Awareness and self-efficacy of pre-service science teachers about STEM Education: A qualitative study

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Contents

Abstract

This study aimed to determine the views of pre-service science teachers about STEM education. A two-hour Arduino based STEM learning activity was conducted for fifteen pre-service science teachers. Afterwards, the views of the participants were investigated by conducting an online survey consisting of open-ended questions. Finally, the obtained data were analysed with the content analysis technique using NVivo 12. As a result of the analysis, it was concluded that pre-service teachers do not know the content of the STEM approach but at the same time, they think that STEM education should be applied in schools, and they want to learn how STEM can be used in classes. Based on the results, it is suggested that it should be beneficial to provide professional development to pre-service teachers regarding the content of the STEM approach.

Keywords: STEM, pre-service teachers, science education

Introduction

STEM is an acronym formed from combining the initials of the disciplines of Science, Technology, Engineering, and Mathematics. STEM education is an integrated approach that joins all the sciences mentioned, in the context of real-life (Bybee, 2010). From preschool to higher education, STEM brings life-related interdisciplinary experience and skills and prepares students for knowledge-based economics (National Research Council [NRC], 2011). The aim of STEM, which consists of four disciplines, is to provide students with a learning environment to apply the knowledge and skills required for the 21st century (Bybee, 2013; Sanders, 2009). Furthermore, STEM education brings different fields together and provides multi-dimensional learning with an interdisciplinary approach (Smith & Karr-Kidwell, 2000).

With its wide knowledge base, STEM can have a positive effect on the self-confidence of the students as well as contribute to their training towards technological literacy (Morrison, 2006). STEM is a new educational approach that aims to provide students with the skills of interdisciplinary cooperation, systematic thinking, being open to communication, having ethical values, research, production, creativity, and solving problems in the most appropriate way (Bybee, 2010). STEM education has had a serious impact in the classroom over the past two decades (Banks & Barlex, 2014). This situation led to the need for both in-service and pre-service teachers to learn the STEM approach.

As it is understood that the priority in increasing the quality of education is the high qualifications of teachers (Lawless & Pellegrino, 2007), researchers have become more concerned with the professional development of teacher candidates (Moon, Lee & Xu, 2021). Developing pre-service teachers' skills in STEM fields in teacher education and ensuring integration of these fields is a phenomenon that researchers focus on (Constantine et al., 2017).

Self-efficacy can be defined as an individual's belief in his or her capacity to successfully perform a particular task, and that self-efficacy is situational, that is having high self-efficacy in one context (e.g. STEM teaching) does not mean having high self-efficacy in another context (e.g. science teaching) (Bandura, 1977; Leithwood & Jantzi, 2008). Individuals with high self-efficacy see difficulties as challenges to cope with continued effort and opportunities to acquire the necessary knowledge and skills. Individuals with low self-efficacy, on the contrary, tend to doubt their competence and beware of challenges, resulting in low ambitions and limited persistence when faced with difficult conditions (Bandura, 1994). Teacher self-efficacy widely influences teachers' preparation, teaching strategies, and pedagogical approaches in a topic (Bray-Clark & Bates, 2003; Yoon, Evans & Strobel, 2014). Teachers' self-efficacy for teaching STEM content increased significantly after participating in integrated STEM professional development (Nathan, Atwood, Prevost, Phelps, & Tran, 2011).

Another concept that can affect the practice of teachers in utilizing STEM education is STEM awareness. STEM awareness differs among teachers, students, parents, school leadership and STEM professionals (Watson, Williams-Duncan & Peters, 2020). Teachers' knowledge, confidence and awareness of the integration of STEM practices play a major role in the successful implementation of STEM in the classroom (Nadelson & Seifert, 2013, 2017). Edwards and Loveridge (2011) argued that due to a lack of pedagogical awareness of how to teach science, teachers often do not recognize available learning opportunities. Bybee (2013) indicated various perspectives of STEM awareness. He defined nine different levels of STEM awareness which are listed as follows:

- Single-discipline reference (STEM Equals Science or Mathematics)
- STEM as reference for Science and Mathematics
- Separate Science disciplines that incorporate other disciplines
- Separate disciplines (also called silos)
- Science and Mathematics connected by Technology or Engineering programs
- Coordination across disciplines
- Combination of two or three disciplines
- Integration across disciplines
- STEM as a transdisciplinary course or program

There is a need to search deeper into how to improve pre-service teachers' awareness and intentions about STEM education (Karisan, Macalalag & Johnson, 2019). Based on all the above, this study aimed to investigate pre-service teachers' STEM awareness, STEM self-efficacy, and general thoughts about integrated STEM education.

Integrated STEM

The current educational approaches give students a disconnected science, mathematics, and technology content, while the STEM approach provides learning connected with real-life situations instead of teaching the four disciplines separately

(Hom, 2014). STEM can be performed in four different ways; as independent topics, with emphasis on one or two topics, integrating one STEM discipline into the other three, and mixing four disciplines (Dugger, 2010). This integration is the integration of the engineering design process into education, which will enable students to develop their technological literacy and use them in mathematics and science. The integrated STEM, which is the educational model that emerges, is a mechanism based on education systems and content areas that have the potential to provide school changes (Felix, Bandstra & Strosnider, 2010). Integrated STEM education aims to provide students with an interdisciplinary perspective, to gain scientific literacy, knowledge, and skills, to gain 21st-century skills, and provide opportunities for students to specialize in science, technology, engineering, and mathematics disciplines (Meyrick, 2011). The integrated STEM includes knowledge and practices from multiple STEM disciplines to learn and solve multidisciplinary problems (Nadelson & Seifert, 2017). In this study, the expression STEM approach or STEM education refers to integrated STEM education.

A Teacher's professional development in STEM

The professional development of the teachers should be focused on the students' ability to learn, inquire, and reflect, as well as the development of a teachers' subject knowledge and focus on practical pedagogical skills. The support from school leaders and the involvement of external experts (Widjaja, Vale, Groves & Doig, 2015) is also a factor that is crucial in their professional development. It is important how teachers effectively use other disciplines in their courses. Integrated approaches lead to positive learning outcomes (Becker & Park, 2011; Stohlmann, Moore & Roehrig, 2012). STEM education is more progressive, student-centered, and experimental, in comparison with traditional teacher-centered education. STEM disciplines encourage the teacher to create a learning environment based on the constructivist approach that students learn by doing and living (Fioriello, 2010).

The National Science and Technology Council (NSTC, 2013) has suggested ways to include STEM education more frequently in lessons, starting from preschool to higher education by using pre-service teachers and teachers' professional development, in order to guide future research. According to the results of some STEM-related researches, STEM education is very important for teachers to develop STEM thinking (Reeve, 2015). Moreover, STEM teacher development has not been well defined or carefully examined throughout the years (Rinke, Kinlaw, Brown & Cappiello, 2016). Teacher training in many countries is focused on discipline-based fields and theoretical courses, which are mainly provided by Mathematics and Science disciplines, and therefore giving insufficient knowledge and experience in STEM (Epstein & Miller, 2011). Today, instead of programs where technology integrated knowledge is limited mainly to technology lessons, approaches to support technological understanding together with field experience and field-specific pedagogical methods are suggested (Mishra & Koehler, 2006).

Teacher perceptions about STEM

According to Brown and Cooney (1982), teachers' attitudes and beliefs originate from their actions and are the main determinants of their behaviours. For this reason, many researchers have investigated the teachers' perceptions and attitudes regarding STEM education. Some studies have revealed that teachers think that students are not capable of solving STEM problems. (Al Salami, Makela & de Miranda, 2017; Bagiati & Evangelou 2015; Goodpaster, Adedokun & Weaver, 2012; Van Haneghan, Pruet, Neal-Waltman & Harlan, 2015). According to Margot and Kettler (2019), teachers think that the measurement and evaluation tools, planning time, and insufficient knowledge about the STEM disciplines are the main difficulties and obstacles to the STEM initiatives. According to teachers, the structure of the schedule of students and lack of flexibility is one of the main obstacles to STEM education (El-Deghaidy, Mansour, Alzaghibi & Alhammad, 2017). In addition, according to teachers, the sequence of subjects in the curriculum and urgency to complete the curriculum complicates the integration of more than one discipline in the nature of STEM (Herro & Quigley 2017). According to teachers, typical school structures are one of the obstacles to the implementation of STEM education (Margot & Kettler, 2019). Teachers think that STEM education creates an extra workload. They need more time to plan other subjects and prepare the necessary materials for students. Individual needs of students can also cause time loss in lessons. This leads to the conclusion that teachers complain about lack of time when implementing STEM (Bagiati & Evangelou 2015; Hsu, Purzer & Cardella 2011; Goodpaster et al., 2012; Park, Byun, Sim, Han & Baek, 2016). Teachers stated that inadequate administrative and financial support may be a challenge when it comes to STEM implementation (Clark & Andrews 2010; Hsu et al., 2011).

According to the results of the researches, teachers believe that their subject knowledge about STEM is missing. They think that pre-service and in-service training is insufficient for the implementation of STEM. Moreover, they feel that they need more clarity on how the STEM content can be applied to existing programs (Nadelson & Seifert 2013). In addition, they do not feel fully ready to integrate the STEM disciplines (Al Salami et al., 2017; Hsu et al., 2011). Teachers also believed that the lack of teaching resources was an obstacle to providing STEM opportunities for students (Park et al., 2016). Although they found STEM education important and valuable, they were not fully equipped to meet the high teacher expectations they thought were related to STEM. When a teacher’s ability to teach STEM is inadequate, it can lead to reduced self-confidence. (Bagiati & Evangelou 2015; Clark & Andrews 2010; Holstein & Keene 2013).

Rationale of the study

Teachers need professional development programs for the use of STEM education in their classrooms. Assuming that STEM education can be applied at all levels from pre-school to higher education, the number and variety of teachers who need professional development programs are quite high. While determining the needs of the teachers, it is necessary to reflect the point of view of the teachers in the process. Therefore, teachers' STEM perceptions are important. There are many studies investigating the perceptions of in-service and pre-service teachers. This study was offered a sample STEM learning activity to pre-service teachers, unlike other researches in the literature. First, a science subject in the seventh grade was presented to the participants as an Arduino based STEM lesson. Second, the views of pre-service teachers were collected with open-ended questions. In the research, the following question was asked: What are the views of pre-service teachers STEM awareness, school dimension of STEM, STEM concept, and STEM self-efficacy? The answers to this research question are expected to be a guide for the content preparation of the trainers, especially in pre-service teacher training.

Methodology

Research Design

The case study methodology was used in this research. According to Creswell (2013), a case study is a qualitative approach in which the researcher collects detailed and in-depth information about real life or a limited system with the help of various data collection tools. The case investigated in this study was the pre-service science teachers' views about STEM education. This method was preferred to reveal the pre-service science teachers' views about STEM in detail. A two-hour Arduino based STEM learning activity was conducted for fifteen pre-service science teachers who have not received any STEM course or training before. After the activity, the views of pre-service teachers were collected using an online survey.

Participants

This research was carried out with 15 university students who are studying at a state university in Turkey. Participants have been training to become science teachers at a secondary school level (5th-8th grades). For this reason, they were qualified as a pre-service teacher. Pre-service science teachers undergo a four-year education and study physics, chemistry, biology, technology, and pedagogy. The selection of the participants was made on a voluntary basis. While determining who the participants were going to be, brief information was told about the research to all participants. It was explained that the activity about STEM will be completed in 120 minutes and then they would have to do a survey. Among the nearly 100 pre-service teachers, 15 participants volunteered to participate in the research. When the responses to the survey were examined, it was determined that two preservice teachers did not respond to the survey. Therefore, the opinions of 13 pre-service teachers were examined and the demographic information of the teachers participating in the study was presented as shown in Table 1.

Table 1. Demographic information of the participants

	f	**%**
Gender		
Male	4	30.76
Female	9	69.24
Age	**M**	
Mean age	22	
Minimum age	21	
Maximum age	24	
Students' level	**f**	**%**
3rd year	5	38.46
4th year	8	61.54

Data collection process

The pre-service teachers were invited who participated in the research to the computer laboratory of the faculty where they studied. There are 40 desktop computers in that laboratory. Preservice teachers worked individually on those computers. A 120-minute STEM activity was conducted using problem-based learning. Problems in problem-based learning are presented to the students within the context of a scenario by the instructor and it is tried to find solutions to the problem in the axis of research, analysis, and discussion. The problems faced by a seller were presented who wanted to make a LED panel as a scenario. The Colors of Light as the science content was chosen which is a topic in the secondary school science curriculum. STEM activity was started with the integration of mathematics and continued with technology, science, and engineering. In the mathematics discipline, participants sought a solution to an algebra problem from daily life. Participants used an Arduino Uno microcontroller in the discipline of technology and engineering in the STEM approach. In the activity, the primary and secondary colors were discussed that compose light in the science stage of STEM. The different stages of STEM education can be found in Figure 1. Figure 2 was exhibited photos taken during the activity. In order to hide the identity of the participants, stickers were placed on their faces.

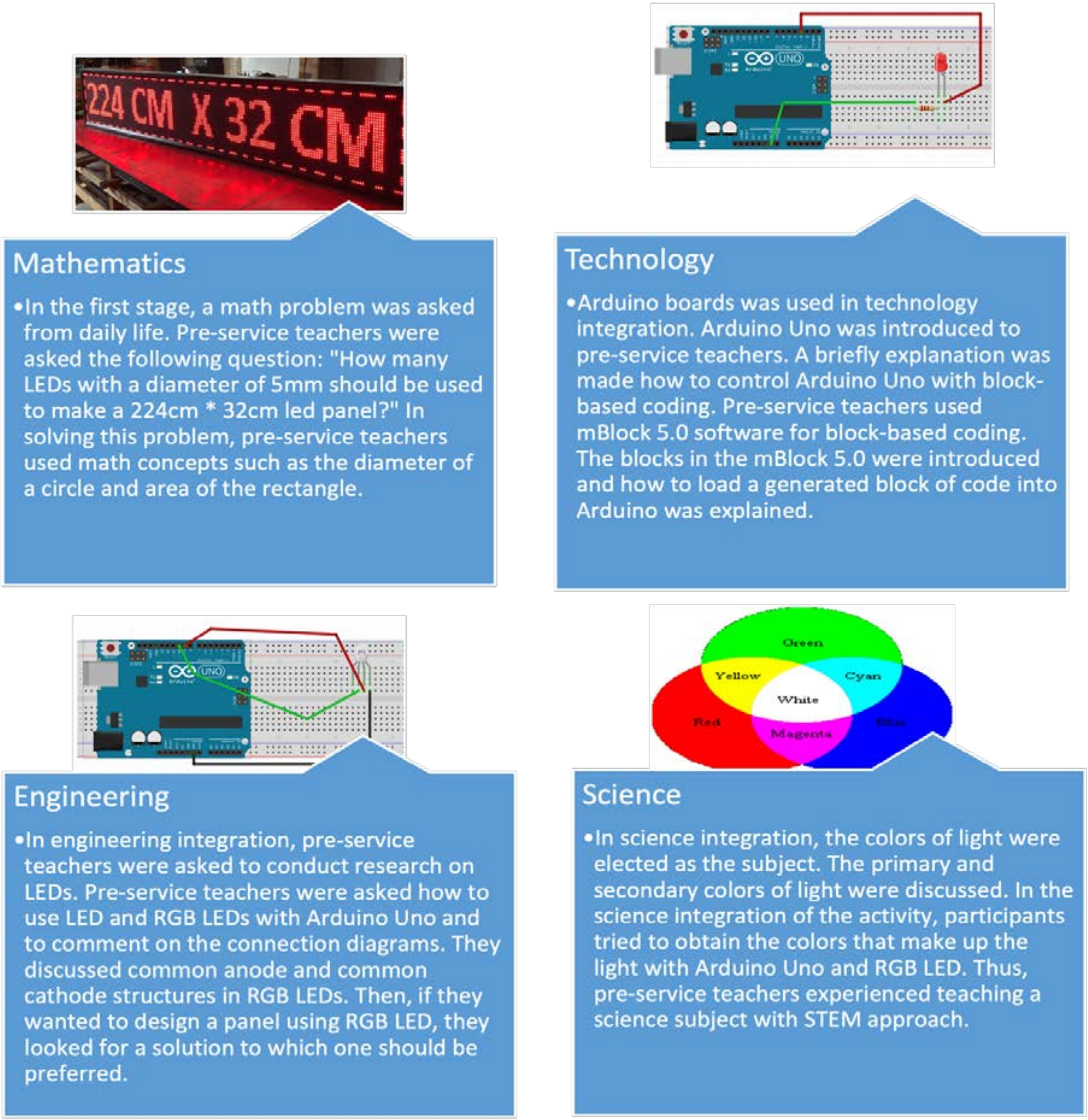

Figure 1. Stages of STEM

Figure 2. Photos from the activity

Data collection tool

An online survey was used as the data collection tool. The survey was sent to the e-mail addresses of the participants after the activity. The survey consisted of two parts. In the first part, participants were asked about their age, gender, and what grade they were in. In the second part, there were 11 open-ended questions in four different themes. Questions and themes are shown in Figure 3.

While preparing the questions of the survey, studies were examined that were investigating the perceptions of teachers about STEM in the literature (Goodpaster et al., 2012; Herro & Quigley 2017; Park et al., 2016). In addition, after the preparation of the survey, it was presented to two researchers in the field of STEM in order for them to share their views and then the necessary corrections were made.

Awareness

- Is there a relationship between science, mathematics and technology? If there is a relationship, what is the it?
- Have you heard of the STEM approach before? How did this training change your knowledge about STEM?

School dimension

- Should STEM education be provided at the secondary school level? Why?
- In your opinion, what does STEM education contribute to the characteristics of students? How?
- Would you like to include STEM applications in your classroom when you become a teacher? Why?

STEM concept

- What are your thoughts on the STEM approach?
- What do you think about the sustainability of STEM education? Do you think it will be permanent or temporary in the education system?
- How do you evaluate the relationship between STEM education and real life?

Self-efficacy

- Do you consider yourself competent in terms of pedagogical and subject knowledge to teach a science course? Please explain.
- What would you like to learn apart from what you know during your university education for science teaching? Please explain.
- Can you use this approach in your class after having received a training on the STEM approach?

Figure 3. Survey questions

Data analysis Form

NVivo 12 computer program was used in the analysis of the qualitative data obtained in the research and the data was analysed with the content analysis technique. The stages followed in the analysis process were:

- Since the survey was conducted online, the answers were recorded in pdf format. 18-page answers were recorded on the NVivo 12 software on a question basis.
- Responses were coded given to the questions under four themes. In the findings section of the research, the names of the pre-service teachers, which the interviews were held with, were not clearly stated and encrypted such as T1, T2, T3,… were used for the pre-service teachers.
- The data was shared with a researcher who had previously conducted qualitative research using NVivo. After giving information about the themes, the researcher was asked to code the data. The reliability formula proposed by Miles and Huberman (1994) was used to calculate reliability between encoders. If the result was calculated with the reliability formula it was over

70% (Miles & Huberman, 1994, p.64), assuming the reliability among the encoders was provided. As a result of the calculations made in this research, the reliability between encoders was 84% and the encodings were accepted as reliable.

- The codes were supported with various quotations that were said by the participants. The findings were explained in relation to the research question.

Findings

Awareness theme

The pre-service teachers' awareness of STEM education was revealed by analysing two questions. The codes, the sample coding, and the coding frequency can be seen in Table 2. Looking at Table 2, it can be deduced that most of the pre-service teachers think that science is related to mathematics and technology. But it can be postulated that the students may think of this relationship of maths-science and technology-science like a binary interaction and that it does not present a correlation between the three disciplines. Pre-service teachers also discussed the relationship between these disciplines from a teaching perspective. One pre-service teacher referred to the relationship between science and math from the perspective of science teaching and said that “The science lesson becomes difficult to understand without the knowledge of mathematics (T5)”.

Seven of the pre-service teachers stated that they had not heard of STEM education before, two of them heard it but did not know the content. That meant that approximately 70% of the participants did not know the content of STEM. After the activity, the participants had some positive reviews. For example, one participant stated that STEM education can be used in schools by saying “It is very useful and can be added to the school curriculum (T11).” Pre-service teachers believe that STEM education will create long-lasting knowledge for students. One participant expressed this opinion as "I think STEM is very useful and it can provide mastery in learning (T2)." Two pre-service teachers stated that STEM education is a focused approach to solving problems in daily life. A pre-service teacher stated his thoughts on STEM by saying “I learned that STEM helps solve a problem more easily and fun (T9)”.

Table 2. Codes in awareness theme

Questions	Codes	Examples of open coding	Coding frequency

Is there a relationship between science and mathematics and technology? If there is a relationship, what is the relationship?	There is a relationship.	• There is a relationship. It is related to numerically.	7
	Mathematics and Science	• Many calculations are made with mathematics and transferred to daily life with science. • Mathematical calculations are needed to advance in the field of science.	3
	Teaching perspective	• Mathematics and science courses are difficult courses for students. For this reason, if we associate these lessons with technology instead of teaching them abstractly, the lesson becomes better concrete and easy in the student's minds.	3
	Technology and Science	• Technology cannot exist without scientific knowledge.	2
Have you heard of the STEM approach before? How did this training change your knowledge about STEM?	Never heard	• I had never heard of it before. • No, I hadn't heard of it.	7
	Positive thoughts	• I learned about how it can make our daily lives more convenient • I think STEM is useful and necessary.	6
	Long-lasting knowledge	• I think that STEM education can be much more helpful in providing long-lasting knowledge.	3
	Heard it but not know its content	• I heard it before, but I didn't know enough about its content.	2
	Problem solving	• This activity informed me that STEM was developed to find better solutions to daily problems.	2

School dimension theme

The views of pre-service teachers about the use of STEM education in schools were investigated with three questions. Table 3 presented the codes, sample coding, and coding frequency in the theme of school dimension. According to Table 3, nine participants thought that STEM education should take place in secondary school, while two participants said that they should definitely be given. In this question, it was seen that only one participant thought that STEM education should not be given at the secondary school level. No coding was done because one participant said. The participant named T6 stated that "it can be a bit hard at the secondary level ..." and stated that secondary school students are not ready for STEM education especially in terms of coding. Pre-service teachers who think that STEM education should be given in secondary school consider that STEM education will increase the students' interest, embody abstract knowledge, and contribute to meaningful learning.

Table 3. Codes in school dimension theme

Questions	Codes	Examples of open coding	Coding frequency
Should STEM education be provided at the secondary school level? Why?	Yes	I think it should be applied Yes	9
	Mastery and meaningful learning occur	Because, in terms of visuality, topics become more long-lasting.	4
	Increases interest	It should be applied for students to take an interest in science and mathematics.	3
	Embody abstract knowledge	Children of that age learn abstract things in a concrete way.	2
	Definitely yes	Definitely should be applied	2
In your opinion, what does STEM education contribute to the characteristics of students? How?	Creative thinking	Improves creativity aspects.	7
	Psychomotor skills	Contributes to the development of practical skills.	4
	Problem solving ability	It provides development to find solutions to problems.	2
Would you like to include STEM applications in your classroom when you become a teacher? Why?	I would like to use	Of course, I would like to use it.	13
	Long-lasting knowledge	It makes a great contribution by providing long-lasting learning experiences for the student.	4
	Enjoyable	So nice, fun.	3
	Remarkable	Because the students' interest in the course increases.	3

Pre-service teachers think that STEM education will develop the students' creative thinking skills the most. A teacher candidate expressed this opinion by saying “It contributes to the development of the student's imagination (T1).” The most cited skill after creative thinking is psychomotor skill. One pre-service teacher said about STEM education, "It can contribute to the development of both the cognitive and motor skills of students (T3)." In addition, pre-service teachers think that STEM education will improve students' problem solving skills.

All pre-service teachers want to use STEM education when they start working as teachers. Because in general, they think that STEM education will provide lasting knowledge, is fun, and will attract the students' attention. A pre-service teacher stated that “With STEM education, lessons will not become monotonous and will become more fun (T9).” He stated that STEM education is fun.

STEM concept theme

The general impressions of pre-service teachers about STEM education were investigated with three questions. Table 4 shows the codes obtained in the theme of STEM concept, sample coding, and coding frequency. In the general thoughts of pre-service teachers about STEM education, its effect on learning comes to the forefront. Pre-service teachers think that the STEM approach should be used especially in science education. In addition, they stated that before they become a qualified teacher, STEM education should be explained to them.

Table 4. Codes in school dimension theme

Questions	Codes	Examples of open coding	Coding frequency
What are your thoughts on the STEM approach?	Effective in learning	I think it is very effective in student learning.	6
	Should be used in science education	It should be used in education and business life.	3
	Should be involved in teacher education	It should be introduced in detail, taught in education faculties, and brought to a level that all teachers can use.	2
What do you think about the sustainability of STEM education? Do you think it will be permanent or temporary in	Can be permanent	I think it will be permanent.	8
	Substructure should be supported	It will be a very good practice in the education system if all the schools are supported.	3
	It won't be permanent	It may be very fashionable for now, but if a breakthrough in science is made in the coming days, it may not be preferred as much.	2

the education system?			
How do you evaluate the relationship between STEM education and real life?	Seeks a solution to real-life problems	Problems in daily life can be solved with technology in easier ways.	5
	Intertwined with real life	It is completely related to real life.	4
	Reflects the purpose of engineering	It can be used for students who are prone to engineering to notice their talents.	3

The majority of pre-service teachers think that STEM education will remain important in the coming years. Only two pre-service teachers stated that STEM could fall off the agenda with the emergence of new approaches. The pre-service teachers stated that the substructure in schools is very important in STEM education and that these conditions should have a connection with each other.

Pre-service teachers explained the relationship between STEM education and real-life by seeking solutions to real-life problems. One participant expressed this view by saying “When the student encounters a similar problem in the future, he knows how to solve the problem (T12).” Pre-service teachers stated that STEM education has a correlation with conventional education and is intertwined with real life. In addition, three participants stated that this approach is related to real life and can introduce engineering with STEM education.

Self-efficacy theme

The self-efficacy of pre-service teachers about STEM education were investigated with three questions. Table 5 gives the codes, sample coding, and coding frequency in the theme of self-efficacy. According to Table 5, most of the pre-service teachers stated that they do not see themselves as ready to attend science classes, they want to take courses about STEM education and coding, and that they will use the STEM approach if they become familiar with it.

Table 5. Codes in self-efficacy theme

Questions	Codes	Examples of open coding	Coding frequency
Do you consider yourself competent in	I don't have competent motivation	No, I don't have competent motivation.	6

terms of pedagogical and content knowledge to teach science course? Please explain.	I have to improve myself although I am ready	I see myself sufficient enough to express myself and transfer knowledge to students, but I need to improve myself.	4
What would you like to learn apart from what you know during your university education for science teaching? Please explain.	STEM	I would like to take a course on STEM education.	5
	Coding	I would like to do training in coding.	3
	Instructional technologies	I would like to learn and use the technologies employed in education more.	3
Can you use this approach in your class after having received a training on STEM approach?	Definitely yes	I would definitely consider using it.	8
	I use it if I learn enough	Of course, if I believe I have reached a sufficient level.	2

Discussion and Implications

When STEM awareness of pre-service teachers was analysed, it was deduced that pre-service teachers did not express an opinion that mathematics-science and technology are directly connected. The failure of pre-service teachers to see the connection between mathematics, science, and technology means that they may experience integration difficulties in STEM applications in their classrooms. Considering that content integration among disciplines is very important for effective STEM teaching (Chan, Yeh, & Hsu, 2019), it can be said that prospective teachers cannot achieve an efficient STEM integration with their current perceptions. Based on the findings, it is understood that most of the pre-service teachers do not know the content of the STEM approach. According to Nadelson and Seifert (2013), there are insufficiencies in STEM teacher education. Of course, it would not be correct to generalize this finding to all international institutions that educate teachers. This perception will be the opposite of teacher training programs that provide STEM education within the curriculum. The thought of pre-service teachers that STEM education is necessary and useful can be described as a positive outcome. In researches, it is found that teachers generally think that STEM education is a useful approach (Bagiati & Evangelou 2015; Clark & Andrews 2010; Holstein & Keene 2013).

Pre-service teachers thought that STEM education should be applied in secondary schools. They supported these thoughts with the claim that STEM education could increase students' interest, embody abstract knowledge, and contribute to mastery in learning. In the researches based on the literature, it was revealed that STEM education brings different disciplines together and provides multi-dimensional learning with an interdisciplinary approach (Smith & Karr-Kidwell, 2000), and the motivation of students towards a lesson can be changed positively with STEM education (Niess, 2005). For this reason, it can be said that the views of pre-service teachers are in line with the researches in the literature. It is an important finding that pre-service teachers think that STEM education will improve students' creativity and psychomotor skills. Especially, creativity is one of the expected characteristics of students nowadays, because it is among the desired 21st-century skills (Brown, 2009). In addition, it was found in qualitative studies that STEM education increases students' psychomotor skills (Kanadli, 2019). All of the pre-service teachers who participated in the research stated that they want to use STEM education in their class when they become teachers. Similarly, Cetin and Balta (2017) concluded that pre-service teachers want to use the STEM approach in their professional lives. On the other hand, it can be said that in-service teachers are not as eager as pre-service teachers due to curriculum restrictions (Herro & Quigley 2017), difficulties in assessment and evaluation (Margot & Kettler, 2019) as well as planning STEM content (Bagiati & Evangelou 2015; Hsu et al., 2011).

Pre-service teachers stated that STEM education is effective in learning, it should be used in schools and they want to learn how to use STEM in class before graduation. According to Margot and Kettler (2019), teachers believe that well-organized and frequently available in-service training opportunities will facilitate STEM initiatives. The pre-service teachers emphasized that the substructure in schools is important for the applicability of STEM education. In similar studies, teachers stated that inadequate administrative and financial support may be a challenge for STEM implementation (Clark & Andrews 2010; Hsu et al., 2011). Pre-service teachers think that the STEM approach seeks solutions for real-life problems and is intertwined with real life. According to Bybee (2010), students who absorb the STEM approach have the necessary knowledge and skills to solve real-life problems.

Pre-service teachers stated that they want to learn the STEM approach better and they want to get training on it. After participating in professional development programs, teachers felt significant increases in their confidence, knowledge, and effectiveness to teach STEM (Lesseig, Slavit, Nelson & Seidel, 2016; Nadelson & Seifert 2013; Van Haneghan et al., 2015). The pre-service teachers stated that they wanted to receive training, especially in coding. One e reason for this may be the use of Arduino in the activity. When we think that coding is one of the important elements of STEM education (Bender, 2016), it is normal that pre-service teachers want to improve their knowledge and skills related to coding.

Recommendations and Limitations

Pre-service teachers should be given training on the content of the STEM approach. In particular, the relationship between STEM disciplines should be taught to them. Since pre-service teachers are eager to use STEM education when they start their careers, these motivations can be encouraged and they can use the STEM approach in the future. Pre-service teachers can be trained on how to apply STEM education in schools where technological conditions are insufficient. Thus, there will be a chance in less equipped districts and schools for teachers to use the STEM approach. It is recommended to improve the coding skills of pre-service teachers in STEM-related pre-service vocational education programs.

Limitations of this research include the relatively small size of the participant group, which impacts generalizability in other settings. In addition, increasing the time and diversity of the STEM-based sample activity can give pre-service teachers a different perspective. Finally, the pre-service teachers who participated in this research can be assessed when they are fully qualified in terms of using STEM.

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