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## **Determining the STEM Discipline Identities of Female Students**

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**Abstract:** Different meanings can be attributed to STEM education, which is the trend approach of recent years, by societies and individuals. In order to understand the STEM approach in the mind of the individual, it is necessary to learn the perspective of STEM education or STEM disciplines. It is necessary to determine the STEM identity of female individuals, especially because of the differences between men and women who prefer STEM professions or their perspectives on STEM disciplines. In this research, it is aimed to determine the identity of the disciplines of Science, Technology, Engineering and Mathematics in female individuals. Within the scope of this aim, 125 female students studying child development were reached. Data were collected online with a short-answer form. In this form, the reasons for being a scientist, technologist, engineer or mathematician were asked. As a result of the analysis of the data, it is understood that almost half of the participants stated that they wanted to be scientists and engineers, and nearly half of them stated that they could be technology experts. In addition, it was determined that very few of them believed that they could be mathematicians. When the reasons for these data are examined, it is understood that they determine their identities in these disciplines due to reasons such as love, interest, curiosity, research, intelligence, willingness, and using their imagination. Likewise, it is understood that they cannot choose these disciplines due to reasons such as fear, anxiety, competence and unwillingness.

**Keywords:** STEM education, STEM identity, women

### **Introduction**

STEM is an educational approach that emerged on the integration of science, technology, engineering and mathematics disciplines. It was born as a result of the technological and industrial competition of societies. The aim is to gain qualifications of individuals and indirectly to contribute to the economic welfare of societies. It is expected that individuals who make up the society will achieve success by using the identity of STEM disciplines in solving daily life problems. Regardless of gender, this success is expected to be achieved (Dönmez & Gülen, 2021; Hanson, & Krywult-Albanska, 2020).

One of the most popular goals of the STEM education approach is to establish gender balance. It is aimed that women and men have STEM disciplines and identities and gain STEM professions (Dönmez, 2021). In general, the STEM approach has emerged because the societies have low rates of choosing STEM disciplines, choosing a profession or creating a STEM identity. Although the goal of the STEM education approach is to increase this rate, it is thought that the increase in the STEM discipline identities of the female participants should be at the forefront. A lot of work is being done to support the attraction, retention and identity formation of STEM studies and careers around the world (McKinnon, 2020).

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STEM identities can be formed within the framework of social and cultural values, as well as the individual's own abilities, interests and role models (Gülen, 2019). When it comes to STEM disciplines in general, male occupations or identities are understood first. STEM occupations and identities in society are predominantly male (Sattari & Sandefur, 2018). This is due to the societal perspective. In fact, reasons such as women's preference for housework or being directed to housework affect this. In addition, it does not mean that women's work in societies, regardless of any discipline, has lost their duty in these household chores. Moreover, it is known that women with STEM disciplines have to deal with similar burdens. Women working in society should be given privileges in this regard (Xu, 2016). In addition to all these, it should not be forgotten that traditional gender norms have an impact on STEM identities (Vleuten, Steinmetz, & Werfhorst, 2019). For these reasons, various factors need to be taken into account in order to create the identity of women's STEM disciplines in societies. Gender inequality of women in society should be eliminated, especially in the formation of STEM disciplines and identity (Ro, Fernandez, & Ramon, 2021). In addition, STEM identity is not a subject that can be explained to women simply. This is a life problem to be motivated from an early age (Heybach & Pickup, 2017). Undoubtedly, the family and role models have a high impact on the formation of these identities (Boateng & Sharman, 2017). In general, women's inability to choose STEM disciplines is known (Hughes, Nzekwe, & Molyneaux, 2013). What is meant by inadequacy here is women's perspectives on these disciplines. Especially in the society where cultural and social reasons are intense, this should be prevented. Women need to recognize and internalize STEM disciplines (Carlone & Johnson, 2007; Gülen & Yaman, 2019).

Although the choice of STEM disciplines is often tied to academic success, it should be known that the belief or emotional state of the individual is effective in this (Dönmez, Gülen, & Ayaz, 2021; Sakellariou & Fang, 2021). Apart from academic success, internal and external factors affect the STEM identities of women or men (Sainz & Müller, 2017). These factors should be examined and women should be injured at similar rates to men. In addition, in the developing and industrializing society, it is necessary to look at the job opportunities of men and the job opportunities of women (Hagglund & Leuze, 2020). In these job opportunities, trainings or opportunities should be created by considering the qualifications of men and women. Activities that promote STEM and create identity in the society should be organized. Because women participating in STEM programs are more likely to choose a STEM discipline (Shahbazian, 2021). Considering that STEM disciplines are also used in daily life, it is thought that women can use these disciplines at the rate of men or interact with these disciplines (Schmuck, 2017). Although many purposes of the STEM education approach are to provide gender balance, it is important to determine the perspective of women on their STEM identities. Therefore, in this study, it is aimed to examine women's thoughts on the identities of STEM disciplines.

### **Purpose of the research**

The main purpose of this research is to determine the STEM discipline identities of female students studying in a child development program. For this purpose, answers to the following questions were sought.

A) What are the STEM discipline identities of the child development program students?

1. What are the reasons why students can or cannot be a scientist?
2. What are the reasons why students can or cannot be a technologist?
3. What are the reasons why students can or cannot be an engineer?
4. What are the reasons why students can or cannot be a mathematician?

### **Method**

Qualitative method was used in this study. In order to identify a particular research problem with its reasons, a phenomenological framework was preferred to determine the ideas and beliefs of the participants (Creswell & Plano Clark, 2015). Data were collected using a semi-structured interview form.

### **Sample**

All of the women participating in the research are continuing the child development program in the Malazgirt district of Muş province. There are 150 students in the child development program. Although all of them participated voluntarily, the data of 25 participants were not included in the analysis due to technical (internet, telephone) failures and missing data. In this context, the answers given by 125 female students studying child

development to the scale were accepted by creating a purposeful sample. It was determined that 95% of the participants were of similar socio-economic level (father a farmer, mother a housewife and all from eastern and southeastern provinces).

### **Data collection tool**

A semi-structured interview form was used in the research. This form was integrated into the online environment, enabling data to be collected online. The data collection tool prepared by the researchers basically consists of four questions. In addition, when asked about the reasons to be given to these questions, the number of questions increases to eight. For example, "I can/can't be a scientist. Why;" The participant who chose the first part of the question then writes the reason for the choice. A similar situation applies to Technology, Engineering and Mathematics (Appendix 1).

### **Analysis of Data**

Since all data were collected online, they were transferred to Microsoft Excel Program and analyzed. Although there is a content analysis, the origin of participant answers is shown with quantitative data. As a matter of fact, presenting qualitative data by digitizing is important for the reader (Yıldırım & Şimşek, 2013).

### **Results**

When the answers given by the participants were examined, the table and quotations presented below were obtained. In Table 1, the statuses of STEM disciplines regarding their identities are given.

Table 1. STEM disciplines identity preferences

Preference	Scientist		Technologist		Engineer		Mathematics	
	f	%	f	%	f	%	f	%
Can be	64	51.20	56	44.80	62	49.60	38	30.40
Can't be	61	48.80	69	55.20	63	50.40	87	69.60

As can be seen in Table 1, the preferences of the participants towards STEM disciplines are seen. According to this, it is understood that the participants have preferences about being a scientist, technologist and engineer by half. However, it is understood that 69.60 % of the participants expressed a negative opinion towards the discipline of mathematics. Along with this table, the themes and categories created as a result of the analysis of participant responses are presented below.

### **Theme 1. Identity of Women in STEM Disciplines**

There are four categories under this theme. Analyzes with random quotations from the views of the participants are presented below. Quotations were coded as there were no participant names (encodings were assigned to participant=P and numerical numbers were assigned to be different from each other).

#### *Category 1. I Can / Can't Be a Scientist*

When the answers given by the participants in this category were examined, 51.20% of them stated that they could be scientists. Examining the quotes below;

*I like to do research (P2)*

*I always think about discovering new things why things happen, why they happen. I like research to deal with things (P50).*

*Because I am open to science and innovation, I like to discover new things, so I can be a scientist.*

*Nothing is impossible after we believe and want it (P75).*

*Because: I am interested in discovering new things and collecting information (P79).*

*I enjoy doing scientific and experimental work and learning new concepts (P102)*

*Because: I love doing research. I am good at problem solving, very confident in my guesses (P115).*

According to the quotations, it is understood that the participants stated that they could become scientists because they wanted to “gather information”, learn “new concepts” with “scientific and experimental” works, “solve problems” and make “predictions” based on data, and make “discoveries” with situations such as “reasons”. It is understood that the participants want to be scientists because they want to make new discoveries by estimating with relationships such as experimenting, problem solving, cause and effect. According to this, it is understood that less than half of the participants could be scientists. It was also determined that 48.80% of the participants stated that they could not be scientists. Examining the following quotations;

*I do not like research (P32)*

*Science is not a field to be taken lightly. Research and observe all aspects of it. He does research. Scientists have the ability to observe things (P44).*

*Curiosity for knowledge, the effort to understand the universe, and the inability to be content with what they know, and the desire to learn more are an innate desire. It does not just about want to be (P51).*

*A very stressful and tiring job does not lift my body (P69).*

*Because I think scientists have a certain level of intelligence (P110).*

*Because I don't think I can be as patient as those people and try again and again when my attempts fail (P117).*

*I am not very curious (P120).*

According to the quotations, it is understood that the participants stated that they “do not like research”, research “should be done in all aspects”, “observation should be made”, a “certain level of intelligence and patience” is required, innate “curiosity” is “not just willing”, and they cannot be a scientist because it is a “stressful and tiring” work area. From this, it is understood that scientists have an innate curiosity, patience and intelligence. It is understood that the participants do not want to be scientists because they do not have enough intelligence, patience, curiosity, love to research, and observation. In addition, the category obtained from the answers given by the participants regarding the technology identity is presented below.

#### *Category 2. I Can / Can't Be a Technologist*

When the answers given by the participants under this category were analyzed, it was determined that 44.80% of them stated that they could be technology experts. When the citations for this break, which is less than half of the participants, are examined;

*I have a desire to produce the features that should be in some technology tools myself (P12).*

*I'm too lazy to use a school bag. I would like to make a school bag with me that can help me with my steps (P59).*

*I would like to work for what will benefit people (P77).*

*Everything related to technology excites me. I like to explore. Thanks to technology, I can easily find new things (P92).*

*I would be happy to invent and introduce new things (P97).*

*I am interested in technological tools and subjects related to technology (P105).*

The participants stated that they could become technology experts because of the reasons such as “carrying the school bag”, wanting to make the “features of the technological devices” themselves, “excitement”, “curiosity”, “happiness” feelings created by technology and making inventions for the “benefit of humanity”. In general, it is understood that the participants want to be technology experts because it provides desire, excitement, curiosity and happiness. Despite all this, it is understood that more than half of the participants (55.20%) do not want to be technology experts. Examining the following quotations;

*Because you are surrounded by too much technology, your only mistake can turn into a huge problem (P49).*

*I am a person with the capacity to do what I see well with the Internet. I can gather information. However, I have no desire to do technology (P56).*

*I don't believe myself about that (P81).*

*I like the innovations of technology, but I do not find myself competent in the field of design (P113).*

*I'm not good with metal tools (P118).*

From the quotations above, it was stated that the participants could not become a technology expert due to reasons such as being “*afraid*” of causing huge problems due to the “*mistakes*” that could be made, lack of “*desire*” to deal with technology, “*not believing*” in themselves, being inadequate in technology-related designs and not “*liking metal tools*”. In general, it is understood that the participants stated that they cannot become a technology expert due to reasons such as fear, not wanting, not believing, not loving and seeing themselves as inadequate in the field of technology. Apart from these, the following category is formed when the citations of the participants regarding their engineering identities are examined.

### *Category 3. I Can / Can't Be an Engineer*

In this category, almost half of the participants (49.60%) stated that they could be engineers. When these expressions are examined;

*Depending on the field, I can't actually be a technology engineer, mechanical engineer, but I can be a food engineer, civil engineer or chemical engineer. I like doing numerical operations and researching (P9).*

*Because my imagination is wide and I try very hard to put forward what I want, I don't give up when a problem arises; I like to make new breakthroughs in order to solve that problem (P31).*

*It could be because of the fact that engineering branches are different and all of them are very important today and because of my interest in mathematics (P63).*

*I can be. Because: I love innovations. In my opinion, such a thing in being an engineer is putting forth new things and striving for it (P84).*

*I see that capacity in myself, I can be like everyone else (P124).*

Although the participants have “*different*” engineering branches, it is understood that they can become engineers for reasons such as doing “*numerical operations*” and research, using their “*imagination*” to “*solve problems*”, loving “*innovations*” and self-confidence. In addition, it is understood that liking the discipline of “*mathematics*” also affects the engineering identity. In general, it is understood that half of the participants stated that they could become an engineer because of their ability to do numerical operations, their desire to use their imagination, their love of innovations and their self-confidence. Apart from these data, it was determined that the other half of the participants (50.40%) stated that they could not be engineers. According to this;

*I do not like research (P21).*

*I don't think it's a profession for me (P38).*

*I am not inclined to produce things (P59).*

*I don't like it, I'm afraid of that part (P96).*

*I am not interested because it is outside of my field of interest (P108).*

As it can be understood from the quotations, it is understood that the participants stated that they cannot become an engineer because they “*do not like research*”, “*are not inclined to produce*”, have “*fear*” and “*no interest*”, and “*do not see engineering as a profession*”. In general, it is understood that the participants do not want to be an engineer because of their indifference, fear, dislike of research and their profession perceptions. Finally, when the mathematics discipline identity of the participants is examined, the following category is obtained.

### *Category 4. I Can / Can't Be a Mathematician*

Within the scope of this category, it is understood that a small part of the participants (30.40%) want to be a mathematician. When the citations are examined;

*I both love it very much and find a practical solution (P5).*

*I could be because of my interest and love for mathematics (P12).*

*I love numbers. I love getting lost in numbers. I struggle for hours (P36).*

*Even if it is difficult, mathematics is actually fun for me (P47).*

*I love math and I can do it when I listen. In a way, it happens when you want it (P58).*

*Because: I have a fascination with mathematics (P94).*

It has been determined that there is an admiration for mathematics due to reasons such as the participants' "love" of the discipline of mathematics, their "interest" in mathematics, its "practicality", "dealing with numbers" and it's "fun". In general, it is understood that a small part of the participants stated that they might prefer the discipline of mathematics due to their interest, love, admiration and the fact that mathematics is fun with numbers. Apart from these, it is understood that the majority of the participants (69.60%) stated that they could not be mathematicians. According to this;

*Fear of never being able to do math (P3).*

*I don't like this lesson. I cannot do it (P11).*

*I don't like to calculate (P22)*

*I definitely can't. Because: I don't have a mathematical acumen. That's why it never interests me (P37).*

*I like math, but I wouldn't lock myself into the world of numbers. I mostly like to make my own paintings using my creativity and to be free (P41).*

*Although I hate math class, I avoid anything related to math (P62).*

*Since I am not very good with numbers, I have difficulty in coming to a conclusion after (P97).*

*I can't go after a job I don't like. I couldn't be a mathematician because I don't like math. Even if I were, I wouldn't do it happily (P100).*

According to the quotations, it is understood that the participants stated that they cannot become a mathematician due to reasons such as "not liking" mathematics, being "afraid", "not having mathematical intelligence", having "difficulties" and showing "interest in different professions". In general, it is understood that the majority of the participants stated that they could not be a mathematician because they did not like mathematics, had difficulties and were afraid of mathematics.

Looking at the general results of this theme, it is understood that half of the participants want to be scientists and engineers, and nearly half of them say they can be technology experts. In addition, it was determined that very few of them believed that they could be mathematicians. When the reasons for these data are examined, it is understood that they determine their identities in these disciplines due to reasons such as love, interest, curiosity, research, intelligence, willingness, and using their imagination. Likewise, it is understood that they cannot choose these disciplines due to reasons such as fear, anxiety, competence and unwillingness.

## **Discussion**

The data collected in determining the identities of women in STEM disciplines were interpreted. Accordingly, it can be said that half of the participants can be scientists, technologists and engineers. However, it is understood that the majority of the participants expressed a negative opinion about the identity of the discipline of mathematics. Prejudice or emotional traumas towards the discipline of mathematics are thought to be effective in this (Delaney & Devereux, 2021). In addition, it is thought that this preference, which is half of the participants' scientist, technologist or engineer identities, can be increased. It is thought that STEM education, STEM camps or science centers will be effective in this (Dönmez, 2021; Hughes, Nzekwe, & Molyneaux, 2013).

When the reasons for the identities of the participants towards science, technology and engineering are examined, it can be said that the reasons related to love, interest or talent are stated rather than social and cultural factors. According to this, it can be said that less than half of the participants can become scientists because they want to make experiments, solve problems, make guesses by establishing a cause-effect relationship and make new discoveries. It can be said that the rest of the participants do not want to be scientists because they do not have enough intelligence, patience, curiosity, love of research, and observation. Similarly, Fisher, Thompson, and Brookes (2020) determined in their study that the most obvious reasons why women prefer STEM disciplines or have low STEM identities are low self-efficacy and gender differences in science identity. However, in some studies, it has been determined that women are more autonomous in science (Modrek et al., 2021).

For the identity of a technology expert; It has been determined that the participants want to be a technology expert because it provides desire, excitement, curiosity and happiness. On the other hand, it is understood that the participants stated that they cannot be technology experts due to reasons such as fear, not wanting, not

believing, not loving and seeing themselves as inadequate in the field of technology. However, gender has a significant effect on technological and robotic STEM education attitude (Küçük & Şişman, 2020; Gülen, 2019). Today, there is no education or thought left without technology. While half of the participants find themselves sufficient in this regard, the other halves have negative thoughts about it. In this regard, it is thought that career days and role models can develop positive emotions (Dönmez, 2021).

When the reasons for the engineer's identity are examined; it is understood that half of the participants stated that they could be an engineer because of their ability to do numerical operations, want to use their imagination, love innovations and self-confidence. However, it can be said that the other half of the participants do not want to be an engineer because of their indifference, fear, dislike of research and their profession perceptions. Although the research findings suggested emotional reasons, it is known in the studies of Vleuten, Steinmetz, and Werfhorst (2019) that women from societies with traditional gender norms are also affected by their friend environment, and therefore STEM identity is greatly reduced. In addition, the fact that male-oriented job opportunities are at the forefront in the industrialized society is thought to have an effect on this (Hagglund & Leuze, 2020).

When the data for mathematical identity is analyzed; It is understood that a small part of the participants stated that they might prefer the discipline of mathematics for reasons such as their interest, love and admiration for the discipline of mathematics and the fact that mathematics is fun with numbers. However, it is understood that the majority of the participants stated that they could not become a mathematician because they did not like mathematics, had difficulties and were afraid of mathematics. As a matter of fact, Sakellariou and Fang (2021) determined in their study that women's careers in STEM disciplines depend on their abilities in mathematics discipline. Identity formation and achievement in STEM disciplines are largely linked to the discipline of mathematics. In addition, Delaney and Devereux (2021) determined in their study that ranking high in mathematics increases the probability of choosing STEM and decreases the probability of choosing Arts and Social Sciences.

It is known that the level of interest in STEM increased after students got to know STEM and created awareness. It is known that the implementation of STEM activities contributes to the increase of STEM career interest. It has been determined that the increase in the individual's STEM career preferences is in parallel with the increase in in-out of school activities (Dönmez, 2021). In this context, women need to get to know STEM, create a STEM identity and learn about occupational groups. In general, there is a relationship between gender and STEM disciplines. There are subtle nuances between women's recognition of STEM disciplines and their identity formation (Farrell & McHugh, 2020). The influence of women's close circles in the formation of STEM identities is high. It affects the formation of role model STEM identities from family members and relatives from the STEM discipline (Boateng & Sharman, 2017). It is also known that STEM programs implemented in science centers, STEM schools or practice centers can increase the likelihood of women choosing a STEM discipline (Shahbazian, 2021).

## **Conclusion and Recommendations**

It was determined that half of the women stated that they could be scientists, technologists (technologists) and engineers, but only a few of them identified with mathematics. They stated that half of the women can become scientists because they can produce new things with various scientific activities, but the other half will not be scientists because they do not have the qualities such as patience, curiosity, love of research, and observation. Similarly, technology identities are formed because half of women provide desire, excitement, curiosity and happiness. On the contrary, they have chosen to stay away from technology for reasons such as fear, not wanting, not believing, and not loving. Again, for the engineer identity, it was determined that half of the women could become engineers for reasons such as using their imagination, loving innovations and self-confidence. In addition, it can be said that the other half do not want to be an engineer because of their indifference, fear, dislike of research and their profession perception. Finally, it is understood that while a small part of women create an identity because of their love, interest and admiration for mathematics, the majority of them do not like mathematics, have difficulty and stay away from this identity because they are afraid of mathematics.

It is understood that women form STEM discipline identities for emotional reasons other than social and cultural reasons. First of all, the causes of these emotional states should be investigated and measures should be taken for negative ones. In the research, it is understood that half of the participants can be scientists, technologists and engineers. First of all, the source of the emotions, which is the reason for the absence of the other half,

should be investigated. In addition, it is understood that the majority of women do not want to create an identity for the discipline of mathematics due to fear, difficulty or dislike. The reasons for this situation are important. Reasons for dislike, fear or difficulty in mathematics should be investigated.

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## **Scientific Ethics Declaration**

The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

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## Appendix 1.

- 1) I am a scientist
  - a) Can be
  - b) Can't be
  - 1.1) Why;
- 2) I am technologist
  - a) Could/could be
  - b) Couldn't/couldn't be
  - 2.1) Why;
- 3) I am engineer
  - a) Could/could be
  - b) Couldn't/couldn't be
  - 3.1) Why;
- 4) I am a mathematician
  - a) Could/could be
  - b) Couldn't/couldn't be
  - 4.1) Why;

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