)	18 (72)	8.01	0.001*
	30. Discovering/researching	6 (24)	17 (68)	9.74	0.001*
	31. Experimenting/testing	10 (40)	17 (68)	3.94	0.04*
	32. Explaining/teaching	8 (32)	14 (56)	2.92	0.08
	33. Observing	6 (24)	10 (40)	1.47	0.22
	34. No action	1 (4)	2 (8)	0.35	0.55
	35. Other	-	-	0.00	1.00

Table 2 presents the frequencies and corresponding percentages of the indicators that were examined during the analysis. The participants included almost all of the items from the DAST-C in the pre-test (M = 8.42; SD = 4.60) and post-test (M = 5.28; SD = 4.00). This indicates that they had stereotypical images of scientists before attending the STEM camp. Regarding the differences between the pre-test and post-test, the Wilcoxon test revealed statistically significant differences (z = -2.080, p = .03). Among the items considered, there were changes in the images of lab coats, gender, scientists working inside, and middle-aged or elderly people. While 48% of the participants drew a male image in the pre-test, 12% drew a male image in the post-test and this difference was significant (χ^2 = 7.71, p < .001). In the pre-test, a female figure was present in only 4% of the drawings, while in the post-test, 48% of the drawings featured female figures, again constituting a significant difference (χ^2= 12.58, p < .001). Participants also had changes in the emotions that they represented in their drawings. The drawings from the post-test featured fewer frowning images (χ^2 = 4.50, p = .03). No significant differences were determined for the represented fields for science, but a numerical increase was observed in the portrayals of the fields of physics, chemistry, and biology in the post-test. There was a decrease of percentages in portrayals of indoor activities from 80% to 32% (χ^2 = 11.68, p < .001) and an increase in portrayals of outdoor activities from 12% to 44% (χ^2 = 6.37, p < .001). There were also significant positive increases in portrayals of making things and working with one's hands (χ^2 = 8.01, p < .001), discovering/researching (χ^2 = 9.74, p < .001), and experimenting/testing (χ^2 = 3.94, p = .04).

Perceptions of Technologists Before and After STEM Camp

This sub-section presents an analysis of female students' perceptions of technologists before and after attending the STEM camp. The research question is defined as RQ2, and this section focuses on the participants' perceptions.

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Table 3
Students' Drawings of Technologists

Dimensions	Items	Pre-test (*N* = 25)	Post-test (*N* = 25)	Chi-squared Test	
		f (%)	*f* (%)	χ^2	*p*
Gender	1. Male	11 (44)	4 (16)	4.66	.03*
	2. Female	-	8 (32)	9.52	.001*
	3. Undetermined	9 (36)	10 (40)	0.08	.77
	4. No person	5 (20)	3 (12)	0.59	.44
Expression	5. Smiling	6 (24)	7 (28)	0.10	.74
	6. Frowning	4 (16)	2 (8)	0.75	.38
	7. Facing backwards	8 (32)	2 (8)	4.50	.03*
Technology Symbols	8. Computer/tablet	20 (80)	20 (80)	0.11	.73
	9. Cell phone	18 (72)	14 (56)	1,389	.23
	10. Robot/drone	-	21 (84)	36.20	.001*
	11. None	-	-	-	-
	12. Other	6 (24)	4 (16)	0.50	.48
Workplace	13. Indoors	14 (56)	3 (12)	10.78	.001*
	14. Outdoors	4 (24)	11 (44)	4.66	.31
	15. Undefined	7 (28)	11 (44)	1.39	.23
Action	16. Making/fixing/working with hands	12 (48)	14 (56)	0.32	.57
	17. Discovering/researching	10 (40)	10 (40)	0.00	1.00
	18. Explaining/Teaching	6 (24)	9 (36)	0.85	.35
	19. No action	2 (8)	2 (8)	0.00	1.00
	20. Other	2 (8)	1 (8)	0.35	.55

In Table 3, findings from the students' drawings of technologists are presented in terms of the dimensions, various features, and percentages. Regarding the variable of gender, it is seen that 44% of the participants drew male figures in the pre-test, while only 16% drew male technologists in the post-test ($\chi^2 = 4.66$, $p = .03$). While no women were drawn in the pre-test, 32% of the participants drew female figures in the post-test ($\chi^2 = 9.52$, $p < .001$). When portrayals of emotions were examined, no significant differences were observed. Turning to technology symbols, there was no difference in portrayals of computers, tablets, or phones between the pre-test and post-test, but portrayals of robots and drones were absent in the pre-test and were drawn by 84% of the participants in the post-test ($\chi^2 = 36.20$, $p < .001$). While 56% of the drawings from the pre-test featured people working indoors, 12% of the post-test drawings portrayed indoor locations ($\chi^2 = 10.78$, $p < .001$). On the other hand, 24% of the pre-test drawings and 44% of the post-test drawings portrayed people working outdoors. In the dimension of actions, increases were also observed in portrayals of people making/fixing/working with hands and explaining/teaching.

Perceptions of Engineers Before and After STEM Camp

This sub-section presents an analysis of female students' perceptions of engineers before and after attending the STEM camp. The research question is defined as RQ3, and this section focuses on the participants' perceptions.

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Table 4
Students' Drawings of Engineers

		Pre-test (*N* = 25)	Post-test (*N* = 25)	Chi-squared Test	
Dimensions	Items	*f (%)*	*f (%)*	χ^2	*p*
Gender	1. Male	8 (32)	5 (20)	0.93	.52
	2. Female	2 (8)	8 (32)	4.50	.03*
	3. Undetermined	15 (60)	7 (28)	5.19	.02*
	4. No person	-	5 (20)	5.55	.02*
Expression	5. Smiling	5 (20)	5 (20)	0.00	1,00
	6. Frowning	1 (4)	4 (16)	2.00	.15
	7. Facing backwards	2 (8)	2 (8)	0.00	1.00
Engineering Themes	8. Building/fixing	8 (32)	15 (60)	3.94	.05
	9. Designing	8 (32)	14 (56)	2.92	.08
	10. Mechanical engineering	2 (8)	3 (12)	0.22	.63
	11. Civil engineering	2 (8)	10 (40)	7.01	.001*
	12. None	2 (8)	-	2.08	.15
	13. Other	2 (8)	8 (32)	4.50	.03
Workplace	14. Indoors	10 (40)	5 (20)	2.38	.12
	15. Outdoors	2 (8)	16 (64)	17.01	.001*
	16. Undefined	13 (52)	2 (8)	11.52	.00
Action	17. Building	10 (40)	17 (68)	3.94	.05
	18. Fixing	6 (24)	13 (52)	4.16	.04*
	19. Projects/planning	4 (16)	12 (48)	5.88	.02*
	20. No action	2 (8)	2 (8)	0.00	1.00
	21. Other	2 (8)	2 (8)	0.00	1.00

Table 4 provides information about the students' drawings of engineers before and after the STEM camp. In the pre-test, the gender of the figures was unclear in a majority of the drawings (60%). Male figures were depicted in 32% of the pre-test drawings and 20% of the post-test drawings. The portrayal of female figures increased from 8% of all pre-test drawings to 32% of all post-test drawings ($\chi^2 = 4.50$, $p = .03$). Thus, there was a significant decrease in the participants' portrayals of engineers of undetermined gender ($\chi^2 = 5.19$, $p = .02$). While no significant differences were observed in portrayals of expressions, a significant increase was observed in portrayals of the field of civil engineering ($\chi^2 = 7.01$, $p < .001$). Regarding portrayals of workplaces, 40% of pre-test drawings involved indoor settings compared to 20% of post-test drawings. Depictions of work conducted outdoors increased significantly from 8% to 64% ($\chi^2 = 17.01$, $p < .001$). Finally, considering engineering practices, significant increases were seen in portrayals of engineers fixing things ($\chi^2 = 4.16$, $p = .04$) and working on projects/planning ($\chi^2 = 5.88$, $p = .02$).

Perceptions of Mathematicians Before and After STEM Camp

This sub-section presents an analysis of female students' perceptions of *Mathematicians* before and after attending the STEM camp. The research question is defined as RQ4, and this section focuses on the participants' perceptions.

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Table 5
Students' Drawings of Mathematicians

		Pre-test (*N* = 25)	Post-test (*N* = 25)	Chi-squared Test	
Dimensions	Items	*f (%)*	*f (%)*	χ^2	*p*
Gender	1. Male	8 (32)	5 (20)	0.93	.33
	2. Female	6 (24)	5 (20)	0.11	.73
	3. Undetermined	11 (44)	11 (44)	0.00	1,00
	4. No person	-	4 (16)	3.19	.07
Expression	5. Smiling	7 (28)	10 (40)	0.80	.37
	6. Frowning	6 (24)	2 (8)	2.38	.12
	7. Facing backwards	-	3 (12)	3.19	.07
Mathematical Symbols	8. Numbers	9 (36)	18 (72)	6.52	.01*
	9. Arithmetic	4 (16)	13 (52)	7.21	.001*
	10. Geometry	4 (16)	17 (68)	13.87	.001*
	11. None	-	-	-	-
Instruments/Elements	12. Blackboard	7 (28)	12 (48)	2.12	.14
	13. Desks	5 (20)	7 (48)	0.43	.50
	14. Textbooks	6 (24)	2 (8)	2.38	.12
	15. Writing materials	5 (20)	3 (12)	0.59	.44
	16. Calculator/computer	-	-	-	-
	17. None	-	-	-	-
Workplace	18. Indoors	16 (64)	10 (40)	2.88	.89
	19. Outdoors	2 (8)	10 (40)	7.01	.001*
	20. Undefined	7 (28)	5 (20)	0.44	.50
Action	21. Calculating/solving problems	14 (56)	10 (40)	1.28	.25
	22. Explaining/teaching	8 (32)	5 (20)	0.93	.33
	23. Discovering/researching	2 (8)	10 (40)	7.01	.001*
	24. No action	1 (4)	-	1.02	.31
	21. Other	-	-		

In Table 5, findings from the students' drawings of mathematicians are presented. There were no significant differences in the portrayals of gender or expressions between the pre-test and post-test. However, significant increases were observed in the portrayals of mathematical symbols including numbers ($\chi^2 = 6.52$, $p = .01$), arithmetic ($\chi^2 = 7.21$, $p < .001$), and geometry ($\chi^2 = 13.87$, $p < .001$). There were no significant differences in the instruments or elements portrayed in the drawings, but in the dimension of fields of work, a significant increase was seen in portrayals of the discovering/researching field ($\chi^2 = 7.01$, $p < .001$). A significant increase from 8% to 40% was also observed in portrayals of professionals engaged in discovering/researching ($\chi^2 = 7.01$, $p < .001$).

Discussion

The purpose of this research was to examine the changes in stereotypes held by female students regarding STEM professionals. With this aim, students were asked to draw pictures of STEM employees and their environments and to explain their drawings. This allowed the students to reflect on changes in their views, personality traits, and practices related to STEM professionals before and after attending a STEM camp. The relevant literature suggests that girls are negatively affected by a lack of STEM knowledge and low self-esteem (Merayo & Ayuso,

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2022; Pilotti, 2021). Therefore, in the present study, changes in female students' perceptions of STEM professionals after attending workshops and career talks given by female STEM professionals were examined. The findings are discussed in more detail below in connection with the relevant literature.

Students' images of scientists have been of interest to researchers for nearly 50 years. Multiple research studies have demonstrated that when adolescents are tasked with drawing images of scientists or STEM professionals, their drawings typically embody stereotypes associated with these fields (Aguilar et al., 2016; Ateş et al., 2020; DeWitt & Archer, 2015). Similarly, in the pre-test of the present research, it was seen that female students had fixed views of people working in scientific fields. However, stereotypical images may be changed with intervention programs, as both the present work and various past studies have found that intervention programs have a positive effect on changing students' images of science (Emvalotis & Koutsianou, 2018; Karacam et al., 2021; Leblebicioglu et al., 2020). Interactions with female STEM professionals positively contributed to an increase in portrayals of scientists as women in the present study. In addition, changes were observed in the portrayals of lab coats, people working indoors, and scientists as middle-aged or elderly people. These findings may be due to the fact that students had fixed thoughts and stereotypical images of scientists at the beginning of the study because they did not have any previous relationships with professionals (Pan et al., 2022) working in the fields of science. As a result of the STEM camp, female students' ideas about the work of scientists matured. They showed conceptual development in their perceptions of scientists engaged in actions such as making things/working with hands, discovering/researching, and experimenting/testing. Although the present findings were obtained via informal education in a short period of time, it can be suggested that professionals should also interact with students in and out of the classroom in more formal applications.

It is known that students have positive attitudes toward technology. However, their images of professionals working in the field of technology are limited and there has been insufficient research on this subject (Jung & Kim, 2014). In the first stage of the present study, when the students drew pictures of individuals working in the field of technology, they generally portrayed people working at desks with computers, tablets, or phones and the people portrayed in these drawings were usually male. In the drawings from the post-test, however, portrayals of women working in the field of technology increased significantly. Portrayals of robots and drones increased in the post-test drawings. Thus, it can be concluded that the workshops conducted during the STEM camp affected the students' perceptions of technologists. The students' perceptions of workplaces in this field also changed over the course of the research, as their drawings shifted from portrayals of indoor environments to outdoor environments. To develop students' rational and comprehensive understandings of technology in the context of effective STEM education, students must have an in-depth and accurate understanding of the nature of the different components of this professional field (Blom & Abrie, 2021).

Similarly, in the field of technology, students have limited perceptions of engineering as a professional field (Fralick et al., 2009). In the present study, students generally drew figures of undetermined gender in the pre-test. Interest in engineering-related research has increased recently with the aim of changing gender stereotypes in perceptions of engineers. Female students tend to have limited perceptions of engineering professionals, and they are most likely to draw images of men wearing helmets and working indoors when asked to portray an engineer (Capobianco et al., 2011). Similar studies have found that students tend to portray engineers as people who do physical work, such as repairing and constructing, in pre-test drawings (Chou & Chen 2017). In the drawings produced in the post-test session of the present study, it was seen that portrayals of female engineers working outdoors had increased. This supports previous claims that intervention programs are effective in changing students' stereotypical (Kelly et al., 2017; Kuvac & Koc, 2022) and limited (NAE, 2008) perceptions of engineering. This may be achieved by balancing out male-oriented images (Fralick et al., 2009; Karatas et al., 2011) with the participation of female professionals in STEM programs (DeJarnette, 2012; Wyss et al., 2012). As a result of the STEM intervention program applied in the present study, in addition to a decrease in gender stereotypes, students' perceptions of engineering-related work including actions such as repairs and project management were also strengthened. It can be concluded that STEM programs are effective in eliminating students' misconceptions about engineering. However, the lack of fixed courses or programs addressing science, technology, and mathematics remains an obstacle in many schools for improving students' perceptions of the engineering profession.

It is widely agreed that men are more represented than women in mathematics as well as in science (Gjøvik et al., 2022). Picker and Berry (2000) found that students' portrayals of mathematicians involved bald or messy men. However, contrary to the literature, the findings obtained in the present study did not show a statistically significant difference in the gender representations of the students in their pre-test and post-test drawings. Students'

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images of people working in the field of mathematics tended to be vague. Rock and Shaw (2000) concluded from an analysis of students' images of mathematics and mathematicians that the students perceived mathematics as an unattractive subject. However, in the present study, portrayals of the mathematical concepts of arithmetic and geometry increased. Since mathematics courses in formal school settings are often only concerned with problem-solving skills, students may not have enough knowledge about what mathematicians do. For example, in this study, they were also described as people who could work outdoors. Overall, gender representation in mathematics in STEM education remained uncertain, and the students' knowledge of mathematics-related occupations was also limited. They lacked a realistic understanding of the people working in these fields. Overall, students' impressions of scientists and technologists are typically superficial and misleading and may sometimes reflect ignorance (McCreedy & Dierking, 2013; Scherz & Oren, 2006). Considering the results obtained here, it is possible to conclude that, in general, students see STEM fields as the realm of men, excluding mathematics (Martins et al., 2021), but this perception can be changed with the application of STEM intervention programs (Baran et al., 2019; González-Pérez et al., 2020). This research is accompanied by a number of limitations. The study focused solely on female high school students, limiting the generalizability of the findings to other populations, such as male students or students from different age groups. The intervention examined was a STEM camp, which may not be representative of all types of STEM programs and initiatives. The study did not include a control group, which would have allowed for a more rigorous assessment of the impact of the STEM camp on students' perceptions compared to a group that did not participate in the intervention.

Conclusions and Implications

This study has shown that an informal STEM education program was effective in changing female students' images of STEM professionals, in support of previous research. The students also generally found the unique features of this informal learning setting to be beneficial, as it provided the freedom to pursue their own interests and values, did not entail pressure related to academic requirements or standardized tests, and allowed them to work in collaborative groups.

When the gender representations of STEM professionals were examined, students' pre-test drawings were found to overwhelmingly represent men in the fields of science, technology, and engineering. The only exception was mathematics. However, in post-test drawings, their representations of female professionals in the fields of science, technology, and engineering numerically increased. Thus, interactions with female STEM role models seem to have had a positive impact on the students' perceptions and STEM stereotypes can be changed in this way.

The results of this research make a valuable contribution to the existing body of literature focused on female students' perceptions of individuals working in STEM fields. It is evident that these perceptions can indeed be positively influenced through extracurricular educational initiatives. To foster a more accurate and positive understanding of STEM professions among students, educators, policymakers, and researchers should be proactive in engaging students in STEM-related activities and providing opportunities for them to interact with a diverse range of STEM professionals. By doing so, we can cultivate more realistic and optimistic attitudes among students toward potential careers in STEM fields.

Socio-cognitive career theory has generally not addressed important factors such as gender roles and gender norms. This research examined in more detail the gender-related factors that influence students' interest and engagement in STEM fields. The research explored effective ways to change gender-related misconceptions and stereotypes, especially in STEM fields, and therefore provided recommendations for improving STEM education. The results of this study can help us understand the impact of programs designed to promote gender equality in STEM fields and contribute to developing strategies to combat gender inequality in STEM at the international level.

The value of this research in an international context lies in contributing to a broader understanding of how educational interventions such as STEM camps and workshops led by female STEM professionals can influence students' perceptions and stereotypes of STEM fields. The findings of the study can provide insights into how students' perceptions of STEM professionals vary across different cultural and educational contexts. Although the research focused on a specific region or country, its methodologies and results can be compared with similar studies in other parts of the world. This cross-cultural perspective can help identify common challenges and effective strategies for addressing gender stereotypes in STEM. The research highlights the effectiveness of informal STEM education, such as STEM camps and workshops, in changing students' perceptions. These informal educational approaches can be adapted and applied to various international settings to promote diversity and inclusion in

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STEM fields. Policymakers and educators worldwide can benefit from understanding the potential impact of such programs. Gender inequalities in STEM fields are a global problem. By revealing how interactions with female STEM professionals positively influence students' perceptions, this study provides valuable insights into strategies for promoting gender equity in STEM education and careers. These insights can inform international efforts to close gender gaps in STEM. While the study focused on upper-secondary school female students in a specific context, its findings can serve as a basis for broader discussions and adaptations. Researchers and educators around the world can examine how the results align with their own experiences and explore the feasibility of implementing similar interventions in their own regions. This research can foster international collaboration among researchers, educators and organizations interested in promoting diversity in STEM. The methods and results of the study can be a starting point for cross-border initiatives aimed at challenging stereotypes and promoting inclusion in STEM fields.

Recommendations

This research examined the impact of image-oriented information about STEM fields provided to female students in the course of a STEM camp. However, the participating students may have already had a high interest in pursuing careers in STEM fields as they were willing to participate in this educational camp. Therefore, future studies should be conducted with female students with different interest levels. In this study, changes in students' STEM perceptions were examined immediately after the conclusion of a six-day STEM camp. Future studies may focus on the permanence of such effects. Finally, this study focused on a mixed-gender group of instructors working with only female students. The question of whether different results would be achieved when female students work with only men or with only women should also be considered.

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