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DETERMINING PRE-SERVICE SCIENCE TEACHERS' UNDERSTANDING ABOUT STEM EDUCATION

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Abstract. *STEM education is included in education programs by many countries on a global scale. Pre-service teachers are also expected to apply STEM education in their future classrooms. The aim of the research was to determine how pre-service science teachers perceived STEM education, whether they adopted it or not, whether they thought of themselves as sufficient, and the environment and situations that affected their STEM experience. The understanding of the pre-service science teachers was tried to be determined before the theoretical STEM education, after the theoretical education and after the STEM application. The study group of the research consisted of a total of 66 pre-service teachers. Content analysis results of the interviews were carried out in three stages. It was found that there was no single STEM definition that pre-service science teachers agreed on. The training provided increased the STEM competency levels of pre-service science teachers. However, the majority of pre-service science teachers defined themselves as having intermediate competence in STEM education. Pre-service teachers adopt STEM education and believe that it will contribute to students. Pre-service science teachers had the most difficulty in disciplinary integration during the STEM theory and practice education. The most preferred model after both theoretical knowledge and application was the problem-based STEM model.*

Keywords: *content analysis, pre-service science teachers, STEM education, STEM understanding*

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Introduction

Today, as we are getting closer to completing the first quarter of the 21st century, the constant change in technology has required countries to adapt themselves to these changes. With every developing technology, new business areas emerge, creating the need for competent employment in these business areas. These obligations and needs have made it essential to raise future generations as individuals who can follow the ever-changing technologies and adapt. It has been noted that students who are expected to struggle with the ever-changing world problems with the integration of engineering in K-12 education will gain the advantage of contributing to their teamwork, communication skills and problem-solving skills (Brophy et al., 2008). At this point, STEM education, which aims to integrate science, technology, engineering and mathematics disciplines, has come to the fore with an interdisciplinary perspective. It has been suggested to create student-centered environments by integrating engineering with science standards (National Research Council [NRC], 2012). In order to popularize the approach led by the United States of America, recommendations for curriculum development in STEM fields have been made in published national reports (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine of the National Academies, 2007). Calls have been made to encourage the applications of the STEM approach in K-12 education, to direct students to careers in STEM fields, and to increase their success in these fields (NRC, 2011). The Next Generation Science Standards, which encourage engineering and scientific applications rather than rote teaching, have been adopted by many states in America (NRC, 2013). Various reports and research, that have adopted the STEM approach in other countries, have been published one after another (Bureau of Labor Statistics, 2020; European Commission, 2015; EU STEM Coalition, 2015; Ministry of Education & Research, 2010; Ministry of Education [MNE], 2016; SINTEF, 2011; The Organization for Economic Co-operation and Development [OECD], 2008; OECD, 2013; Turkish Industry and Business Association [TUSIAD], 2017). These reports, whose common point is to provide learning environments suitable for STEM understanding, are not easy to implement. Despite recommendations to use the STEM approach, it is unclear exactly what it represents

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(Herschbach, 2011). It is seen that STEM is interpreted differently. There are different definitions such as; STEM as an integrated learning and teaching approach that requires making connections between disciplines (Karatas, 2017); as a simple term replacing mathematics or science (Sanders, 2009); accepting the argument that the combining of two disciplines is enough (Kelley & Knowles, 2016). According to Honey et al. (2014), in STEM applications, one discipline is used more dominantly than the others, while the others are used as supportive. In STEM discipline integration, disciplines can also be used as interdisciplinary, transdisciplinary or multidisciplinary (Vasquez et al., 2013). Along with the different definitions of STEM education, another challenge awaiting practitioners is the use of different pedagogy practices (Dare et al., 2019). Problem-based STEM (Breiner et al., 2012; El Sayary et al., 2015; Dischino et al., 2011), project-based STEM (Capraro & Jones, 2013; Capraro & Slough, 2013; Han et al., 2015; Sahin, 2013), engineering design-based STEM (Billiar et al., 2014; Capobianco & Rupp, 2014; Guzey et al., 2016), STEM with 5E model (Bybee, 2019; Sanjaya, 2018) have been suggested to be used in the STEM approach. The STEM literacy levels of the teachers who will interpret the STEM approach, where there is such a diversity, are very important. Teachers have a great role to play in the trainings to be given for the STEM approach. It is necessary to develop teachers' understanding of integrating STEM disciplines in addition to their knowledge of the content, pedagogy and technology (Honey et al., 2014). Although teachers are expected to integrate STEM disciplines, they face a lack of information on how to do so (Dare et al., 2019; Ejiwale, 2013). There is more than one application for the integration of STEM disciplines and there is no single truth that teachers will use (Bybee, 2013; Johnson, 2012; Ring et al., 2017). This status makes it hard for teachers who want to include STEM education in their classrooms. Before applying STEM education, teachers need to understand, make sense of, and determine the appropriate model for their own understanding (Ring et al., 2017). In cases where teachers are not given the opportunity to think about their own STEM models and appropriate environments are not provided. It can be difficult for them to take an interdisciplinary perspective and understand the concept of integrated STEM correctly and can cause contradictions in their beliefs (Moore et al., 2014).

Research Problem

The STEM approach has also been received with interest in Türkiye. In the report arranged by the TUSIAD (2014), it is underlined that countries that want to improve economy and technology will need persons who have studied STEM disciplines. Afterwards, in the STEM education report issued by the Ministry of National Education (2016), it was pointed out that individuals with 21st-century skills would also direct the forthcoming of countries. It keynoted the importance of STEM education in transforming theoretical knowledge into product, practice, and innovative inventions. With the influence of these reports, studies on the STEM approach have gradually increased since 2014 (Akaygun & Aslan-Tutak, 2016; Akgunduz et al., 2015; Baran et al., 2016; Corlu, 2014; Karahan et al., 2015; Kececi et al., 2017; Marulcu & Hobek, 2014). With the applied science unit of the science course curriculum in 2017, the STEM approach, which has been previously given a start by private schools and institutions, took its place in the program. In the science curriculum for secondary schools organized in 2018, the applied science unit was abolished, and students were believed to assign a demand or problem from real life for the subjects in the units and make science, engineering and entrepreneurship practices (MNE, 2018). At this point, the biggest problem is that science teachers are caught unprepared for this situation and have difficulties in applying it (Blackley & Howell, 2015; Corlu et al., 2014). The surprise of teachers who have not been educated in any training on the STEM approach during their undergraduate education can be considered natural. Teachers who use STEM activities with their students during the education and training process should be competent in STEM education. How teachers comprehend STEM understanding, whether they embrace it or not, whether they see themselves as sufficient or not will directly affect the success of the program. However, teachers' studies on how teachers perceive STEM education are limited compared to STEM definition studies (Dare et al., 2019). Although pre-service teachers participated in STEM practices, it was found that they were not confident enough in describing STEM education (Bartels et al., 2019). Alan et al. (2019), in their study that aimed to support pre-service science teachers' integrated teaching knowledge through STEM applications, stated that pre-service teachers believed in the necessity of STEM education, but thought that discipline integration was not easy. When teachers' STEM awareness is increased before they start their profession, they are given the opportunity to establish their own understanding of STEM before the application. In this regard, this study aimed to determine the understanding of pre-service science teachers about STEM education.

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Research Focus

The lack of a single accepted definition of STEM education, which is globally accepted and tried to be integrated into curricula, is an important problem for teachers and pre-service teachers who are STEM practitioners. However, the goal of effective workforce and career planning in the STEM field, which is desired to be achieved with STEM education, is common. Using STEM for equipping future generations with skills such as communication, cooperation, entrepreneurship, critical thinking and problem-solving required by the 21st century is also a common goal of many countries. In this respect, knowing the STEM understanding of pre-service teachers who have not started the profession actively gives education policymakers the chance to make the necessary interventions. In the research, STEM education was determined as a phenomenon, and it was tried to determine how pre-service science teachers perceived STEM education, whether they adopted it, whether they saw themselves as sufficient, and the environment and situations that affected STEM experiences. In the research, pre-service science teachers first participated in the STEM theoretical training, which lasted for six weeks. The pre-service teachers, who were divided into groups after the theoretical training, prepared a STEM activity that they could implement with their students in the future according to a STEM understanding they chose, and a lesson plan on how to implement the activity. Pre-service teachers presented their activities and the STEM approach they adopted to their peers. Pre-service teachers in the role of listeners evaluated the activities of their peers in their individual diaries.

Research Aim and Research Questions

This research aimed to determine the understanding of STEM about STEM during the 14-week theoretical and applied STEM education processes of pre-service science teachers. In this research study, responses to the following questions were explored.

1. What is the STEM understanding of pre-service science teachers before theoretical education and before and after applied education?
2. Which STEM learning and teaching models do pre-service science teachers prefer to use?

Research Methodology

General Background

A phenomenological research design was used in the research. The goal of research using phenomenological design is to search for various ways people use to comprehend, comment on, or make sense of a certain phenomenon or a certain aspect of reality. With this search, meanings are revealed on facts and these meanings are classified according to categories (Çepni, 2010). In phenomenological research, it is tried to understand and describe how people perceive these experiences by examining their daily experiences. In this paper, STEM education was determined as a phenomenon and pre-service science teachers' understanding of STEM was researched. Analysis of personal text, focus meetings, conversations with participants, participant observation, action research and interviews can be used in phenomenological designs (Delve & Limpaecher, 2022). In this research, semi-structured interviews were used for collecting data. All pre-service science teachers participated on a voluntary basis. Interviews were carried out three times: before theoretical education, and before and after applied education.

Participants

The study, in which 49 female and 17 male pre-service teachers participated, was carried out at a state university in eastern Türkiye. The research was carried out within the content of the "Special Teaching Methods II course", in a 14-week period in the 2018-2019 education term. The study group was settled by the purposeful sampling method. The researcher can take as some sample individuals who he believes reflect the generality and fit the characteristics he has determined, depending on his own judgment in this method (Ural & Kılıç, 2011). All of the pre-service teachers participated in STEM education applications, in which models related to renewable energy were designed using educational Lego sets before the research. In addition, all of the pre-service teachers attend the school experience course. Criteria for the study group of the research were preferred because it is thought

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that more realistic comments will be received in terms of the fact that the pre-service teachers have completed the basic courses, they have STEM awareness, and they see the practices of the teaching profession in the real environment during the school experience lesson. While coding the pre-service teachers, the ordinal numbers of the students who took the course and the group numbers during the STEM applications were coded to be written one after the other. For example, "PT37" was written for the 37th pre-service teacher in the class list, then the group number was added as "G11" and coded as "PT37G11". The research process was explained to the pre-service teachers, and it was stated that there was a voluntary basis for the collection of data within the scope of the research. All of the participating pre-service teachers voluntarily agreed to take part in the research. However, there were 14 pre-service teachers (PT3G10, PT5G7, PT7G9, PT9G10, PT15G10, PT31G5, PT40G2, PT41G9, PT45G11, PT47G9, PT57G11, PT62G11, PT63G2, PT65G5) who could not be reached for the interviews in the last stage of the study because it was the end of the semester, and the pre-service teachers went to other provinces due to the holiday period. However, since the data were collected at the beginning and in the middle of the application, the pre-service teachers were not excluded from the study group.

Instrument and Procedures

Pre-service teachers attended the interactive training in the 2018-2019 academic year in a 14-week period, in which theoretical information about STEM theory and applications was given. STEM definitions, history of STEM, national and international reports on STEM, learning-teaching models used in STEM education and STEM application examples were shared with pre-service teachers during the six-week period. After the theoretical knowledge, the pre-service teachers were released to form their groups for the application phase. It has been suggested that they form groups of 5-6 people and that the number of male pre-service teachers (25%) is less than the number of female pre-service teachers (75%) so that they should be homogeneously distributed among the groups. However, at the end of the given week, the pre-service teachers formed 11 groups that were quite different from what was expected. The 66. pre-service teachers did not want to join any group and wanted to carry out their own study. The fact that the groups were formed in different numbers and features suggested that it may be due to the differentiation of the communication and cooperation skills of the pre-service teachers, and the groups formed were not intervened in order to monitor how the process would continue. The experiences of pre-service teachers, who are expected to do STEM applications with their students in their future classes, while implementing their own STEM projects in this process are thought to be very important. In addition, it is considered as an important gain that pre-service teachers have the chance to observe and evaluate different projects in the other groups. The groups constructed an instance lesson plan in line with the STEM understanding they adopted, carried out STEM applications, presented their projects to their peers, and defended the dimensions of STEM disciplines. Pre-service teachers appreciated and discussed the STEM practices presented by their peers in terms of whether they should be integrated into disciplines or not, in terms of the method used. The presentations of the pre-service teachers were completed with self, peer and teacher evaluations. Presentations were recorded in order to understand how the pre-service teachers' understanding of STEM was shaped and how the learned theoretical knowledge was reflected in practice. Pre-service teachers carried out 11 group and one individual STEM activities. In the implementation phase, where the pre-service teachers were expected to do a STEM project in which they integrated the disciplines with their groupmates, all groups, except Group 10 and PT66G12 (who worked individually) preferred to use sensor sets to integrate technology and content-based engineering (Blackley & Howell, 2015; Moore & Smith, 2014) have included the gains of software engineering by coding in accordance with the integration. The number of people in the groups formed and information on the teaching and learning models the groups adopted in STEM applications are in Table 1.

Table 1
Characteristics of the Groups Created

Group	Female	Male	Adopted STEM models
1	PT16, PT19, PT33, PT36, PT38	PT1	Project Based STEM
2	PT24, PT29, PT40, PT58, PT63	PT49	Design Based STEM

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Group	Female	Male	Adopted STEM models
3	PT12, PT32, PT34, PT56, PT59	PT22	Problem-Based STEM
4	PT6, PT18, PT25, PT50, PT52	PT30	Problem-Based STEM
5	PT31, PT39, PT54, PT65	PT4, PT8	Problem-Based STEM
6	PT10, PT14, PT28, PT37, PT60, PT53	PT2	Problem-Based STEM
7	PT5, PT11, PT48, PT55, PT61	PT42	Problem-Based STEM
8	PT23, PT27, PT44	-	Project Based STEM
9	PT13, PT17, PT35, PT41, PT46, PT47, PT64	PT7	Problem-Based STEM
10	PT15, PT20, PT21, PT43	PT3, PT9	Problem-Based STEM
11	-	PT26, PT45, PT51, PT57, PT62	Project Based STEM
12	PT66	-	Project Based STEM

When Table 1 is examined, it is shown that seven of the groups formed by the pre-service teachers consist of six people, one group consists of seven and one group consists of eight people. It is shown that all members of Group 11 are male, and all members of Group 8 are female pre-service teachers. On the other hand, it is shown that a pre-service teacher prefers individual work rather than collaborative group work. It is shown that four groups adopted project-based STEM, seven groups adopted problem-based STEM, and one group adopted an engineering-based STEM approach in their STEM activities.

The data of the study were gathered through semi-structured interviews participated on a voluntary basis of pre-service teachers. Interviews were carried out three times: before theoretical education, and before and after applied education. Interviews lasted between 10-30 minutes. The interviews of the pre-service teachers were recorded using a voice recorder with the authorization.

Data Analysis

Phenomenological data analysis stages, textural descriptions in which data are directly listed, important explanations and quotations are made to understand how the phenomenon is experienced, keywords are specified, expressions are specified within themes; structural descriptions, in which a description of the setting or context that influences the way participants experience the phenomenon; and the "essence" of the phenomenon is conveyed as composite descriptions (Moustakas, 1994). In this study, the data obtained from the interviews were coded, the data were categorized according to their similarities, the categories were associated with each other and supported by direct quotations from the interviews in order to understand how the pre-service teachers perceived STEM education, whether they adopted it or not, and whether they saw themselves as sufficient. To better understand the variation of the codes obtained from the qualitative interviews in three phases, they were required to use bar graphs to represent them graphically. In this respect, embedded quantitative analysis is included.

For the internal validity of the research, the prepared interview form was examined by two science education experts, read by three pre-service teachers, and evaluated in terms of intelligibility. Necessary arrangements have been made. A natural environment was tried to be created during the interviews, and the answers of the participants were confirmed by repeating. The data obtained are presented without modification. The coding made by the two researchers in categorizing the data was checked, the numbers of concurrence and disagreement were defined, and the reliability of the research was checked out using the formula of Miles and Huberman (1994) Reliability=consensus/(consensus+disagreement). A consensus (reliability) of 93% was achieved. For the credibility of the interviews, the researcher spent time with the participants throughout the process. The research process was explained, and it was stated that the data collection was on a voluntary basis within the scope of the research. Instead of participants' names codes were used.

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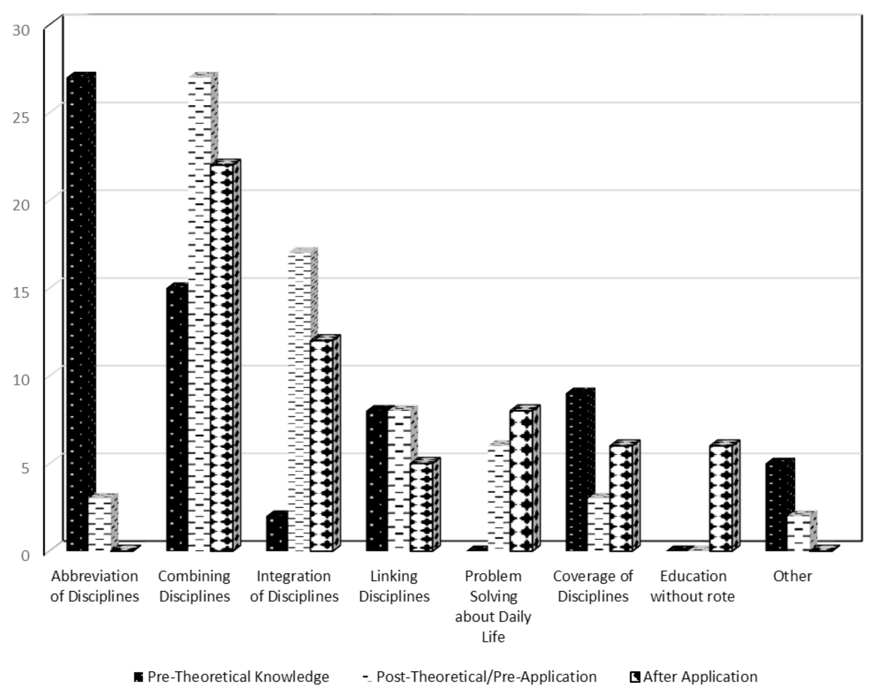
Research Results

In this study, STEM education was determined as a phenomenon, and it was tried to determine how science pre-service teachers perceived and adopted STEM education, whether they saw themselves as sufficient, their experiences, the environment and situations that affected their experiences. In the study, three-stage interviews were conducted with pre-service teachers. Findings from these interviews are given below.

In the study, pre-service science teachers were first asked to define STEM in order to understand the level of STEM comprehension of pre-service science teachers. It was tried to understand whether there were any changes in the definitions of pre-service teachers before and after theoretical knowledge and after the practical knowledge. Seven codes were determined according to the keywords used by the pre-service teachers. The definitions, which were not repeated and only said by a single pre-service teacher, were discussed under the eighth code title by creating the "Other" code. Six pre-service teachers (PT6G4, PT8G5, PT12G3, PT25G4, PT30G4, PT32G11) defined STEM with more than one word after the application. Therefore, these pre-service teachers were coded twice. STEM definitions of pre-service science teachers are given in Figure 1.

Figure 1
STEM Definitions of Pre-Service Science Teachers



At the beginning of the research, overall, the pre-service teachers were aware that the word STEM was the abbreviation of the initials of their discipline, but 27 pre-service teachers (41%) gave only the expansion of the abbreviation without any explanation. For example, the definition of PT7G9 at the beginning of the research is "*STEM is an abbreviation for science, technology, engineering, mathematics.*". All of the pre-service teachers participated in STEM education practices, in which models were designed through instructions on renewable energy using educational Lego sets before the research but did not receive theoretical information. Although STEM is not a concept that they first encountered, it can be said that the pre-theoretical definitions of pre-service teachers are quite superficial. The pre-service teachers (except for three pre-service teachers after theoretical knowledge; PT37G6, PT51G11, PT53G6) developed the definition of discipline abbreviation throughout the process and made changes in their definitions. After the application, all pre-service teachers moved away from using the term "*discipline abbreviation*" while defining STEM. While there were two pre-service teachers who defined STEM as the integration of disciplines at the beginning, it increased to 17 pre-service teachers (25%) after the theoretical knowledge and

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decreased to 12 pre-service teachers (18%) after the application. The definition of PT12G3 after the theoretical knowledge is as follows; *"STEM is an integrated approach to science, technology, engineering and mathematics. Art and entrepreneurship can also be integrated".* The fact that STEM integration definitions were given during the theoretical knowledge may have caused this situation. The decrease in the number of pre-service teachers who define STEM as discipline integration after the application may be due to the difficulties of pre-service teachers in disciplinary integration while developing an exemplary STEM activity. The majority of pre-service teachers defined STEM as the use of disciplines together. 15 pre-service teachers (22%) at the beginning, 27 pre-service teachers (41%) after the theoretical knowledge, and 22 pre-service teachers (33%) after the application explained STEM as using the disciplines together. For example, the opinion of PT18G4 at the end of the application; *"STEM is a system created by the combination of science, engineering, technology, and mathematics disciplines. It is set on a project or a design and gives students different perspectives and creativity instincts".* Although the definitions of "discipline integration" and "combining of disciplines" seem to be similar, pre-service teachers' definition of " combining of disciplines" was accepted that they thought that the disciplines of STEM should be given together but did not express their opinion on how. Discipline integration, on the other hand, has been accepted as a situation in which they have an idea about how the disciplines will be used. Eight (12%) at the beginning, eight (12%) after theoretical knowledge, and five (7%) post-practice pre-service teachers defined STEM as the "linking of disciplines". Six (9%) after theoretical knowledge and eight (12%) post-practice pre-service teachers defined STEM as "solving daily life problems". Nine (13%) before the theoretical education, three (4%) after the theoretical education, and six (9%) post-practice pre-service teachers explained STEM as a top discipline that covers the disciplines. After the application, six (9%) pre-service teachers stated STEM as an approach that takes the students away from rote learning. PT30G4 after the application; *"It is a program that is far from rote learning, which is formed by the coming together of branches such as mathematics and engineering, where students gain experience by using the topics they have learned in the theoretical lessons with different applications",* he defined STEM. No such definition has been found before and after theoretical knowledge. The definitions coded as "Other", which were not repeated and only said by one pre-service teacher, were five (7%) at the beginning of the research, and two (3%) different definitions after theoretical knowledge. Before the theoretical knowledge, "engineering in science class", "education with Legos", "group work", "student-centered lesson", and "education given in private schools"; After the theoretical knowledge, definitions were made as "transfer of knowledge" and "open-ended course". No different definitions were found after the application. In practice, no relationship was found between the group they were in and their individual definitions of the pre-service teachers, who formed 12 different groups.

Pre-service teachers were asked whether they felt competent about STEM education. The responses were collected under three themes as being fully competent in STEM education, partially competent in STEM education, and not being competent in STEM education. While analyzing the data, percentage values were taken as a basis due to the decrease in the number of pre-service teachers who participated in the post-application interviews. An understanding of pre-service science teachers on STEM competencies is given in Table 2.

Table 2
Understanding of Pre-service Science Teachers on STEM Competencies

Themes	Codes	
Fully competent	Predicting what can be done in the STEM	Pre-Theoretical Knowledge PT13G9, PT21G10, PT24G2, PT33G1 Post-Theoretical Knowledge PT13G9, PT14G6, PT21G10, PT24G2, PT29G2, PT33G1, PT34G3, PT36G1, PT40G2, PT43G10 After Application PT14G6, PT24G2, PT43G10, PT55G7
	Be able to use STEM	Pre-Theoretical Knowledge PT10G6, PT44G8, PT54G5, PT60G6, Post-Theoretical Knowledge PT10G6, PT12G3, PT44G8, PT54G5, PT60G6, PT63G2 After Application PT10G6, PT23G8, PT28G6, PT35G9, PT38G1
	Being in the middle of STEM	Pre-Theoretical Knowledge PT64G9 Post-Theoretical Knowledge PT11G7, PT64G9 After Application PT4G5, PT8G5, PT56G3, PT64G9

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Themes	Codes	
Partially competent	Feeling moderately competent	Pre-Theoretical Knowledge PT3G10, PT9G10, PT11G7, PT14G6, PT17G9, PT20G10, PT29G2, PT36G1, PT63G2 Post-Theoretical Knowledge PT3G10, PT9G10, PT17G9, PT20G10, PT46G9, PT48G7, PT50G4, PT66G12 After Application PT17G9, PT20G10, PT44G8, PT46G9, PT48G7, PT50G4, PT66G12
	Finding deficiencies, feeling the need for improvement	Pre-Theoretical Knowledge PT2G6, PT4G5, PT12G3, PT15G10, PT18G4, PT23G8, PT25G4, PT35G9, PT39G5, PT40G2, PT41G9, PT43G10, PT49G2, PT52G4, PT55G7, PT56G3, PT57G11, PT58G2, PT59G3, PT62G11 Post-Theoretical Knowledge PT2G6, PT4G5, PT5G7, PT15G10, PT18G4, PT19G1, PT23G8, PT25G4, PT28G6, PT30G4, PT32G3, PT35G9, PT38G1, PT39G5, PT41G9, PT49G2, PT52G4, PT55G7, PT56G3, PT57G11, PT58G2, PT59G3, PT61G7, PT62G11 After Application PT2G6, PT12G3, PT13G9, PT18G4, PT19G1, PT21G10, PT22G3, PT29G2, PT32G3, PT34G3, PT36G1, PT39G5, PT49G2, PT52G4, PT54G5, PT58G2, PT59G3, PT61G7
	Be proficient in some disciplines	Pre-Theoretical Knowledge PT7G9, PT26G11, PT27G8, PT30G4, PT34G3, PT50G4, PT51G11, PT53G6 Post-Theoretical Knowledge PT6G4, PT7G9, PT16G1, PT26G11, PT27G8, PT30G4, PT45G11, PT51G11, PT53G6, PT65G5 After Application PT6G4, PT16G1, PT26G11, PT27G8, PT30G4, PT33G1, PT51G11, PT53G6
Not being competent	Being at the beginning of STEM education	Pre-Theoretical Knowledge PT5G7, PT6G4, PT8G5, PT19G1, PT26G11, PT28G6, PT30G4, PT32G3 PT37G6, PT38G1, PT42G7, PT45G11, PT46G9, PT48G7, PT57G11, PT61G7 Post-Theoretical Knowledge ÖA8G5, PT26G11, PT22G3, PT37G6, PT42G7, PT57G11 After Application PT11G7, PT25G4, PT37G6, PT42G7, PT60G6,
	Feeling distant from STEM education	Pre-Theoretical Knowledge PT1G1, PT16G1, PT22G3, PT47G9, PT65G5, PT66G12 Post-Theoretical Knowledge PT1G1, PT47G9 After Application PT1G1

Three codes were formed from the data collected under the theme of being fully competent in STEM education. The answers of the pre-service teachers were gathered under the headings of predicting what I can do in the STEM field, being able to use STEM, and being in the middle of STEM. The percentage of pre-service teachers who stated that they were competent in STEM; 13% in pre-theoretical interviews, 27% in post-theoretical interviews, and 23% in post-application interviews. When the data are examined, it is understood that the percentage of pre-service teachers who find themselves competent in STEM increased after the theoretical knowledge but decreased again after the application.

Three codes were formed from the data collected under the theme of being partially competent in STEM education. The answers of the pre-service teachers were grouped under the headings of feeling moderately competent, feeling lacking and needing improvement, and being proficient in some disciplines. The percentage of pre-service teachers who stated that they were partially competent in the STEM field; 56% in pre-theoretical interviews, 63% in post-theoretical interviews, and 63% in post-application interviews. When the data are examined, it is understood that the percentage of pre-service teachers who find themselves partially competent increased after the theoretical knowledge and did not change after the application.

Two codes were formed from the data collected under the theme of not being competent in STEM education. The answers of the pre-service teachers were gathered under the headings of being at the beginning of STEM education and feeling distant from STEM education. The percentage of pre-service teachers who stated that they were not competent in the STEM field is 36% in the pre-theoretical interviews, 12% in the post-theoretical interviews, and 11% in the post-application interviews. When the data are examined, it is understood that the percentage of pre-service teachers who do not find themselves competent decreased after the theoretical knowledge. The percentage values before and after the application changed little.

Examples of pre-service teachers' views on their competencies in the STEM field are given.

PT13G9 felt competent at the beginning of the research under the influence of the training she attended; *"I participated in STEM education using Lego sets. If I have similar sets, I can also practice STEM education with my students"*. She is confident about STEM even though her statements after theoretical knowledge have changed; *"By combining STEM with entrepreneurship, I can help students see and evaluate future opportunities"*. After the application, she stated that she had superficial knowledge; *"I find myself at a superficial level and incomplete in terms of the fact that STEM education is new, and it is a concept and education that I have just seen"*.

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PT1G1 stated that he was far from STEM education in all interviews from the beginning of the research. His opinion in the post-application interview; *"I find myself far from STEM education. Since it is a model, we bought from abroad, I think it will be difficult to adapt it. But I also accept this fact; successful scientists worked in all subjects, that is, in at least 4-5 fields."*

The opinion of PT26G11, one of the pre-service teachers stated that he was competent in some disciplines; *"I consider myself more competent in the field of science. I feel weak in the fields of mathematics and technology"*. The opinion of ÖA53G6 is; *"I think I am good in science, technology and math. But I think I'm more lacking in the engineering part in practice, we had difficulties as a team in the engineering discipline."*

In order to understand whether pre-service science teachers have adopted STEM education, they were asked if they believed in STEM education. All of the pre-service teachers stated that they believed in STEM education in all three stages and answered the question by explaining the possible contributions of STEM education. The answers given by the pre-service teachers and their answers to the possible contributions of STEM education were examined under two themes as contribution to the student and contribution to the society. The codes formed under the theme of contribution to the student were divided into categories under the title of cognitive change, affective change and change in skills. No categories have been created for codes under the theme of contribution to society. The themes, codes and categories of the data obtained in all three stages of the research are given in Table 3.

Table 3

Themes, Codes and Categories Obtained from The Understanding of Pre-Service Teachers About the Contributions of STEM Education

Theme	Category	Codes
Contribution to the student	Change In Skills	Skill Development
		21st Century Skills
		Problem Solving Skill
		Creativity
		Innovative Idea / Innovation
		Entrepreneurship
		Critical Thinking
		Collaboration
		Communication
		Design Skill
	Cognitive Change	Increases Achievement, Knowledge Increase and Transfer
		Persistence in Knowledge, Avoids Rote Learning
		Diverse/Interdisciplinary Perspective
		Increase in Science Knowledge
		Increase in Technology Knowledge
		Increase in Engineering Knowledge
		Increase in Mathematics Knowledge
	Affective Change	Increased Curiosity
		Develops Imagination
Contribution to Society	-	Individuals Compatible with The Developing World
		It Meets the Need of Qualified/Producer People
		Connects Daily Life Problems
		Affects Career Choice

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The first category created under the theme of contribution to students is the category of change in skills. Pre-service teachers stated that STEM activities would change students' skills in all three stages. In cases where it was stated that STEM activities would contribute to students' skills but did not specify what these skills were, the data were collected under the "skill development" code. Similarly, the data stating that STEM activities contribute to students' 21st-century skills and that these skills are not specified are also stated as "21st-century skills" were collected under the code. 51 pre-service teachers before the theoretical knowledge, 14 pre-service teachers after the theoretical knowledge, and one pre-service teacher after the application stated that STEM activities would improve the skills. For example, before the theoretical knowledge, PT33G1 explained the contribution of STEM as *"STEM education allows students' skills to develop."*. After the theoretical knowledge, *"STEM education brings the characteristics of individuals such as critical thinking, problem-solving, being creative and self-directed."* stated the skills by name. After the application, justified it as *"I believe in STEM education because it will enable students to solve the problems they encounter in daily life, design projects, develop their cognitive development and develop their imaginations."*. There was no pre-service teacher who used the statement that "*STEM education contributes to 21st-century skills*" before theoretical knowledge. Seven pre-service teachers used the term 21st-century skills after the theoretical knowledge and five after the application. The fact that the number of participant pre-service teachers was 66 and none of them used the expression at the beginning of the research made us think that pre-service teachers did not associate 21st-century skills with STEM until the theoretical knowledge.

According to pre-service teachers before theoretical knowledge, the skills that STEM education leads to change; Collaboration (87%), designing (75%) and innovation (31%) skills. After the theoretical knowledge, according to the pre-service teachers, the skills that STEM education leads to change; Problem-solving (45%), creativity (18%), innovation (16%), entrepreneurship (13%), critical thinking (6%). After the application, according to the pre-service teachers, the skills that STEM education leads to change; Problem-solving (44%), innovation (32%), creativity (23%), cooperation (5%), entrepreneurship (7%), critical thinking (7%), communication (3%) skills.

In the pre-theoretical interviews, problem-solving skills were never mentioned by the pre-service teachers, but the ability to design was indicated with a percentage of 75%. It is thought that this difference.is because of the fact that the participant pre-service teachers participated in STEM education applications, in which models related to renewable energy were designed using educational Lego sets, and that they completed the projects in line with the instruction. PT20G10's opinion before the theoretical knowledge; *"Of course I embrace STEM education. STEM is more educational and useful. For example, Students will be able to design renewable energy themselves with Lego sets and learn by using their imaginations."* supports this idea. Problem-solving skills are at the forefront of the skills that pre-service teachers think STEM education will contribute to students after theoretical knowledge and practice. This may be due to the introduction of the Problem-based STEM model during theoretical knowledge, and the majority of the groups planning STEM activities for this strategy in practice. After the theoretical knowledge, PT50G4 explained the contributions of STEM to the student through the problem-based STEM model; *"With the problem-based STEM approach, students can find solutions to the problems they encounter in their daily life and do research."*. The post-application opinion of PT11G7 was *"The biggest shortcoming of the students is that they do not use the information they have learned in daily life. I intend to develop students with a problem-based STEM approach."* is in the form.

It is quite surprising that although cooperation skill is mentioned first in the list of skills changed by STEM education before the theoretical knowledge, it is not emphasized after the theoretical knowledge and is mentioned by very few pre-service teachers after the application. The pre-service teachers completed their activities by using instructions in the STEM study they participated in before the research. Knowing the product that will be formed in the directive projects at the beginning may have made the cooperation easier. In this study, pre-service teachers worked with the group to create their own projects like students. Pre-service teachers may have had difficulty collaborating in completing the open-ended STEM activity that required them to come together on a common point.

Both theoretical knowledge and post-practice pre-service teachers stated that STEM education will cause a change in students' creativity and innovation skills. Similarly, it is believed by pre-service teachers that entrepreneurship and critical thinking skills will contribute. After theoretical knowledge PT59G3; "*I believe in STEM education because STEM brings critical thinking, creativity, problem-solving and entrepreneurship in individuals.*" she stated.

The second category created under the theme of contribution to students is the cognitive change category. Pre-service teachers expressed their opinions on cognitive change with high percentages before the theoretical knowledge. They stated that there would be an increase in students' knowledge of each discipline that makes up STEM. At the beginning of the research, pre-service teachers stated that STEM education would increase students' technology knowledge (80%), engineering knowledge (78%), science (78%) and mathematics knowledge (78%).

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However, this high percentage of consensus has not been seen after theoretical knowledge and application. The percentage of pre-service teachers who state that STEM will increase their technology knowledge is as low as 6% after theoretical knowledge and 5% after practice. While the opinion that there will be an increase in engineering knowledge was not encountered after the theoretical knowledge, it was expressed with a rate of 9% after the application. There was no pre-service teacher who expressed the opinion that there would be an increase in knowledge in science and mathematics disciplines after the theoretical knowledge and application. These findings showed that 14 weeks of interactive STEM education made a significant change in the views of pre-service teachers. Pre-service teachers initially interpreted STEM more superficially. *"Since it is mentioned in the name of science, technology, engineering and mathematics disciplines, there will be an increase in knowledge in these fields."* interpreted as. However, the theoretical and practical training provided has led to a change in this way of thinking. Pre-service teachers stated that STEM education provided students with an interdisciplinary perspective; after theoretical knowledge (33%) and after practice (28%). Relatedly, the percentage of opinions that STEM education will increase students' success and increase their knowledge is before the theoretical knowledge (48%), after the theoretical knowledge (24%) and after the application (7%). Opinions on the permanence of the knowledge; It is a decreasing percentage at the beginning of the study (78%), in the middle (10%), and at the end (5%). While pre-service teachers thought of STEM education as a miraculous approach to cognitive development at the beginning of the research, they did not think in the same way after the application phase, which helped them think like a student and formed more cautious statements. For example, PT48G7's opinion on STEM at the beginning of the research; *"I would ensure that STEM education is implemented in every school. In this way, the next generation would be more knowledgeable and cultured, while the knowledge given by heart is forgotten over time, the knowledge learned with STEM becomes permanent."* is in the form. If we look at the view of PT48G7 after the theoretical knowledge, a more cautious point of view is realized; *"STEM education is an application that will be useful in school. It will enable students to transfer knowledge. Time is needed for our country, as it is just beginning to settle down."* The opinion of PT48G7 after the practical training is; *"STEM can contribute to the development of many aspects of students such as conceptual learning skills and 21st-century skills. It can help students to look at the subject from all angles, not just take the knowledge, but question and research it."*

Four codes were determined under the theme of contribution to society. These codes are 1. raising individuals who are compatible with the developing world, 2. meeting the needs of qualified and productive people, 3. raising individuals who are aware of daily life problems, and 4. affecting the career choice of students. There was no pre-service teacher who expressed an opinion on each of the four code headings before the research. The percentage of pre-service teachers who gave their opinions on the topics after the theoretical knowledge decreased after the application. It is believed that this is due to the fact that developed country STEM goals are given during the theoretical knowledge. The decrease after the implementation may be that they think that it will not be so easy to reach the said goals. Percentages of pre-service teachers' opinions after theoretical knowledge; raising individuals who are compatible with the developing world (27%), meeting the needs of qualified and productive people (36%), raising individuals who are aware of daily life problems (21%), and affecting the career choice of students (12%). Percentages of pre-service teachers' opinions after the application; raising individuals who are compatible with the developing world (no opinion), meeting the need for qualified and productive people (13%), raising individuals who are aware of daily life problems (19%), and affecting the career choice of students (1%). A few examples from the views of pre-service teachers are as follows. After the theoretical knowledge PT5G7; *"STEM will benefit not only education but also many other fields, both in Turkey and in the world, and will be a pioneer in the development of societies. With the combination of more than one discipline, a much better product will emerge and there will be well-trained and qualified individuals in every field."* she said. The opinion of PT8G5 is; *"He knows how to use his knowledge skills in the tasks that a person has to do in his daily life and in the problems that need to be solved. In the simplest way, a child can make a fountain to be built in the garden of their house together with his father".*

In the interviews at the end of the research, the pre-service teachers were asked "whether there were any difficulties in the implementation phase" and, if so, "what happened". In addition, how should STEM education be given to teacher candidates? The question has been posed. Pre-service teachers stated that STEM discipline integration is difficult (34%) and they had difficulties in performing STEM activities due to insufficient engineering education (50%). During the application, pre-service teachers wanted to use sensor sets in their projects and they wanted to use "Arduino", one of the programming platforms suitable for this and is thought economical and the programming language is easy. However, they stated that they had difficulties in this adventure and because they did not know coding (50%), they received support from their friends studying in the software engineering

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department. They stated that STEM education should be given as a course during their undergraduate education (67%). Before the training, it was stated that in order for the pre-service teachers to adopt STEM education, their contributions should be explained (11%) and that they should be associated with daily life (7%).

For PT24G2, the part where she had a hard time was; *"We used Arduino in our project, and it was not something I had seen before in my life. It was difficult to work with unfamiliar materials and it was a difficult process in the coding part"*. Regarding providing STEM education to pre-service teachers, *"They must have a readiness before coming to university. STEM should be applied in other education levels, albeit to a lesser extent. Starting from the first grade, the pre-service teacher should see engineering in addition to the field courses, know technology well, and STEM applied courses should be given".* For PT27G8; *"We had a hard time integrating engineering and technology. We got help from our friends studying in the software engineering department".* The opinion of PT61G7 is; *"During this process, I had the chance to do inquiry. I saw that teachers defended the STEM understanding by doing simple repetitive activities that they saw on the internet. They open various courses about STEM that have no theoretical foundation, but I think they are of no use to students. The main thing is to make the student think about STEM. Therefore, the contributions of STEM should be explained to pre-service teachers, and they should be adopted."*

In all three stages, the pre-service science teachers were asked which STEM learning and teaching models they preferred to use. At the beginning of the research, it was understood that pre-service teachers did not adopt a certain STEM learning and teaching model. They answered the question by giving examples from the activities they did using the Lego sets they participated in before the research. I use Lego sets if available at my school (25%), I build a wind/solar car (42%); I can't do without STEM materials (18%), I have no STEM understanding (15%). It was thought that the pre-service teachers could not make sense of the question because STEM theory knowledge was not given in the training they attended before the research. After the theoretical training, the answers of the pre-service teachers were distributed as follows: Four different models were specified: Problem-based STEM (43%), 5E integrated STEM (45%), project-based STEM (13%), and design-based STEM (9%). Seven pre-service teachers (PT8G5, PT17G9, PT27G8, PT31G5, PT39G5, PT41G9, PT52G4) stated more than one option. During the theoretical knowledge, learning and teaching models used in the literature were introduced, and access to the sources with sample applications was provided. The fact that pre-service teachers stated a STEM learning model compared to the beginning of the study showed that it is important to give STEM theoretical knowledge. In the interviews made after the STEM applications, the most preferred learning model was Problem-based STEM (63%). Project-based STEM (23%) ranked second. Eight pre-service teachers stated that a single STEM learning and teaching method is not correct and emphasized that different models should be used depending on the situation (ÖA9G10, PT21G10, PT24G2, PT28G6, PT43G10, PT46G9, PT56G3, PT58G2). One pre-service teacher stated the design-based STEM (PT29G2), 5E integrated STEM (PT52G4), and Science-based STEM (PT4G5) models as the adopted model. During the implementation process, pre-service teachers performed 11 group and one individual STEM activities (Table 1). Seven of these activities were prepared using the problem-based STEM, four of them using the project-based STEM, and one using the design-based STEM model. According to the data obtained, it can be said that the teacher candidates adopt the problem-based STEM model more. Examples of pre-service teachers' opinions;

The opinion of PT66G12, who worked individually during the implementation phase; *"I had prepared my application activity according to the project-based model. But problem-based thinking is actually better. It would be a priority for me to put more creative thinking towards life's problems and put it into practice in life."*

PT34G3*; "We need to analyze a certain problem situation and find various solutions in line with these problems, so I think problem-based STEM would be a better model."*

PT46G9's opinion; *"Our group work was oriented towards a problem-based STEM model. However, any STEM model that the person considers self-sufficient can be used. Model selection may vary depending on which teaching level it is used and for a better realization of the solution and subject. I think the problem-based STEM model is more advantageous because it leads to problems that exist in daily life."*

PT23G8; *"I adopt the project-based STEM model because new products must be obtained to make life easier."*

Discussion

In the study, pre-service science teachers were asked to define STEM at three different times in order to determine pre-service teachers' understanding of STEM and whether their understanding changed according to the training given in the process. The definitions of pre-service science teachers are gathered under seven codes under the headings of abbreviation of disciplines, integration of disciplines, combining of disciplines, coverage of disci-

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plines, problem-solving about daily life, linking of disciplines, and education without rote. In addition, there were five different definitions at the beginning and two different definitions in the middle of the study by pre-service teachers. Eight conceptualized integrated STEM education models were proposed in the study conducted by Ring et al. (2017). Three of these models, an abbreviation of disciplines, integration of disciplines, and problem-solving from daily life, are similar to the definitions of pre-service teachers in this study. Dare et al. (2021) found in their research that teachers have a STEM education perspective in which real-world problems are used after participating in STEM-focused professional development and performing integrated STEM lessons in their classrooms. Sarioglu et al. (2022), the definitions of interdisciplinary approach and understanding real life problems came to the fore in the study they conducted with teachers who had participated in various STEM trainings before. It showed parallelism with the definition of "problem-solving from daily life" obtained in this study. In this research, STEM was expressed by pre-service teachers as "solving real-world problems" after theoretical knowledge and application. STEM definition accepted by more pre-service teachers at the end of the research; definitions of "combing of disciplines " and " integration of disciplines". At the end of the research, pre-service teachers moved away from the non-explanatory definition of "the abbreviation of science, technology, engineering and mathematics disciplines". Pre-service science teachers changed their definitions of STEM during the theoretical and applied education process they attended. However, there is no single definition that all pre-service teachers agree on. The differences in the definitions of the pre-service teachers in the same group showed that STEM was not interpreted the same by the pre-service teachers. According to the studies (Bybee, 2013; English, 2016; Johnson, 2012; Paz et al., 2022) showing that there is no single definition of STEM, this situation was not surprising. However, the point to be discussed is that despite participating in the same theoretical and practical training, STEM education, which is perceived differently, is that the students of pre-service teachers who will do STEM applications with their own students in the future will encounter completely different applications under the name of STEM. Although conceptualizing a common STEM model is difficult, a clearer environment can be created (Breiner et al., 2012).

Pre-service teachers were asked whether they felt competent in STEM education, and the answers were grouped under three themes: being fully competent in STEM education, partially competent in STEM education, and not being competent in STEM education. It was understood that the majority of pre-service teachers think of themselves as partially competent. It is understood that the percentage of teacher candidates who find themselves competent increased after the theoretical knowledge but decreased again after the application. In parallel with this research result, Bartels and Rupe (2019) found that pre-service teachers' understanding of STEM did not increase even after they planned and implemented STEM lessons. This may be because they realize that the points that seem feasible with theoretical education are not as expected in applied education. Teachers' participation in STEM teaching can be supported by improving their self-efficacy in STEM practices (Dong et al.,2019; Shahali et al., 2015). It is thought that pre-service teachers will be more conscious while guiding their students in the future with the proliferation of STEM applications in which they participate as students. Many studies with teachers and pre-service teachers stated that they needed courses and in-service training to improve themselves in the field of STEM (Aydeniz, 2017; Yıldırım et al., 2022; Yıldız, 2023). The decrease in the number of pre-service teachers who do not find themselves competent after the theoretical knowledge has shown that the training to be given, even at the theoretical level, will contribute to the STEM competence of the pre-service teachers. This result is in line with the studies that the courses or trainings provided contribute to the STEM competencies of teachers (Arslanhan & İnaltekin, 2020; Dong et al., 2019).

In the research study, the understanding of the pre-service teacher, who stated that he was far from STEM education because it was a foreign-sourced model, was found to be very important. Çepni (2017) stated that some mistakes were made in the process of spreading STEM education in Turkey, such as giving STEM certificates with a few-day courses, calling hobby courses STEM, and assuming that STEM can only be done with expensive and robotic sets. Although there are some studies carried out in education faculties programs, the absence of STEM courses at the undergraduate level requires pre-service teachers to improve themselves with their personal efforts at this point and to find their own truths in information pollution.

Pre-service teachers stated that they believed in STEM education and explained their possible contributions. The fact that pre-service teachers do not actively teach and have never tested STEM with students is the inference of the possible contributions they have stated as a result of their experiences in their own education processes. The answers of the pre-service teachers regarding the possible contributions of STEM education were examined under two themes as contribution to the student and contribution to the society. According to pre-service teachers, STEM education causes positive changes in students' skills and cognitive and affective development. There are many studies about STEM education, that confirm the inferences of pre-service teachers, contribute to the cogni-

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tive development of students (Fan & Yu, 2017; Wendell & Rogers 2013), contribute to their affective development (Bakirci et al., 2022; Keçeci et al., 2017), contribute to students' skills (Sahin & Top, 2015; Zengin et al., 2022), studies that affect career choices (Chachashvili-Bolotin et al., 2016; Tanenbaum, 2016). In this research, problem-solving and creativity skills were stated as the leading skills that STEM education contributed by the pre-service teachers. Interestingly, collaboration and design skills were stated by the majority of pre-service teachers before the research, but the pre-service teachers who advocated different models had problems in cooperation while working on a project by meeting on a common point. The collaboration skill was emphasized by very few pre-service teachers at the end of the process. Pre-service teachers who advocated different models had problems in cooperation in this research, where they met on a common point and completed a project. Collaboration may have been easy for pre-service teachers in STEM applications, which they designed based on the instructions they participated in before the research. In this case, it can be concluded that the method followed in STEM applications and the skills affected at the end of the process will vary.

Pre-service teachers' understanding about the contribution of STEM education to society is raising individuals who are compatible with the developing world, meeting the needs of qualified and productive people, raising individuals who are aware of daily life problems and making connections, and affecting the career choice of students. These results are consistent with the targeted outcomes in STEM reports (MNE, 2016; NRC, 2012; TUSIAD, 2014). There were no pre-service teachers who expressed similar views before the research, it increased after the theoretical knowledge and decreased after the application. It is believed that this is due to the fact that developed country STEM goals are given during the theoretical knowledge. The decrease after the implementation may be that they think that it will not be so easy to reach the said goals.

In the application part of the research, pre-service teachers prepared a STEM activity that they could apply with their students in the future, and a lesson plan on how to implement the activity, according to a STEM model they chose with their group friends. The pre-service teachers stated their science, technology, engineering and mathematics achievements in their activity plans and presented to their friends how they integrated the disciplines and which STEM approach they adopted. Pre-service teachers had a very difficult time in STEM discipline integration. Vasquez et al. (2013) stated that integration can be used at various levels such as transdisciplinary, interdisciplinary, multidisciplinary and disciplinary. The difficulty of pre-service teachers may be that they cannot choose from this diversity. Dare et al. (2019) stated that teachers have a limited understanding of what STEM is and what it means for their teaching, despite all the guidance. Alan et al. (2019), in their study that aimed to support pre-service science teachers' integrated teaching knowledge through STEM applications, found that pre-service teachers believed in the necessity of STEM education, but thought that discipline integration was not easy. Pre-service teachers stated that they had the most difficulties in the implementation process due to the inadequacy of their engineering education. Except for two groups, other groups wanted to use sensor sets in their projects and wanted to use "Arduino", one of the programming platforms suitable for this. However, they stated that they received support from their friends studying in the software engineering department because they did not know coding. It has been stated in many studies that pre-service teachers think that they are inadequate in engineering and that they do not trust themselves (Akgündüz et al., 2015; Avsec & Sajdera, 2019; Aydeniz & Bilican, 2017; Aydeniz & Cakmakci, 2017; Blackley & Howell, 2015). Pre-service science teachers stated that engineering and STEM education should be given as a course in undergraduate education, especially coding learning is necessary. Aydeniz (2017) stated that students studying in science and mathematics departments should take at least two practice-oriented coding courses. When it comes to engineering content integration, it is thought that software engineering comes to the fore because most of the current technologies require coding and the spread of STEM education in Turkey is mostly through robotic sets.

Pre-service science teachers adopted the problem-based STEM model among STEM learning and teaching models and preferred to use it. Pre-service teachers emphasized problem-solving in their STEM definitions and contributions questions. It was an expected result that the STEM learning model they chose was a problem-based model. 5E integrated STEM, project-based STEM, design-based STEM, and science-based STEM models were also shared by pre-service teachers. Yıldırım (2018) stated STEM models as project-based learning, inquiry-based learning and problem-based learning models in his research. In this research, project-based STEM was preferred in the second place. Eight pre-service teachers stated that a single STEM learning and teaching method is not correct and emphasized that different models should be used depending on the situation. There is no single model in STEM education with which consensus has been established (Dare et al., 2019; Sarıoğlu et al., 2022; Selvi & Yıldırım, 2017). Therefore, the important thing is that teacher candidates know the models, have a good command of STEM education and can apply any model they want.

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Conclusions and Implications

In the study, in which STEM education was determined as a phenomenon and how the pre-service science teachers adopted it, what the understanding of pre-service teachers' STEM education was, whether they thought of themselves as sufficient, and their predisposition to STEM teaching and learning models, valuable results were obtained. The results help us to look at STEM education from the perspective of pre-service science teachers. There is no single definition that pre-service science teachers agree on. Despite their collaborative work during the implementation phase, the pre-service teachers did not unite in a common definition, and each pre-service teacher expressed their own definition of STEM. Most of the pre-service science teachers defined STEM as "the abbreviation of disciplines" without going into details at the beginning of the research, but they moved away from this definition after theoretical knowledge and practical training. STEM definitions prominent by pre-service teachers are; "combining of disciplines", "integration of disciplines" and "solving daily life problems".

Today, when we are about to complete the first quarter of the 21st century, it is very important to increase the competencies of our teachers who will raise the generations that will deal with much bigger problems in the future. The number of pre-service science teachers who did not consider themselves competent at the beginning of the study decreased after the theoretical and practical training. The number of science teachers who consider themselves competent has increased. However, some of the pre-service teachers who felt fully competent after the application defined themselves as moderately competent. Although the majority of pre-service teachers participated in theoretical and practical training, they defined themselves as intermediate level competency in STEM education. The trainings provided contributed to the STEM competencies of pre-service science teachers. As stated by the pre-service teachers, the self-confidence of the pre-service teachers can be increased by providing the trainings throughout their undergraduate education.

Participating pre-service science teachers believe in STEM education. They explained the reason for their belief through the possible contributions they would make to the students. According to pre-service teachers, STEM education contributes to both students and society. Pre-service science teachers had the most difficulty in disciplinary integration during the STEM theory and practice education process they attended. The pre-service teachers stated that their engineering knowledge was lacking and stated that they should especially receive coding training. The majority of pre-service science teachers preferred to use the problem-based learning model among STEM learning and teaching models. Some pre-service teachers stated that a single model would not be correct and that different models should be used depending on the situation.

Unlike the studies examining the understanding of pre-service teachers about STEM education, in this study, it was tried to determine the changes in pre-service teachers' understanding of STEM during the STEM education process.

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