International Journal of Progressive Education, Volume 18 Number 3, 2022

Evaluation of STEM SOS Model: Pre-Service Science Teachers' Opinions

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Abstract

This study aims to evaluate the STEM SOS model based on the opinions of pre-service science teachers. For this aim, the contributions and the challenges of the STEM SOS model to pre-service science teachers were investigated. The participants consisted of 23 pre-service science teachers studying in the 4th grade of science teaching at a state university during the fall term of the 2018-2019 academic year. The descriptive case study design was used for the study's research method. The implementation was performed in an elective course called New Approaches in Science Teaching, and the implementation process study took nine weeks, two hours a week. Firstly pre-service science teachers were given theoretical knowledge about STEM education and the STEM SOS model and were informed about the purpose of the study. The participants were asked to decide on their project groups of 2-6 people and to perform Level III projects based on the STEM SOS Model by each group in implementation. A open-ended survey form developed by the researcher was used as a data collection tool at the end of the implementation. The data were analyzed by using the content analysis method. As a result, it was determined that the STEM SOS model has many contributions for pre-service science teachers grouped under five categories, such as producing products, satisfaction, developing skills, increasing research interest, and the ability to act with the group. In addition, the study concluded that pre-service science teachers encountered some challenges during the implementation of the STEM SOS model, grouped under three categories as the barriers related to the project, lack of knowledge skills, and disagreement with group mates. In the light of these findings, necessary suggestions were made.

Keywords: Level III Projects, Pre-Service Science Teachers, STEM SOS Model

DOI: 10.29329/ijpe.2022.439.4

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INTRODUCTION

STEM, an acronym for science, technology, engineering, and mathematics, has been seen as the most important and the most recent reform movement in science education (Bybee, 2010; National Academy of Engineering [NAE] & National Research Council [NRC], 2009). STEM is an interdisciplinary approach that integrates science, technology, engineering, and mathematics (Morrison, 2006). It is at the forefront of international discourse in innovation and competition (Marrero, Gunning, & Germain-Williams, 2014).

STEM was not a new concept because STEM originated in the 1990s at the National Science Foundation (NSF) in the United States (Bybee, 2013). Nevertheless, in 2011, the president's speech of the United States on the importance of science, technology, engineering, and mathematics was a milestone of STEM education (White, 2014). Because of this speech, the success rank of the United States in the field of science and mathematics has decreased in the international exams between the Organization for Economic Co-operation and Development (OECD) countries. Also rate of students who prefer engineering is much lower than the other countries, such as Taiwan and the United Kingdom. This speech was the decrease in the United States' success in the field of science and mathematics in international exams among the Organization of Economic Cooperation and Development (OECD). The rate of students who prefer engineering was much lower than in other countries such as Taiwan and the United Kingdom (Koonce et al., 2011).

STEM education is an interdisciplinary approach that combines science, technology, engineering, and mathematics with school, society, business, and global enterprise to compete in the new economy (Tsupros, Kohler, & Hallinen, 2009). In our century, education aims to prepare students entirely equipped with 21st-century skills, such as adaptability, complex communication, social skills, non-routine problem solving, self-management, and systems thinking in order to ensure their competitiveness in this era of globalization, especially in the science and technology (Bybee, 2000; Husin, 2016). It has become the biggest challenge of our century that every student receives an education that 21st-century skills can gain to become individuals who will solve collective problems such as global warming, curing diseases, and ending poverty (Trilling & Fadel, 2009). STEM enables students to be equipped with technical knowledge and skills, turn to STEM professions and become STEM literate individuals to overcome these significant challenges of the 21st century (Bybee, 2010). The primary purpose of STEM education is to prepare the 21st-century workforce to take what they learn in school and apply it to their future jobs in the real world (Ejiwale, 2013). With STEM education, students acquire critical thinking skills and thus become creative problem solvers. As a result, they form a well-marketable workforce (Butz et al., 2004). In addition, entrepreneurship with an emphasis on innovation and invention is the best way for science students to prepare for the 21st-century workforce (Camesano et al., 2016).

As an approach, it can say that STEM education has two features (Roberts, 2013). First, STEM education is a component of the curriculum. It is not intended to represent a new set of core subjects of the 21st century to replace the traditional subjects. Rather it is intended to integrate STEM subjects (science, technology, engineering, and mathematics) as one subject (Morrison & Bartlett, 2009, Wang and al., 2011). Second, STEM education is an approach to learning. STEM education can refer to teaching strategies used to strengthen student understanding of complex concepts (Roberts, 2013). As a learning approach, STEM is used with problem-based learning, project-based learning, full learning model, 5E learning model, and STEM Students on the Stage (SOS) Model in science education (Selvi & Yıldırım, 2018).

STEM SOS Model was first developed in 2001 by the Harmony Public Schools (HPS) in Texas, USA. HPS has developed its STEM curriculum, which is called "STEM Students on the Stage (SOS)," by incorporating project-based and inquiry-based learning (Sahin, 2015). STEM SOS Model aims to increase students' STEM knowledge interest and produce self-motivated and self-regulated learners (Harmony STEM Program, 2013, as cited in Sahin & Top, 2015). The STEM SOS Model is composed of two aspects. First, teacher-directed learning with hands-on activities and student teaching in which a group of students taught content, and second, student projects in which students prepared as experiments or hands-on activities on a content (Phan, 2020).

In STEM SOS Model, there are three levels of projects: Level I, II, and III. Unlike other project models, students have to complete multiple projects, including a level I project followed by either average level II or advanced level III projects (Top & Sahin, 2015). Level I projects are short-term projects with a length of 1-2 weeks. Level I projects are conducted with small groups that include 3-4 students in each core subject area in a lesson. These projects are more teacher-driven and only completed in the classroom. Level II and III projects are long-term projects lasting yearlong and include work outside the classroom. Students can do their projects individually or as a group at both project levels. Unlike level III projects, level II projects are student-driven with teacher support. Also, a project hand-out is available. The teachers form STEM SOS project banks and allow students to choose from these projects. The teachers give students project hand-out and guide them to complete their projects.

Level II projects are mostly implemented at the secondary level. Level III projects are student-driven with teacher or mentor advice. At this level, a project hand-out is not available. STEM SOS projects are created entirely by students and are not planned by teachers earlier. These level projects can be described as advanced research projects and are primarily implemented at the high school level (Koyuncu, 2019; Selvi & Yıldırım, 2018; Top & Sahin, 2015¸ US Department of Education, 2015). However, technology is integrated into every phase to progress and complete projects successfully (Ozer, Ayyildiz, & Esch, 2015). Using technology is moderate-high in level I projects, is very high in level II and III projects (US Department of Education, 2015). Technology is used to share information, create projects, collaborate, showcase completed work, and final video presentations (Doğan & Robin, 2015).

STEM education is increasing in popularity all over the world. However, studies on STEM education have increased in recent years (Akcanca, 2020; Çalisici & Sümen, 2018).However, there is limited number of studies about STEM SOS model in the literature (Akgül & Yıldırım, 2018; Calore, 2018; Karakaş & Schultz-Jones, 2019; Koyuncu, 2019; Sahin, 2015; Talip & Aliyu, 2019; Sahin & Top, 2015; Top & Sahin, 2015). According to teachers who utilize the STEM SOS model in their teaching, STEM SOS Model provides teachers with rigorous content benefits for classroom management, classroom climate, student-teacher communication, and professional growth (Sahin & Top, 2015). However, according to Koyuncu (2019) 's study, there were some challenges for teachers and administrators during the implementation of the STEM SOS model, such as poor time management, inadequate attempts at technology integration in classrooms, and lack of a straightforward way to assess students' knowledge and skills during PBL Level II and III projects.

Furthermore, there are studies in the literature investigating the effect of the STEM SOS model on students (Akgül & Yıldırım, 2019; Top & Sahin, 2015). In Top and Sahin's (2015) study, the effects of the STEM SOS model on high school students' learning experiences were examined by open-ended survey form. This study revealed that the STEM SOS model helped students be more active in more times, learn STEM subjects better, develop STEM subjects interest, and develop skills for their school lives and real lives. Moreover, the study findings revealed that the STEM SOS model helps students gain academic and 21st-century skills. STEM interest, knowledge, and research interest in higher education were found as academic skills that the STEM SOS model provided. The self-confidence, technology skills, life/career skills, collaboration skills, and communication skills were founded as 21st-century skills that the STEM SOS model provided to the students. In another similar study, Akgül and Yıldırım (2019) aimed to determine the opinions of students about the projects prepared to depend on the STEM SOS model. As a contribution to the students, the STEM SOS model increased their knowledge, interest, and motivation and improved their self-confidence, scientific process skills, general culture, and cooperation skills. Also, the STEM SOS model encouraged students to experiment and reduced students' prejudices against the biology lesson. In addition, the students stated that the most significant contribution of the STEM SOS model to society was in the economic field, and later as knowledge and awareness in the field of mathematics. Also, only 1 of the ten projects developed by the students was a Level III project. Most projects were Level I and II projects in the study. For this reason, at the end of the study, it recommended that students conduct projects independently and carry out studies in which level III projects developed. All stages of the project are responsible.

Consequently, the STEM SOS model is new and has just begun to be used in STEM education. The number of publications related to this model is limited in the related literature. For this reason, it can say that the current study will contribute significantly to the knowledge pool about the STEM SOS model.

Purpose of the research

This study aims to evaluate the STEM SOS model based on the opinions of pre-service science teachers. For this purpose, this study seeks to answer the following two questions:

1. What are the contributions of the STEM SOS model according to pre-service science teachers who developed level III projects based on the STEM SOS model?

2. What challenges did pre-service science teachers who developed level III projects on the STEM SOS model encounter?

METHOD

Research Design

In this study, a descriptive case study, a qualitative research design, was utilized as a research method. In the case study, the researcher investigates a contemporary phenomenon within its real-life context (Yin, 1984), and in this method, an entirely limited system is in-depth defined (Merriam, 1998).

Participants

The study participants consisted of 23 pre-service science teachers (18 girls, five boys) studying in the fourth year of the science education department in the faculty of education at a state university located in Southeastern in Turkey during the spring term of 2017–2018 academic year. Participants were identified through convenience sampling voluntarily. Each participant took a codename (e.g., P1, P2) to protect the identity of the participants for research ethics.

Data Collection Tool

Open-ended survey form. In the study, for the purpose of determine the opinions of pre-service science teachers about the project development process based on STEM, a form developed by researcher was conducted, consisting of two ended questions. In this form, the pre-service science teachers were asked to explain their opinions about the benefits and limitations of STEM education, field/fields of science that are more suitable for STEM education, difficulties and favorites of the STEM SOS model. The questions in the open-ended survey form are as follows:

1. What are the contributions of the STEM SOS model?

2. What are the challenges of the STEM SOS model?

Procedure

Implementation was conducted in an elective course, called New Approaches in Science Teaching, in the last year of the science teaching department for two hours per week. The implementation process took nine weeks. In the first two weeks, the participants were given theoretical knowledge about STEM education and the STEM SOS model. The participants examined the projects and reports developed on STEM-based in the next two weeks. The participants were informed about the purpose of the study, and they were asked to decide their project groups consisted of 2-6 people. As a result, six groups were formed by the pre-service science teachers. In the fifth week, they were asked to discuss problems they encountered in daily life. In the sixth week, they were asked to bring about possible solutions to the determined problems as a project to the classroom. They were asked to discuss whether the project is a STEM SOS model-based project by the groups. They were reminded that the project is related to STEM disciplines (science, technology, engineering, mathematics) and innovation. They were asked to determine the project's necessary materials in the seventh week and calculate the cost. Mainly, they were recommended to choose the cheaper and more easily accessible materials whether they have an alternative. It was asked to each group to develop a model (prototype) as a project product throughout eight weeks and to test and evaluate this model in the classroom. In the ninth week, it was asked to the participants to present and promote their projects in the classroom. They are also asked to present the project reports to the researcher. Pre-service teachers were asked to write the project reports for the project they prepared for each group. In this report, the project's name, its purpose, the materials used in the project, the science, technology, engineering, and mathematics fields, and the resources utilized were requested. These reports aimed to evaluate whether pre-service teachers understand the purpose of STEM and develop STEM-based projects. Table 1 contains information about Level III projects based on the STEM SOS model developed by the pre-service science teachers in the study.

Table 1. The information about the projects developed in the study

Group No	Name of the Project	Participants	n	Aim of the Project
1	The automatic fish feeding machine	P6, P10, P11, P15, P17	5	In case of not being home for a long time, the fish can continue to be fed
2	The stale-free bread box	P2, P9, P18, P22	4	Keeping the bread fresh for a long time with blue light
3	The automatic pen opening machine	P3, P5, P7, P12	4	Little children who have difficulty opening a pencil can easily open their pens
4	The automatic foam machine	P14, P16, P20, P23	4	Making a toy that kids will love to play
5	The mixer	P13, P19	2	Making a mixer that works with very little energy
6	The solar powered charger	P1, P4, P8, P21	4	Charging the phone with solar energy

Table 1 shows names and aims of the projects developed in the study. As seen in Table 1, six groups developed six Level III projects based on STEM SOS model. The number of participants in the groups varies between 2 and 5.

Data Analysis

The data obtained with the open-ended survey form were analyzed through content analysis. In content analysis, similar data are combined and organized in a way that readers can understand (Yıldırım & Şimşek, 2013).

The data were divided into codes, and the categories were reached from the codes by the researcher. In order to ensure the reliability of the data analysis, another expert in qualitative data analysis re-analyzed the data. However, direct quotations are given for each code. The reliability of the study was calculated as 878% by using the reliability formula (Reliability: number of agreements/ total number of agreements + disagreements) developed by Miles and Huberman. Reliability should be 80% for consensus among coders (Miles & Huberman, 1994).

RESULTS

The contributions of STEM SOS model

Pre-service science teachers' statements about the contributions of the STEM SOS model were collected with open-ended survey form. In Table 2, there are content analysis results of these statements.

Table 2. The contributions of the STEM SOS model

Categories	Codes	Participants	f_{code}	$\%_{code}$	$f_{category}$	$\%_{category}$
Producing a product	Designing and producing a product	P1, P7, P9, P10, P11, P12, P13, P15, P16, P17, P18, P23	14	60.87	14	60.87
	Producing a product that can be used in daily life	P6, P22	2	8.70		
Satisfaction	The feeling of achieving something	P8, P16, P21	3	13.04	8	34.78
	Solving a daily problem	P1, P2, P5	3	13.04		
	Learning new things	P10, P20	2	8.70		
Improving skills	Improving technology and engineering skills	P1, P5, P7	3	13.04	6	26.09
	Improving psychomotor skills	P19, P21	2	8.70		
	Improving communication skills	P2	1	4.35		
	Improving creativity	P2	1	4.35		
Increasing research interest	Researching to determine the project subject	P3	1	4.35	3	13.04
	Doing detailed research on the subject after determining the project subject	P11	1	4.35		
	Determining the project subject by discussing in group	P4	1	4.35		
The ability to act with the group	Exchange of ideas	P22, P23	2	8.70	3	13.04
	Collaboration	P20	1	4.35		

f_{code}: mean frequency of code; $\%_{code}$: mean percentage of code; $f_{category}$: mean frequency of category; $\%_{category}$: mean percentage of category

According to Table 2, the contributions of the STEM SOS Model to pre-service science teachers are grouped under five categories: producing a product, satisfaction, improving skills, increasing research interest, and the ability to act with the group.

As seen in Table 2, most pre-service science teachers stated that the STEM SOS model contributed to them producing a product (60.87 %). According to the producing a product category, more participants stated that the STEM SOS model contributes to designing and producing a product (60.87 %). However, fewer participants stated that the STEM SOS model contributes to producing a product used in daily life (%8.70). Some of the statements of the pre-service science teachers belonging to this category are below.

"Designing the project was nice. I could find the best by doing multiple designs. This part was fun." (P12)

"Producing something and producing something useful gives people the pleasure of doing something." (P16)

"I enjoyed working with my own product and using it." (P6)

"I loved thinking about where the product we will obtain is in our daily life and what it will do for us." (P22)

In Table 2, which includes the statements of the pre-service science teachers regarding the contribution of the STEM SOS model, it is seen that the second-highest number of statements is satisfaction (34.78%). In the satisfaction category, it is seen that there are three different opinions close percentage to each other. These are respectively the feeling of achieving something (13.04%), producing a solution to a daily life problem (13.04%), and learning new things (8.70%). Some of the statements related to this category are as follows:

"We had the pleasure of being able to achieve something, to think. We had the happiness of fulfilling the given responsibility." (P8)

"Solutions to the problems of daily life by uniting parts." (P1)

"I liked learning topics we didn't know by doing research." (P10)

As seen in Table 2, the third-highest number of opinions about contributions of the STEM SOS model is improving skills (26.09%). According to this category, it is seen that there are four different opinions. Improving technology and engineering skills has the highest number of opinions in this category(13.04%). Improving psychomotor skills has the second-highest number of opinions (8.70%). It is seen that the opinions called communication skills and creativity share the last rank with an equal percentage (4.35%). Some examples of opinion belonging to this category are as follows:

"My favorite step in the STEM SOS application was to produce a technological product by using technological tools in the field of technology and engineering." (P7)

"I like to do handwork. I realized that there are some things that can be done by examining the electrical installation. I mean, it made me happy to see that I could do something that I did not understand before at the end of the endeavor." (P21)

"I love the group work that I have established with friends during the project development process, as it increases my communication skills." (P2)

"I liked the STEM SOS model as it reveals my creative side." (P2)

Table 2 shows that the percentages of the last two categories, increasing research interest and the ability to act with the group, are equal (13.04%). In the increasing research interest category, it is seen that there are three different opinions in equal percentage (4.35%). These are researching to determine the project subject, doing detailed research on the subject after determining the project subject, and determining the project subject by discussing in a group. Some of the statements related to this category are as follows:

"My favorite phase was the research phase. Because we learned the solution to many problems by doing research. We have observed our general culture and all scientific and social studies that are happening around us, whether they have been done or not." (P3)

"It was a great contribution to research the theoretical information of the project I will do and to investigate what kind of benefits it has." (P11)

In the ability to act with the group category, two different opinions are seen. It is seen that the opinion called exchange of ideas (8.70%) has a higher percentage than the opinion called collaboration (4.35%). Some examples of the opinions related to this category are as follows:

"During the STEM SOS practice, I liked to exchange ideas with our friends during the project development process." (P22)

"The collaboration enabled me to gain different perspectives and to discover things I did not know." (P20)

The challenges of the STEM SOS model

The challenges pre-service science teachers encountered while experiencing the STEM SOS model in the study were collected with open-ended survey form. In Table 3, there are content analysis results of the challenges that pre-service science teachers encountered.

Table 3. The challenges of the STEM SOS model

Categories	Codes	Participants	f_{code}	$\%_{code}$	$f_{category}$	$\%_{category}$
Barriers related to the project	Determining a project subject related to all STEM disciplines	P2, P3, P5, P6, P7, P9, P10, P12, P13, P14, P23	11	47.83	20	86.96
	Determining a project subject that has never been done before	P1, P4, P10, P18	4	17.39		
	Procuring materials	P11, P15, P20, P22	4	17.39		
	Supplying project cost	S9, S18, S19	3	13.04		
	Determining a project subject related to daily life	P16	1	4.35		
	Accessing the correct knowledge about the project	P11	1	4.35		
Lack of knowledge-skills	Lack of knowledge in other STEM disciplines other than science	P9, P10, P17	3	13.04	4	17.39
	Lack of psychomotor skills	P21	1	4.35		
Disagreement with group mates	Disagreement about sharing the work	P8	1	4.35	2	8.70
	Disagreement about determining the project subject	P22	1	4.35		

f_{code}: mean frequency of code; $\%_{code}$: mean percentage of code; $f_{category}$: mean frequency of category; $\%_{category}$: mean percentage of category

In Table 3, it is seen that the opinions of the pre-service teachers about the challenges of the STEM SOS model are grouped under three categories: The barriers related to the project, lack of knowledge skills, and disagreement with group mates.

Table 3 shows that pre-service science teachers mostly encountered barriers with the project (86.96%). In this category, it is seen that six different opinions about the difficulties with the project. Determining a project subject related to all STEM disciplines' opinions has the highest number of opinions among them (47.83%). Determining a project topic that has not been done before and procuring materials shares the second-highest rank with an equal percentage (17.39%). It is seen that supplying project cost is included in the third-highest rank (13.04%), determining a project subject related to daily life and accessing the correct knowledge about the project share the last rank with an equal percentage (4.35%). Some of the statements related to difficulties with the project category are as follows:

"During the STEM SOS practice, while developing a project, it was difficult for me to find a problem, thinking that all four disciplines of science, technology, engineering and mathematics should be together." (P3)

"I had a hard time choosing a project. Because my goal was to create a product that does not exist." (P1)

"The challenging problem for me while developing the project was that I could not quickly obtain the tools and equipment. For this reason, it caused me to give up because of the worry of not being able to present the product." (P15)

"The project we were considering did not fit our plans in terms of cost." (P19)

"It wasn't easy to find the necessary information while doing research. In other words, everything except the requested information is said [on the internet]." (P11)

As seen in Table 3, the second most common challenge that pre-service science teachers encountered was the lack of knowledge skills (17.39%). In this category, there are two different opinions. It is seen that the challenge called lack of knowledge in other STEM disciplines other (13.04%) than science has a higher percentage than the challenge called lack of psychomotor skills (4.35%). Some examples of pre-service teachers' statements on this category are as follows:

"During the practice, we had difficulties because we did not have enough information about all the disciplines." (P9)

"While preparing the project, I had difficulties making some manual skills. Because of my hand skills are not enough. I had a problem with the electrical installation works and fastenings. But, I saw that there are things that can be done after long effort." (P21)

In Table 3, it is seen that the third and last challenge that pre-service science teachers encountered was disagreement with group mates (8.70%). According to this category, there are two different challenges with the equal percentage that pre-service science teachers encountered (4.35%). These challenges are disagreement about sharing the work and disagreement about determining the project subject. The opinions belonging to this category are as follows.

"I had difficulties in teamwork. We could not agree on task sharing with group members, and there were communication gaps." (P8)

"We differed with our group members during the project subject development process in this practice." (P22)

DISCUSSION AND CONCLUSION

This study aimed to investigate the experiences of pre-service science teachers implementing the STEM SOS model. For this aim, the pre-service science teachers' opinions determined the contribution of the STEM SOS model and the challenges they encountered. Participants developed six Level III projects based on the STEM SOS model in the implementation. As a result, although the pre-service science teachers encountered many various challenges during the implementation of the STEM SOS model, the STEM SOS model had many positive contributions for them.

In this study, the results indicated that the most significant contribution of the STEM SOS model to pre-service science teachers was to produce a product. As a result of the projects that participants designed, it has been observed that pre-service science teachers liked it very much to produce a product and especially one that could be used in their daily lives. Additionally, satisfaction was the second significant contribution of the STEM SOS model. It seems that this sense of satisfaction was provided by the feeling of achieving something, producing a solution to a daily problem and learning new thing. It is concluded that these two findings support each other because it can be said that producing a new product causes pre-service science teachers to feel a sense of satisfaction.

Furthermore, the current study achieved quite similar results with literature about the contributions of the STEM SOS model (Akgül & Yıldırım, 2019; Top & Sahin, 2015). For example, as in Top and Sahin's (2015) study, improving skills such as communication technology, increasing research interest, and the ability to act with the group such as collaboration were obtained in this study as the contributions of the STEM SOS model. Also, unlike these studies, it was found that the STEM SOS model improved pre-service science teachers' other skills such as engineering skills, psychomotor skills, and creativity. In addition, it was observed that the STEM SOS model gave the participants the ability to act together with the group by exchanging ideas.

According to another result of the research, pre-service science teachers encountered some challenges in implementation, which were collected in three categories: barriers with the project, lack of knowledge skills, and disagreement with group mates. It was concluded that the significant challenge of the STEM SOS model was determining a project subject related to all STEM disciplines in the category of barriers with the project. In light of the findings, it can be said that pre-service science teachers did not have sufficient knowledge about STEM disciplines other than science, which is why they had difficulty determining a project subject that included all STEM disciplines. Lastly, determining a project subject related to daily life, accessing the correct knowledge about the project, lack of psychomotor skills, disagreement about sharing the work, and determining the project subject with group mates were less common challenges.

There is no study investigating the difficulties faced by pre-service science teachers about the STEM SOS model in the literature. However, in general, some studies identify the difficulties faced by pre-service teachers by using STEM and other different teaching models of STEM. The current study findings support some of the findings of those studies. For example, Tarkın-Çelikkıran and Aydın Günbatar's (2017) study, STEM integrated approach with design approach model, was conducted to pre-service chemistry teachers. This research reported that pre-service chemistry teachers had difficulties in deciding on the materials to be used, how to design the product, and obtaining the necessary information. Mainly, some studies reported that procuring materials was an important challenge of STEM education (Altan, Yamak, & Kırıkkaya, 2016; Stohlmann, Moore & Roehrig, 2012). In addition, it was obtained that determining a project subject that has never been done before, obtaining materials, and supplying project cost were minor challenges encountered by fewer pre-service science teachers.

The current study has shown that the STEM SOS model has made significant contributions to pre-service teachers who develop Level III projects based on this model. Therefore, it may be suggested that the STEM SOS model should be used for pre-service science teachers to gain these contributions. Hence, it should be investigated the contributions of STEM SOS model has on students by developing Level I and II projects at the recommended training levels.

In addition, the other result of this study showed that pre-service science teachers encountered some challenges developing Level III projects based on the STEM SOS model. In particular, it has been observed that the main challenge was to determine a project subject related to all STEM disciplines. It can be said that this is because STEM disciplines are treated as separate courses in science teaching programs. For this reason, courses in which STEM is taught with a holistic approach should be recommended to give in science teaching programs. Lastly, it was observed that pre-service science teachers also had difficulties in procuring materials and supplying project costs. For this reason, researchers who will work on this subject in the future should be advised to start to studies on Level III project based on the STEM SOS model by solving the financial resources required for the provision of sufficient materials and materials.

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