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Unraveling the Situation of Women in STEM Areas from the European Teacher Perspective: Insights from FEMALES Project

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Abstract

The purpose of this study is to examine the views of teachers on the number and situation of women in STEM areas as well as ways to encourage female students to STEM areas. We carried out the study through basic qualitative research. The participants of the study included 39 teachers from Turkey, Italy, Spain, Greece, and Romania. For data collection, focus group interviews were carried out in each country. The collected data were analyzed through content analysis. The study yielded similar findings in almost all the countries showing that the number of women was not sufficient, and the participants mostly had negative views regarding the visibility of women, gender equality, and societal roles posed to women. We found that female students could be encouraged to STEM areas through the use of appropriate role models who carried some inborn and achieved traits.

Keywords

STEM, female students, encouraging female students to STEM, basic qualitative research

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Unraveling the Situation of Women in STEM Areas from the European Teacher Perspective: Insights from FEMALES Project

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The purpose of this study is to examine the views of teachers on the number and situation of women in STEM areas as well as ways to encourage female students to STEM areas. We carried out the study through basic qualitative research. The participants of the study included 39 teachers from Turkey, Italy, Spain, Greece, and Romania. For data collection, focus group interviews were carried out in each country. The collected data were analyzed through content analysis. The study yielded similar findings in almost all the countries showing that the number of women was not sufficient, and the participants mostly had negative views regarding the visibility of women, gender equality, and societal roles posed to women. We found that female students could be encouraged to STEM areas through the use of appropriate role models who carried some inborn and achieved traits.

Keywords: STEM, female students, encouraging female students to STEM, basic qualitative research

Introduction

Defined as the integration of science, technology, engineering and mathematics, STEM is a learning approach that eliminates the traditional viewpoint separating these disciplines and integrates them with real world learning experiences for students (Vasquez et al., 2013). STEM, which was coined in the 1990's, serves as a milestone and relates to a paradigm shift in the sense that several countries have used it to restructure their education systems and prepare their students for their future careers in an interdisciplinary way (Ruff, 2017). STEM concentrates mostly on science and mathematics disciplines but includes technology and engineering as well. It is an approach that encourages students to learn directly, helps students fulfill their dreams by creating projects, and enables them to transfer what they learn to new and different learning environments. Focusing on the integrity of science, technology, engineering, and mathematics knowledge and skills, STEM enables students to cultivate their skills in problem solving, to use their creativity, to engage in interdisciplinary cooperation, and to be effective in the fields of communication and entrepreneurship (Thomas, 2014).

Through application-based, problem-focused activities, STEM education aims to help students develop cognitive and critical thinking skills through finding solutions to problems using their knowledge and skills in science, mathematics, and technology. Teachers who are working in STEM areas make use of natural and active exchanges of knowledge, skills, and beliefs among four disciplines with a flexible approach to teach the subjects in their natural context without separating the disciplines with rigid boundaries (Çorlu et al., 2014). While doing so, teachers also utilize required 21st century knowledge and skills, which includes activities that will enable them to focus on science, technology, engineering, and mathematics

in an elaborate manner (Baran et al., 2015). This helps both teachers and students focus on skills such as critical thinking, creativity, communication, and collaboration, which, as Çorlu (2013) implies, is also a demand of 21st century economies to foster interdisciplinary knowledge, skills, and values that are germane to real life skills and requirements.

Countries that focus on the production of information and technology attach more importance to STEM education to improve students' skills accordingly. In the studies conducted so far, it has been found that countries such as the USA, England, and Japan that integrate STEM into the education system have grown economically and there has been an increase in students' achievement in international exams such as PISA and TIMSS (Acar et al., 2018). In addition, European universities are attempting to establish STEM departments aligned with the goals set by the European Commission, to meet standards by focusing on the question of how students might be prepared to be skilled, engaged, and self-regulated innovators and how such skills can be assessed (Çorlu, 2013; Lazonder & Harmsen, 2016.

The Position of Women in STEM Areas

Societal beliefs and the learning environment have strong effects on girls' achievements and interest in science and math. When they are nurtured in their intelligence and potential by both their teachers and parents, they are more likely to produce tangible outcomes (Hill, et al., 2010). In this respect, regarding high school achievement, boys did better than girls in math in the past, but in recent years the gender gap has narrowed, and girls are doing as well as boys in math on average (Hyde et al., 2008). When it comes to the transition from high school to college, statistics show that many young women prefer not to continue in STEM career paths. Of the total number of students in the college, women constitute the majority; however, they are less in number than their male peers to study for a bachelor's degree in STEM areas. Moreover, their representation in groups studying for a doctoral degree is also below the expectations although there has been an increase in the number of female PhD students in STEM areas (Hill et al., 2010).

Despite increased participation by women in the workforce in STEM areas, women are still underrepresented. According to a study conducted by PwC (2017), females are less likely to pursue a career in STEM areas. Their better grades in other areas, lack of interest in STEM areas, STEM topics' lack of relevancy to their career choices, uninteresting learning environments that do not attract their attention, and the need for achieving high grades to succeed in university entrance exams can be mentioned among some of the reasons why women prefer not to work in these areas. In addition, Mishel (2016) signals the existence of discrimination against women in the workforce and society's expectations of women to care for family, therefore interrupting their work for family and household issues. Considering all these, the reasons for underrepresentation of women in STEM areas can be enclosed within three main areas, namely, stereotype threat, lack of interest, and lack of role models.

In male-dominated fields women frequently face implicit as well as explicit stereotypes. According to role congruity theory, stereotypes originate from observing people in the social roles that they typically occupy. Since men have traditionally occupied positions in STEM areas, people generally associate these areas with masculine figures, wearing glasses and working in laboratories. As a result of this association, women are regarded as unsuitable figures to match with STEM and are likely to be treated negatively when they occupy positions. Women are generally believed to be less likely to succeed, to get promoted, and to occupy a leadership position in sectors where there is male dominance (Meyer et al., 2015). It is also worth emphasizing that women who succeed despite these negative views usually experience a reaction for not performing their socially prescribed duties. It is also a striking fact that

women in management positions typically have less authority, receive fewer rewards, and are paid less compared to their male counterparts (Lips, 2015).

Women in STEM areas unfortunately face inaccurate and derogatory assumptions about their skills in both educational background and career pursuits. These threatening experiences can lead to women's low self-efficacy and self-imposed isolation (Picho, 2016). When they become aware of these ubiquitous inaccuracies, they might fear confirming these unfair beliefs, and they might underperform as a result. Fear of confirming negative stereotypes (e.g., women are worse at math than men) can be described as stereotype threat (Steele et al., 2002). Ongoing research has shown that unless gender expectations are consistent with field norms, women will be less likely to persevere and achieve success (Picho & Stephen, 2012).

Many studies that are conducted to examine the reasons why women are underrepresented conclude with the finding that males show higher interest in working with objects while women are more interested in working with people (Su et al., 2009). Men are referred to as individuals who have little interest in people and singular focus in computer science while women are more interested in arts or communication-based areas. Although different at the beginning, women start showing less interest in computer-related tasks such as programming and coding, by which it becomes more and more difficult to retain their attention in STEM. Hango (2013) found out that in Canada, even a high level of mathematical ability was not a predictor of a choice in STEM areas for women whereas men with less mathematical ability were more likely to enter STEM areas.

Because of the aforementioned reasons, women are underrepresented in STEM areas, resulting in a scarcity of STEM female role models who can easily be noticed and followed by female students. As PwC (2017) suggests, females are more committed to changing the world to make a better place to live and they are in search of a career opportunity that will enable them to make this positive contribution. Surely, this is not an innate difference between gender groups, but rather an acquired one via socialization into assigned gender roles based on apparent sex. However, their working in STEM areas can help them take initiatives to satisfy desires and to be encouraged to these areas, they need real role models who have already fulfilled their dreams by working in these areas. Hill et al. (2010) implies that the depiction of successful female role models can help females realize that people like them can be successful, and in this way, stereotype threat can also be managed and overcome.

As a result of all the mentioned facts, there is a huge gender gap in STEM areas against girls in many parts of the world similar to other areas (Mishel, 2016; PwC, 2017). Many countries are struggling to fill this gap and are developing policies to reverse this ongoing trend as a larger and larger workforce will be necessary in STEM areas and there will be a demand for skilled workers in the aforementioned fields (Mishel, 2016). Thus, under the coordination of Bahcesehir University, Turkey, five countries came together in Female Legends of Science Project (FEMALES) with the aim of supporting girls in STEM areas. The project focuses on role model and game-based teaching, so it presents women role models in STEM areas using gamification. The outputs of the project cover making desktop research about all related topics, creating a game about role models in STEM areas and creating game-based STEM activities and an online educational platform in which teachers can reach all the materials. In this vein, this study is substantively impactful in the sense that it provides the European perspective on how teachers see the situation and the number of women in STEM areas and how different countries can work cooperatively to encourage female students to these areas. To sum up, the purpose of this study is to examine the views of teachers on the number and situation of women in STEM areas as well as ways to encourage female students to STEM areas. The following research questions were specifically addressed throughout the study.

1. What are the participating teachers' views on the number of women in STEM areas?
2. What are the participating teachers' views on the situation of women in STEM areas?
3. What are the participating teachers' views on how female students can be encouraged to STEM areas?
4. What are the participating teachers' views on the qualifications for being a female role model in STEM areas?

The Context of the Researchers

The authors of this research work are currently employed at Bahcesehir University in Turkey and BAY Atlantic University in the USA. All the authors are originally from the Faculty of Educational Sciences. Associate professor Dr. Ayşin Kaplan Sayı is the coordinator of the FEMALES project who has been working on STEM for ten years. She works with and organizes workshops for gifted children based on STEM, critical thinking and creativity. Associate professor Dr. Nihal Yurtseven is a member of the curriculum and instruction department, and she is working on teachers' design-oriented professional development, UbD-based school development, instructional design, professional learning communities, curriculum development, and individual differences in learning. Professor Dr. Şirin Karadeniz is from the computer sciences department and is the academic advisor of the HAREZMI project which is the Turkish adaptation of STEM. Professor Dr. Sinem Vatanartiran is the advisor of the project and founder of the science and technology high schools in Turkey. She is one of the pioneers of STEM education in Turkey and is now working at Bay Atlantic University. All the authors are interested in STEM areas, published articles using quantitative and qualitative research methods, and think that STEM education has a sociological aspect and that there are nearly no studies around Europe focused on this part. For this reason, the authors carried out the FEMALES project, which aims to fight to stereotypes and gender discrimination in the field of STEM. While doing this, authors and the other partners firstly made an extensive literature review about women's situations regarding STEM in European countries, role model education in STEM, STEM materials used, and gamification in STEM education for forming the theoretical background of the project. Additionally, we would like to see the teachers' views regarding to the situation of women and the ways to encourage female students to STEM areas. Thus, this study importantly demonstrates the European situation of women in STEM and how female students can be encouraged to work in STEM areas. We also developed a cooperative card game which presents information about female role models in STEM fields and prepared an e-learning platform in which teachers can get an online training about STEM education, which can be reached here: https://elearning.femalesproject.eu/en/.

Methodology

Research Design

We used the basic qualitative research in the study as our research design. This research design helps researchers understand how a group of participants perceive a particular phenomenon, and the main focus of researchers is to uncover or interpret their way of assigning meaning to that phenomenon (McMillan & Schumacher, 2006; Merriam, 2009). Basic qualitative research is most appropriate when researchers need to explore a poorly understood situation or when the research includes questions about lived experiences (Kahlke, 2014; Kim et al., 2017). In this vein, we tried to understand teachers' perspectives regarding the situation

of women in STEM areas in their countries and suggestions for encouraging female students to these areas.

Setting and Participants

The study was carried out in five different countries simultaneously with the participation of 39 teachers from five countries. For the selection of the participants, the authors used a purposive sampling with a convenience case strategy. Creswell et al. (2007) outlines that the concept of purposive sampling is used in qualitative research. This means that the researcher selects individuals for the study because they can purposefully inform an understanding of research problems and convenience cases, which represent individuals from which researchers can access and easily collect data. The underlying reason for using this strategy was the availability to access and collect data from the participants.

In terms of ethical considerations, we did not obligate participants to participate in the research. A consent letter informing the nature and purpose of study was initially sent to them and the consent form was signed by the participants and their approval was taken for recording before each interview.

Table 1
Participants Demographics

		Turkey		Italy		Spain		Greece		Romania	
Demographics		*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
	Female	6	67	5	71	4	57	6	60	4	67
Sex	Male	3	33	2	29	3	43	4	40	2	33
	Other	0	0	0	0	0	0	0	0	0	0
Age	17-22	0	0	0	0	1	14	1	10	0	0
	23-30	1	11	1	14	1	14	1	10	1	17
	31-40	4	44	1	14	2	29	3	30	2	33
	41-50	3	33	4	57	3	43	3	30	2	33
	51+	1	11	1	14	0	0	2	20	1	17
Total		9	100	7	100	7	100	10	100	6	100

As it is seen in Table 1, the participants were from five different countries: nine of the participants (23%) were from Turkey, seven (28%) were from Italy, seven (28%) from Spain, ten (26%) from Greece and six (15%) from Romania. Twenty-five participants (64%) were female while 14 participants (36) were male. Six of the participants (15%) were preservice teachers while 33 of the participants (85%) were in-service teachers. Two of the participants (5%) were 17-22 years-old, five of the participants (13%) were 23-30 years old, twelve of the participants (31%) were 31-40 years old, 15 of the participants (38%) were 41-50 years old, and five of the participants (13%) were older than 51.

Data Collection Tools

As part of data collection, focus group interviews were held with participants in each country. Focus group interviews can be said to be an ideal way to create a lively discussion atmosphere in which the participants do not feel threatened and express their ideas freely. In addition, an individual's opinions can trigger another individual's opinions and this kind of an environment can help ideas to flourish more easily (Berg, 2001; Yin, 2011). The interviews

were held in English. The researchers organized the interviews but preferred to be minimally involved in the conversation to enable teachers to share their opinions freely. So, project partners and designated representatives in each country conducted the sessions face to face and the researchers participated online to conduct interviews.

The researchers prepared a focus group interview protocol to help all the partners understand the requirements of a focus group interview. Before the interviews, they organized a silent place where the participants could see each other and discuss the ideas easily. They were also guided about the ideal number of participants and the requirements to choose a participant. During the interviews, they used a tape recorder, tried not to dominate the discussion, and made every effort to give voice to each participant. Focus group interviews were conducted twice in each country and each interview lasted around 60-90 minutes. The opinions of two field experts were taken to ensure the validity of the interview questions. The participants were asked questions about the situation of women in STEM areas, their numbers, and ways to encourage female students to these areas.

Data Analysis

Focus group interview data were analyzed using content analysis (Hsieh & Shannon, 2005) starting with the transcription of interview records. Data coming from five different countries were first transcribed, then the transcribed data were read carefully by the researchers to extract codes, categories, and themes. By doing so, they had the opportunity to merge similar concepts and create meaningful patterns (Glesne, 2015; Yin, 2011). The researchers tried to ensure the validity and reliability of the study with Lincoln and Guba's (1985) terms of credibility, transferability, dependability, and confirmability. To ensure credibility, researchers tried to identify the participants in an explicit way. For the transferability, the researchers tried to provide a detailed description of the data collection and analysis process. To ensure dependability, the researchers asked the opinions of two field experts about the content analysis. Finally, the researchers tried to ensure the confirmability by member checking. In this respect, the content analysis documents were shared with the participants and their confirmation was gathered.

Findings

The Number of Women Working in/Studying at STEM Areas

The first research question was about obtaining the views of the participants on the number of women working in/studying at STEM areas. Content analysis revealed that two categories emerged under the theme, "number of women in STEM areas": "sufficient" and "insufficient." Findings can be found in Table 2.

Table 2
Content analysis on the number of women working in/studying at STEM areas

Theme	Category	Sample Codes
Number of Women in STEM Areas	Sufficient Number	• Enough for inferior positions • Good in some chemist labs or medicine facilities • Gradual increase in women's number in STEM areas • In progress

	• Increasing number in IT field • Increasing popularity • No huge gender gap in studying • Universities
Insufficient Number	• A long way to go • Cultural barriers • Few women • Gender discrimination • Gender gap in academia/workplace • Gender limitation • Lack of educational policies • Lack of investment • Lack of role models • Less women in leading positions • Limited opportunities • Low numbers in physics, chemistry etc. • Man-dominated STEM areas • Need balance • No boss roles • No women in computer companies • Not attractive for Spanish women • Not educating girls • Not equal in all areas • Not having awareness • Orientation of females to human-related fields • Prejudice of the society • Quitting career after giving birth • Role of women at home • Societal beliefs • Societal expectations • The need to have more scientists

Although less in number, some of the participants stated that the number of women was sufficient in STEM areas in the first category. They drew attention to the increasing number in the IT field and the increasing popularity of science for female students. For example, participant four stated that:

> Romania can be considered as a good practice model for women in the IT field. At the same time, it is one of the countries with the highest percentage of women in technology, almost 30%, along with Bulgaria and Latvia, according to statistical data for 2018. In comparison, the United States ranks around 25%. Also, we have a steady increase in the number of young girls who become students in technical faculties, as this recent analysis shows. However, deeper research shows that this number is amazing or even a drop when it comes to young ladies / girls choosing a STEM university or staying in STEM. (P4, 30, female, Romania).

On the other hand, most of the participants agreed with the idea that the number of women in STEM areas was insufficient. Participant six emphasized this situation and said that,

> No, I absolutely don't think the number of women working in/ studying at STEM areas is sufficient. First of all, we can't deny the fact that gender discrimination hasn't been totally eliminated from society in Turkey. In my opinion, that is an important fact which affects the number of women working in/ studying in STEM areas. (P6, 43, female, Turkey).

Other participants pointed out that STEM areas were male-dominated and there was gender discrimination in the related areas. They said that female students were low in numbers in the areas of physics and chemistry, adding that there was a general tendency to direct female students to human-related fields. In conclusion, the majority of the participants believed that the number of women in STEM areas was insufficient while a small minority stated that the number of women in those areas were improving and promising.

The Situation of Women in STEM Areas

To find an answer to the second research question, the participants were asked about the situation of women in STEM areas. Content analysis revealed two different themes, "positive views" and "negative views." Under the "positive views" theme, three categories emerged, namely, "gender equality," "opportunities," and "achievement," and five categories emerged under the "negative views' theme: "visibility," "gender inequality," "societal roles," "representation," and "policies." A more comprehensive picture of the content analysis can be seen in Table 3.

Table 3
Content analysis on the situation of women in STEM areas

Theme	Category	Sample Codes
Positive Views	Gender Equality	• Empowering women to pursue career • Improving situation in gender equality • No discrimination between male and female • Women with same opportunities with men
	Opportunities	• Access to education • Access to technology • Encouragement towards women entrepreneurs • Good number of women in health • Increasing number of women • Women occupying important positions in STEM areas
	Achievement	• Active women in certain fields (e.g., architecture, biology, medicine etc.) • Gradual increase in women's number in STEM areas • Having successful women scientists

		• Highest percentage of women in technology • Possessing the necessary attributes • The increasing number of women in STEM
Negative Views	Visibility	• Difficult to make a name in STEM as a woman • Low visibility • Not enough in number • Not known by the community • Underrepresentation of women
	Gender Inequality	• Far from gender equality • Few opportunities for girls • Gender discrimination • Male-dominated • No equal access to education • Numerical domination of men • STEM positions reserved for men
	Societal Roles	• Burden • House working mother as a role model • Lack of female solidarity • Leaving the job for family • Motherhood • No women collaboration • Societal beliefs • Society prejudices
	Representation	• Few in the workplace • Insufficient number of women • Limited number of women in mathematics, engineering, technology • No early incorporation of women to STEM areas
	Policies	• Lack of support by the governments • No state policy to empower girls • Slow advancement in making policies

Although it is difficult to say that the theme, "positive views" generated as many categories and codes as "negative views," the participants with positive views about the situation of women in STEM areas gave reference to gender equality, opportunities given to women, and women's achievement in recent years. In the "gender equality" category, the participants stated that women had the same opportunities with men and there was an improvement in the situation of women regarding gender equality. For example, participant one thought that, "There are currently many women who opt for scientific studies (engineering, architecture, computer science, etc.)." (P1, 37, Male, Spain).

Some of the participants set forth the idea that there was no discrimination between male and female scientists and women were encouraged to pursue careers in STEM areas. Some participants thought that, particularly in the "opportunities" category, the number of

women in STEM areas is increasing and women have important positions and access to education and technology. Participant four explained the topic as follows:

> In Romania only 42% of women are employed in the STEM field, leaving us only a few percent behind the international average of 48% of women employed. With regard to young women, access to education and technology, combined with rapid globalization, have created an adequate environment for access to jobs. (P4, 30, female, Romania).

In the "achievement" category, the participants stressed the importance of the gradual increase in women's number and their achievements in the mentioned areas. They emphasized the importance of long-term professional support for women in STEM areas, promoting inclusivity and diversity in the working environment.

In the "negative views" theme, one of the most important concerns of the participants was women's visibility. Generally, opportunities are served to boys and even women who have the same potential are ignored in STEM areas. Participant two underlined that,

> The situation of women in the STEM camps in Italy is terrible. There are few opportunities for girls and it is a man-dominated field. In my day, it was very difficult to see girls in these fields, now I see that there are many girls who come across STEM, but very often they are not considered! (P2, 48, male, Italy).

They also put forward the idea that it was difficult to make a name in STEM areas as a woman, they were not widely known by the community, and they were underrepresented because the power is distributed unequally between women and men. Thus, some of the participants referred to gender discrimination advocating that these positions were only reserved for men and there was only a male-dominated STEM society.

In the "societal roles" category, the participants depicted the ongoing role of women in their societies. Not surprisingly, almost all participants referred to societal roles and prejudices taking women to the position of leaving the job for family, taking care of the children at home, and having a house-working mother as a role model. They also thought that companies are not eager to include women in STEM positions due to the rights and responsibilities of motherhood. Participant five summarizes the situation as follows:

> I believe that in Italy there are few in the workplace and many who undertake these studies. In fact, we have many capable girls in STEM but it is difficult for them to overcome the prejudices of society for their role, often the potential does not count but the gender. The woman in a company is increasingly problematic, because there is the possibility that she becomes a mother and therefore forms a family. (P5, 46, female, Italy).

Many of the participants also underlined that though it is not proven any statistics, society has a perception that girls are not as successful as boys in science and women in science are generally ugly.

In the "representation" category, the participants emphasized that the number of women in STEM areas was still insufficient, women were still fewer in the workplace, and there was no early incorporation of women to the related areas. Because they thought that STEM fields are dominated by men who see women as adversaries. Lastly, they made the association of the situation to policies, saying that there was no state policy to encourage female students, there

was a lack of support by the governments, and countries worked very slowly to make policies to include female students in STEM areas.

In summary, the participants' views on the situation of women in STEM areas were distributed under positive and negative themes. Positive views were gathered under women's achievement and gender equality while negative views mostly referred to low visibility of women, gender inequality, and lack of related policies.

Encouraging Female Students to Join STEM Fields

The third question was about how female students could be encouraged to STEM areas. To find an answer to this question, data coming from the focus group interviews were read carefully and the content analysis referred to two main themes: "actions" and "precautions." Five categories made up the "actions" theme: "modelling," "encouragement," "changing the mindset," "campaigns," and "teaching." The "precautions" theme contained two categories: "developing policies" and "preventing gender discrimination." Content analysis can be examined in a more detailed way in Table 3.

Table 4

Content analysis on how female students could be encouraged to STEM areas

Theme	Category	Sample Codes
Actions	Modelling	• Highlighting the figure of women in STEM areas • Imprinting success stories in girls' minds • Introducing role models • Offering women experiences • Presenting successful careers • Providing behavior patterns • Showing examples • Showing success stories • Telling stories to girls about successful women in STEM • Getting to know the trajectory of relevant women in STEM areas
	Encouragement	• Encouraging girls to STEM areas at school • Encouraging girls' participation in scientific events • Giving examples about facing challenges • Helping girls to believe in themselves • Highlighting the obstacles • Inspiring girls • Introducing female students to science at a younger age • Promoting female students in rural areas • Providing trainings and courses • Raising awareness in girls • Scaffolding girls

	Changing the Mindset	• Changing the attitudes of others • Changing the beliefs of parents • Changing the beliefs of the society • Stop thinking in boxes • Talking about students' prejudices they bring from home, TV etc.
	Campaigns	• Conducting campaigns • Gaining public support • Informing society • Inviting role models to schools • Organizing events to encourage female students
	Teaching	• Arousing curiosity • Creating an environment like laboratories • Creating different and interesting experiences for girls • Encouraging project-based learning • Encouraging students about doing experiments • Encouraging students to express their opinions properly • Helping girls explore technology in an interactive and intuitive way • Providing girls with practical knowledge • Providing hands-on activities
Precautions	Developing Policies	• Financial support to STEM programs • Managing HR effectively • Promoting mentoring programs • Promoting student career discovery programs
	Preventing Gender Discrimination	• Eliminating gender discrimination • Ensuring equality of genders • Eradicating macho stereotypes • Preventing societal prejudices • Treating boys and girls equally

In the "actions" theme, the participants referred to several steps which should be taken to encourage female students to STEM areas. In the "modelling" category, they frequently suggested that introducing role models, showing examples, and demonstrating some success stories could be very helpful to encourage female students. Showing success stories and providing behavior patterns were also among the suggestions on modelling. Participants think that they cannot change social beliefs easily and in a fast way, but they can inspire girls by demonstrating good role models. Participant 6 stated that,

> We have to change things. I am very negative that we can change things because all of these are society related problems. I think perhaps examples that have

> addressed these challenges could be inspirational for some of them. Examples of strong women, both working women and mothers. (P6, 41, female, Italy).

The other participants also underlined that women generally don't choose STEM careers because they are not well informed about STEM careers, or they are not sure about they can succeed in STEM careers.

In the "encouragement" category, the participants highlighted the importance of numerous activities to encourage students, that is, providing training, promoting female students in rural areas, and encouraging girls' participation in scientific events. Regarding the "encouragement" category, participant three reported that,

> To encourage female students, we have to organize events only for them, to show them what they can do in STEM, to imprint in their minds success stories of women in STEM, and do a strong fact check on their performance in math and science, which is surely not what their parents or themselves think about it. (P3, 41, male, Greece).

Likewise, they pointed out that changing the beliefs of parents and societies were among important actions to encourage female students to STEM areas in the "changing the mindset" category. Regarding the actions, the "campaigns" category included the participants' suggestions about informing the society, gaining public support, and organizing events to encourage female students. Lastly, in the "teaching" category, the participants stressed the importance of integrating more innovative teaching methods and techniques to attract the attention of female students. Encouraging students about doing experiments, creating a learning environment like laboratories, and encouraging project-based learning were among the most frequently mentioned alternatives.

In the "precautions" theme, the participants stressed the importance of two major components. In the "developing policies" category, they emphasized that there must be financial support to STEM programs. In addition, they pointed out that governments should promote student career discovery and mentoring programs. "Preventing gender discrimination" was the second category as a precaution. The participants stated that it was important to ensure the equality of genders and treating boys and girls in an equal way, as these were important parameters of preventing gender discrimination. Participant eight summarized this situation:

> The first step could be eliminating gender discrimination. Introducing young female students to STEM values at a younger age could also be an option to encourage female students to STEM fields. (P8, 49, female, Turkey).

Apart from ensuring the equality of both genders, eradicating the macho stereotypes and putting an end to societal prejudices were mentioned as important precautions to encourage female students to STEM areas. For putting an end to societal prejudices and encouraging girls to STEM, participant one stated that,

> From my experiences and observations, I think the best way to ensure girls' participation in STEM areas is to promote student career discovery programs that allow them to explore the potential, curiosity and passion for these areas. By creating different and interesting experiences for girls, where they can explore technology in an interactive and intuitive way - such as robotics, mechanics and coding workshops - it is possible to provide them with practical knowledge and understanding of the impact that careers can have STEM. (P1, 45, female, Romania).

Overall, actions and precautions were the main ways of encouraging female students to STEM areas. The participants made several suggestions on how to take actions to demonstrate good examples, transform mindsets, and change the classroom environment to provide an inspiring atmosphere for learning STEM. Developing policies and preventing discrimination were also important aspects of encouraging female students stated by the participants.

The Qualifications for Being a Female Role Model in STEM Areas

To find an answer to the fourth research question, the participants were asked about the qualifications for being a role model in STEM areas. Answers coming from the participants referred to "innate traits" and "acquired traits" as the main themes. Content analysis also revealed that three categories emerged under innate traits: "characteristics," "skills," and "interest." Similarly, under the "acquired traits" theme, three categories emerged: "knowledge," "achievement," and "studies." A clearer picture of the content analysis can be seen in Table 5.

Table 5
Content analysis on the qualifications for being a female role model in STEM areas

Theme	Category	Sample Codes
Innate Traits	Characteristics	• Brave • Collaborator • Committed • Creative • Curious • Dedicated • Deterministic • Generous • Grateful • Hardworking • Independent • Ingenious • Innovative • Inspiring • Involved • Motivating • Multidimensional • Optimistic • Passionate • Patient • Persistent • Precise • Strong • Visionary
	Skills	• Analytical thinking • Being innovative • Creativity • Finding solutions to real life problems

		• Following scientific research procedures • Having a multidisciplinary perspective • Multifaceted thinking • Putting theory into practice • Taking initiatives • Updating knowledge • Using STEM materials effectively • Using technology effectively
	Interests	• Design • Information technologies • Innovation • Productivity • Research • Science
Acquired Traits	Knowledge	• Being an expert in the field • Good content knowledge • Good technology knowledge • Having good knowledge base • Having practical experience in STEM areas • Master in STEM
	Achievements	• A recognized leader in the professional / academic world • Contributing to the field • Development of products • Good career • Good public appearance • Having an important invention • Having an important position in academia • Having an important prize • Having important publications • Work power
	Studies	• Transdisciplinary studies • Specialization in STEM areas • High quality publications • Being a STEM communicator • Proved excellency and work done in a STEM areas

The "innate traits" theme includes characteristics, skills, and interests. In the "characteristics" category, the participants referred to several characteristics of a female role model such as being brave, dedicated, independent, persistent, and so forth. Regarding to characteristics, participant seven underlined especially being adaptive:

> The attributes of a role model in STEM must be that of an optimistic person, who knows how to adapt very well to changes, and who, above all, has a passion

> for what she does and knows how to transmit it. I would also highlight persistence, positivity and generosity, since I consider that all the characteristics described above make people worthy of admiration. (P7, 46, female, Spain).

The "skills" category revealed abilities such as creativity, analytical thinking, and finding solutions to everyday problems. Participants also underlined that a good role model should be creative and a good researcher. Regarding to this topic, participant eight said that,

> First of all, being a role model in STEM requires being aware of technology literacy, they must be creative and have a broad perspective. A role model must have the ability to design and produce, must be a good researcher and an examiner and must try to find a way out of a problem. A role model must have analytical thinking and put theoretical knowledge into practice. (P8, 49, female, Turkey).

In the "interests" category, the participants pointed out that a female role model should be interested in science, technology, design, and innovation. Participant one stated that besides being interested, a role model should also be an expert in these fields.

> A role model must be an expert in these fields both at the level of knowledge and at the level of practical experience. She must have an innovative attitude, use new technologies, and recycle and update knowledge. (P1, 37, male, Spain).

In the "acquired traits" theme, knowledge, achievements, and studies were among the categories that the participants mentioned. In the "knowledge" category, the participants stressed the importance of being an expert in the field, having practical experience in STEM areas, and having deep knowledge in technology. In the "achievements" category, the participants stated that a female role model should have a good career, have an important invention, and be a recognized leader in the professional world. The "studies" category referred to the participants' opinions on what kind of studies a female role model could have done. Answers included, but were not limited to, transdisciplinary studies, high quality publications, and proved excellency in STEM areas. All in all, the belief was that role models should have an award that affirms all these attributes. However, participant one emphasized the importance of an award as:

> I think a prize or an honor is important! Maybe having a Nobel or another award in any STEM field or having something named after you (a formula, an invention, a protocol, a building, a street, a university) is what makes a female model in STEM. I think it's very rewarding. (P1, 33, female, Italy).

In summary, innate traits included characteristics, skills, and interests, while acquired traits referred to knowledge, achievements, and studies. For the participants, the qualifications for being a female role model in STEM areas required the possession of the mentioned attributes.

Discussion

This study was conducted with the aim of unraveling the situation of women in STEM areas with the lens of teachers' views. One of the findings of the study indicated that the number of women in STEM areas was believed to be insufficient by the majority of the participants

due to gender discrimination, cultural barriers, male-dominated STEM areas, and not having enough awareness to support female students in their STEM-related career path. This finding is consistent with the literature in the sense that several studies (Blackburn & Heppler, 2019; Corbett & Hill, 2015; Pearson et al., 2015) refer to the outnumbering of men in these areas. As Blackburn and Heppler (2019) imply, the question "Why so few?" is almost the same although there have been studies (Rossi, 1965; Hill et al., 2010) addressing the scarcity of women in science and academic positions since the 1960's. Although the Organization for Economic Co-operation and Development (OECD) report (2018) shows that the proportion of women university students is increasing day by day, it is not easy to see the reflections of this increase in the workplace. As this scarcity and disparity among the number of women and men leads to the loss of rich insights and perspectives in the related areas, it is still necessary to fully understand the problems to resolve the issue and erect the barriers against women.

Another finding of the study demonstrated that the participants generally had strong negative views on the situation of women in STEM areas. For many of the participants, regardless of their nationality, it was difficult to make a name as a woman in those areas; their visibility was below average; and as an inevitable consequence of this, they were underrepresented in the mentioned areas. Reilly et al. (2019) emphasize the existence of two major reasons for this situation: (1) gender differences in mathematics and science education; (2) attitudes towards mathematics and science and self-efficacy. Interventions that are aimed at supporting female students can be a way to deal with these reasons and there are different alternatives to handle the problem (Gold et al., 2021). Nevertheless, caution must be taken without making overgeneralizations as a more comprehensive understanding of the situation can lead to better opportunities for female students in different learning settings. At this point, Reilly et al. (2019) refers to country- and context-specific differences about the underlying reasons for the low number of women in STEM areas.

Findings gathered from the interviews also showed that there were some actions and precautions to be taken to encourage female students to STEM areas. One of the most frequently mentioned actions was to show female role models to support girls in their career path. Supporting female students through the employment of role models can be motivating and can help stigmatized groups reduce self-stereotyping (Lockwood, 2006; Betz & Sekaquaptewa, 2012; O'Brien et al., 2017). Herein Gladstone and Cimpian (2021) draw attention to the fact that this method can only be successful if it is part of a larger set of actions aimed at making STEM more welcoming to all students interested in pursuing it as a career path.

Another important action that was mentioned by the participants was to change the mindset of society through some awareness-raising activities and campaigns. Education systems cannot bring about transformational change alone. In this vein, the vision for stakeholders must be to inspire public and private policymakers and practitioners to accelerate change for girls' education and empowerment; to inspire girls to stand up, inspire each other, and build a network of thinkers; to inspire young women transitioning into today's and tomorrow's workplaces; and to inspire communities to transform unequal gender norms that limit opportunities for all (United Nations International Children's Emergency Fund-UNESCO, 2018). In addition to campaigns, effective teaching was another action the responsibility of which belonged to teachers. Yang and Gao (2019) advocate that female students are more likely to be assigned to recording experiment data, whereas male students are given the chance to participate in experiments in some teaching contexts. Female students' academic and professional growth are harmed by the gender-biased STEM education approach. Vooren et al. (2022) posit that female students are less interested in STEM degrees and are less likely to graduate on time. In the long run, however, females and males are equally well-represented in STEM higher education. In this respect, approaches and policies aiming at

enhancing female STEM students' academic achievement in terms of nominal graduation rates can help the inclusion of female students in STEM areas.

As a precaution, developing policies to promote mentoring programs to encourage girls to STEM areas and conducting more career discovery programs were among the solutions offered by the participants to develop policies. McGee and Bentley (2017) state that there must be ongoing support from knowledgeable mentors as students move up the career ladders, which could act as a buffer against the detrimental effects of gender-related experiences on female students. As a last precaution, preventing gender discrimination such as ensuring gender equality and eradicating stereotypes was strongly emphasized by the participants. Rennie (2003) argues that gender-inclusiveness can be ensured by raising students' awareness with the help of some teaching activities in the classroom. Given enough opportunities, students can be challenged about the way they think about how roles and responsibilities are shaped through stereotypes.

As the last finding, the study revealed some innate and acquired traits of female scientists to be appointed as a female role model. Among the innate traits, characteristics such as being brave, hardworking, dedicated, passionate, and visionary were strongly mentioned. Creativity, problem solving, and innovativeness were among the most frequently mentioned skills. Findings also demonstrated that female scientists must have an interest in research, sciences, design, and innovation. Among the acquired traits, findings signaled the necessity of having knowledge, achievements, and studies. Being an expert in the field and having practical experience were found to be important. Besides, achievements such as having a reward, having good public appearance, and contributing to the field were found to be important achievements. As for studies, it was found that high quality publications and transdisciplinary studies were among the important parameters of qualifications for being a female role model. Herrmann et al. (2016) argues that encouraging female students by use of role models boosts their performance by alleviating their concerns about representing one's group in a stereotyped domain, thus protecting them from the stereotype threat. Likewise, exposure to stereotyped male role models has been proven to reduce female students' interest, belonging, and perceived success in STEM because of perceived differences. When provided with a role model, female students can find hope to continue in these areas and can take necessary steps to attain the identities they are provided through those role models. According to Ko et al. (2020), an ideal female role model should clearly exemplify that the success she demonstrates is attainable. Role models should create personal bonds with female students and should convince them about their capability in STEM areas. Moreover, Hu et al. (2020) imply that a female role model's effectiveness can be determined through certain attributes. To this end, a female role model's success should be perceived as something achievable through struggle. Secondly, the role model that is met should have competence in a particular field. Thirdly, a female role model should be seen as someone similar or relevant to the self, based on the assumption that similar interests can help students demonstrate better performance in the related areas. Taken together, the findings of the current study build on existing literature by adding more perspective on the attributes of female role models.

When the literature was reviewed, similar studies that support the findings of the study were also found. For instance, Guy and Boards (2019) aimed to examine the barriers that the women faced in STEM areas and found out that lack of mentoring was among the most important problems in this area. Under mentoring, they also found out that lack of shared experiences, availability and guidance were the main sub-areas about which women in STEM areas were not supported enough. Another study, carried out by Gonzálés-Perez et al. (2020), sheds light on how female students could be encouraged to STEM areas through the use of role models. The findings of this study indicate that exposing young girls to the professional and personal experiences of actual female role models with a successful professional trajectory in

STEM areas is one of the most effective ways to encourage them to pursue emerging high-growth roles, particularly those requiring STEM math skills. Lastly, Hu et al. (2020) aimed to examine role aspirants' perceptions of the unique talents of female scientists and the motivational implications of those perceptions. At the end of the study, they found out that providing female students with relevant role models was a promising method to increase their involvement in STEM areas to meet the growing need for STEM professionals.

Conclusion

In conclusion, the situation of women in STEM areas needs to be improved. It was concluded that the number of women in STEM areas was believed to be insufficient by most of the participants. Moreover, they had strong concerns about the situation of women in those areas. Most of the negative views on their situation stemmed from women's considerably low visibility, gender inequalities, and societal roles, as well as governmental policies. It was also concluded that some of the most important steps to be taken to reverse the situation could be showing role models to female students, encouraging them to believe in themselves and succeed, changing society's mindset, and preventing gender discrimination. Lastly, to be shown as a role model, the women scientists needed to have certain innate traits, skills, and characteristics, as well as acquired traits such as knowledge, achievements, and quality studies. In short, the present study contributed to the understanding of the situation of women in STEM areas by demonstrating ways about how we can reverse the situation with the help of female role models in these areas. Teachers, instructional designers, curriculum planners, and policymakers can benefit from the findings of the current study to encourage female students to STEM areas in a more effective way.

Despite its contributions, some limitations of the current study should also be noted to be addressed in future studies. This study is limited to participants from five European countries. Future studies can be conducted with participants representing Asian, American, or African countries to depict a more global picture of the situation of women in STEM areas. Secondly, this study is limited to teachers' views regarding the topic. Future studies can be conducted with either female students or female scientists to understand their perceptions, feelings, and first-hand experiences in their educational or career paths. Lastly, this study has the limitation of providing a general qualitative framework on the situation of women in STEM areas. Further studies can be specifically conducted to elicit more information on different cases observed in various contexts. All in all, this study is believed to help shareholders to collaborate and act together to support and encourage female students about pursuing a career in STEM areas in line with the participants' suggestions.

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