Athens Journal of Education - Volume 9, Issue 3, August 2022 – Pages 469-486

Preschool Teacher Candidates' Ability to Design STEM-Focused Activities and Attitudes towards STEM

*By Neslihan Ültay**

This study aimed to determine preschool teacher candidates' ability to design Science, Technology, Engineering and Mathematics (STEM)-focused activities and their attitudes towards STEM. The research method of the study was determined as a case study. The study was carried out with 35 preschool teacher candidates in the 3rd grade of the Preschool Education program. In the study, it was seen that the preschool teacher candidates had prepared the STEM activities at the end of the 14-week STEM education given to them, and they were able to design a sufficient level of activity. In addition, it is seen that the 14-week training provided has a positive effect on their attitudes towards STEM. However, this period is not sufficient to develop attitudes. Therefore, it can be suggested to examine attitudes towards STEM in longer periods.

Keywords: ability to design STEM-focused activities, attitude towards STEM, preschool teacher candidates, STEM-focused activity, STEM education

Introduction

The emergence of Science, Technology, Engineering and Mathematics (STEM) education was born out of the necessity of raising individuals with interdisciplinary perspectives, scientific and technology literate and 21st century skills. STEM education, which first appeared in the US, later became popular in many countries' educational reform programs. Turkey also has paid attention to the STEM education, STEM is not added directly to the education system (because it would require very radical changes), and it begins to be carried out with STEM activities with teachers' efforts. Designing a product especially in preschool education is considered the best way to integrate STEM into education (Çil, 2019). However, according to some researchers, STEM is not a chain of activities, but a teaching-learning mentality (Reighard, Torres-Crespo, & Vogel, 2016).

When STEM first appeared, it was intended for primary and secondary school students, and the focus was on students of this age group. However, it was later realized that it is actually a learning approach that can be used for preschool children. Because the focus of STEM is the children's creativity, asking questions, researching, and creating solutions for a problem from daily life in cooperation. Since these features are the skills and abilities that preschool children naturally possess, STEM's preschool applicability has come to the agenda (Chesloff, 2013; Ültay & Ültay, 2020). Preschool children are curious about events around them like natural scientists, they have personality like researchers, they learn concretely,

*Associate Professor, Department of Preschool Education, Education Faculty, Giresun University, Turkey.

https://doi.org/10.30958/aje.9-3-7 doi=10.30958/aje.9-3-7

and have tendency to group work. These are some of the features required to conduct STEM-focused activities (Aldemir & Kermani, 2017).

The applicability of STEM education in preschool period has been highly criticized by some researchers. The reasons for this may be that preschool teachers have not received adequate training on this subject (Whitebook & Ryan, 2011), preschool education program is not suitable for implementing STEM and preschool children are not suitable for STEM education (Atiles, Jones, & Anderson, 2013). However, many learning activities performed in preschool education program overlap with STEM activities (Aldemir & Kermani, 2017). For example, designing and producing a bird house together to protect birds from cold weather is an activity that is naturally present in the programs of preschool children and is implemented in almost all countries, and this activity can be considered as an activity in accordance with STEM (Ültay & Ültay, 2020). In addition, preschool education of universities in Turkey, although there is no direct course related to STEM education in undergraduate programs, through some elective courses, this shortcoming is been trying to shut down. For example, the course "Modern approaches in preschool education" may be an elective course suitable for teaching STEM education as a content.

In this study, it was aimed to design exemplary STEM-focused activities by preschool teacher candidates at the end of STEM education. Although there are many researches on STEM education and there are a lot of sample activity books on the market, a road map that can be used to design STEM activity is not clear yet. However, based on some criteria/features that should be present in STEM activities, in some studies, these criteria are expressed as follows: (1) Starting the activity with a real life problem and presenting it to the students in an appropriate context (2) Bringing the activity into integration of two or more STEM disciplines (3) Making the activity student-centered (4) Adapting the activity suitable for the characteristics of project and problem based learning approaches (5) Configure group work in the activity (6) Redesign (7) Evaluating designs (Aydın-Günbatar, 2019; Ültay & Aktaş, 2020). Teacher candidates also made sure that these criteria were found in the STEM-focused activities they designed.

Studies on the application of STEM education to learning environments have shown that STEM causes a positive increase in students' attitudes towards science (e.g., Campbell, Speldewinde, Howitt & MacDonald, 2018; Chen, Huang, & Wu, 2021; Hackman, Zhang, & He, 2021; Karahan, Canbazoğlu Bilici, & Ünal, 2015; Yamak, Bulut, & Dündar, 2014). Interestingly, students developed positive attitudes toward STEM disciplines, ranging from positive to negative attitudes, engineering, science, technology, and mathematics (Tseng, Chang, Lou, & Chen, 2013). It will be a significant step forward for our country's education and economy to raise awareness about STEM by increasing interest in the disciplines that comprise STEM, to make people like STEM, and to foster a positive attitude toward STEM (Azgın, 2019, Hacıoğlu & Dönmez Usta, 2020). Because at this age, students develop scientific attitudes and scientific process skills, and these attitudes carry over from the university to their everyday lives (Uştu, 2019). Students are expected to maximize their theoretical, process-oriented, and practical competencies in the field of STEM until the end of the fourth and fifth grades, to recognize professions related to STEM education, and to gain the ability to integrate them with other disciplines related to STEM education (Bybee and Fuchs, 2006; Bagiati, Yoon, Evangelou and Ngambeki, 2010). In addition, STEM education has positive effects on students' academic success, development of scientific process skills, and career choice for engineering (Kong & Huo, 2014; Cotabish, Dailey, Robinson, & Hunghes, 2013). From studies conducted on STEM education, for example, Çınar, Pırasa, Uzun, and Erenler (2016) investigated the effect of STEM education on interdisciplinary educational approaches of teacher candidates. As a result of the study, teacher candidates stated that STEM education would contribute to the individual and social development of students and they wanted to use interdisciplinary applications in their classrooms. Sümen and Çalışıcı (2016) conducted the environmental literacy course in accordance with STEM education and investigated the teacher candidates' thoughts and mind maps regarding STEM. As a result of the research, teacher candidates found the activities effective, easy, and fun. In addition, Hacıoğlu (2017) found that science teacher candidates' STEM-based activities could improve their scientific creativity and critical thinking skills. However, one point that should not be forgotten is the content knowledge of the teacher performing the activity about the discipline to which the design made in STEM activities belongs and the attitude towards that area (Bozkurt, 2014). Indeed, the lack of sufficient knowledge of teachers and lack of infrastructure in schools are best known difficulties about STEM (Herdem & Ünal, 2018; Ültay & Ültay, 2020).

When we look at the studies about the effect of STEM education on attitude in the literature, it is seen that there are many attitude scales developed for STEM education and many of them are translated into Turkish (e.g., Derin, Aydın & Kırkıç, 2017; Yıldırım & Selvi, 2015; Yılmaz, Yiğit Koyunkaya, Guler, & Guzey, 2017). However, it is noteworthy that the number of studies investigating the attitudes of prospective teachers towards STEM education is low. Hacıömeroğlu (2018) determined that the attitudes of teacher candidates towards STEM were positive in their study conducted with 401 teacher candidates. However, this study differs from other studies as it aims to determine the attitudes of preschool teacher candidates towards STEM after giving STEM education to preschool teacher candidates during an academic period. Based on this, it can be said that the aim of this study is to determine preschool teacher candidates' ability to design STEM-focused activities by considering the characteristics that should be present in a STEM activity mentioned above and their attitudes towards STEM.

Methodology

The study has been identified as a case study since it allows for an in-depth study of a class. Case studies may involve many people or communities and require data collection over a long period of time (Creswell, 2003). This study is a case study since it covers an academic period and requires in-depth information collection.

Sample

The study was carried out with 35 preschool teacher candidates enrolled in the 3rd grade of the Preschool Education program of a university in the Eastern Black Sea Region in the spring term of the 2018-2019 academic year. 30 of the teacher candidates were women and 5 of them were men and their age ranges were 20-32. All ethical responsibilities were considered and informed consents were taken from sample. The study was conducted within the scope of the elective course of "Modern approaches in preschool education," 3 hours a week for a total of 14 weeks. The preschool teacher candidates were divided into 10 groups and designed the STEM-focused activities as a group. The groups were named as G1, G2, …., G10. The groups were formed as the teacher candidates wanted, so G6 consisted of two people, G1, G5 and G10 were consisted of three people, and G2, G3, G4, G7, G8 and G9 were consisted of four people.

Data Collection Tools and Data Analysis

STEM-focused activities developed by preschool teacher candidates were evaluated in the research, and at the beginning and end of the academic term to determine their attitudes towards STEM "the STEM Education Attitude Scale" was implemented. The attitude scale which was originally developed by Berlin and White (2010) was adapted to Turkish by Derin, Aydın, and Kırkıç (2017).

STEM activities developed by preschool teacher candidates were examined within the framework of the criteria set by Aydın-Günbatar (2019) and scored with a scoring scale developed in accordance with these criteria. Accordingly, the total score of teacher candidates of STEM-focused activities was evaluated as their ability to design STEM activities. Scoring scale is shown in Table 1.

The attitude scale implemented to determine preschool teacher candidates' attitudes towards STEM is a time-saving scale as the difference in the meanings of the words requires very well organized. In this sense, there are 33 expressions and their opposite expressions on the scale, and teacher candidates were asked to make close markings to whichever of these expressions they feel close to. For example, among the expressions "useful… ..,… ..,… ..,… ..,… .., harmful" teacher candidates marked which one they feel close to for STEM. Accordingly, 5 represents the highest attitude and 1 represents the lowest attitude. Since some expressions were given negative in the scale, the scoring scale specified by Derin, Aydın, and Kırkıç (2017), who made the Turkish version of the scale, was used. The average score obtained from the scoring scale was interpreted according to the Kaptan's (1998) chart (Table 2), assuming that it represents the attitudes of teacher candidates towards STEM.

Table 1. Scoring Scale Used to Evaluate STEM-Focused Activities Designed by Preschool Teacher Candidates

Criteria	**Sufficient (3 points)**	**Partially sufficient (2 points)**	**Should be developed (1 point)**
Starting the activity with a real-life problem and presenting it to students in an appropriate context	The activity is started with a real life problem and presented to students in an appropriate context.	The activity is partially started with the real life problem and presented to students in an appropriate context.	The activity is not started with a real life problem and was not presented to students in an appropriate context.
Bringing the activity into integration of two or more STEM disciplines	The activity involves the integration of two or more STEM disciplines.	The activity partially involves the integration of two or more STEM disciplines.	The activity does not include the integration of two or more STEM disciplines.
Making the activity student-centered	The activity is student-centered.	The activity is partially student-centered.	The activity is not student-centered.
Adapting the activity suitable for the characteristics of project and problem based learning approaches	The activity has been adapted suitable for the characteristics of project and problem-based learning approaches.	The activity has been partially adapted suitable for the characteristics of project and problem-based learning approaches.	The activity has not been adapted suitable for the characteristics of project and problem-based learning approaches.
Configuring group work in the activity	The activities are prepared in accordance with the group work.	The activities are partially prepared in accordance with the group work.	The activities are not prepared in accordance with the group work.
Redesign	The activities have been prepared to allow students to redesign.	The activities have been prepared to partially allow students to redesign.	The activities have not been prepared to allow students to redesign.
Evaluating designs	An evaluation rubric is prepared to evaluate designs.	An evaluation rubric is partially prepared to evaluate designs.	An evaluation rubric is not prepared to evaluate designs.

Table 2. The Mean Scores of Scale Points according to Kaptan (1998)

Score ranges	**Meanings of score**
1.00-1.80	Never
1.81-2.60	Rarely
2.61-3.40	Sometimes
3.41-4.20	Often
4.21-5.00	Always

Reliability and Validity

Within the scope of the research, the most important point about content validity is whether there is an area that cannot be evaluated with the scoring scale prepared (Ültay, Ültay, & Dönmez Usta, 2018). In this sense, the scoring scale was examined by a science education specialist and necessary arrangements were made. In addition, according to the opinion of the expert, the scoring scale contains all the important points that should be present in an STEM event. For the reliability of the scoring scale, whether the categories are adequately explained or not (Tuncel, 2011), necessary arrangements were made in line with the expert opinion.

Derin, Aydın, and Kırkıç (2017) applied the attitude scale to 300 teacher candidates for the validity and reliability analysis of the scale and the reliability coefficient (Cronbach alpha) was found 0.77 for the entire scale. Accordingly, the attitude scale of Derin, Aydın, and Kırkıç (2017) was characterized as reliable and suitable for Turkey sample. The reliability coefficient calculated for this study was calculated as 0.74.

Results

In the research, the activities prepared by preschool teacher candidates in order to determine their ability to design activities for STEM were evaluated with the help of the scoring scale and the findings were presented in Table 3.

Table 3. Evaluation of Teacher Candidates' STEM-Focused Activities

Criteria	**Sufficient (3 points)**	***f***	**Partially sufficient (2 points)**	***f***	**Should be developed (1 point)**	***f***
Starting the activity with a real-life problem and presenting it to students in an appropriate context	G5, G7, G8, G9, G10	5	G1, G2, G3, G4, G6	5		
Bringing the activity into integration of two or more STEM disciplines	G2, G4, G6, G7, G8, G9	6	G1, G3, G5, G10	4		
Making the activity student-centered	G1, G2, G3, G4, G5, G6, G7, G8, G9, G10	10				
Adapting the activity suitable for the characteristics of project and problem based learning approaches	G1, G2, G3, G4, G5, G6, G7, G8, G9, G10	10				
Configuring group work in the activity	G1, G2, G3, G4, G5, G6, G7, G8, G9, G10	10				
Redesign	G1, G2, G3, G7, G9, G10	6	G4, G5, G6, G8	4		
Evaluating designs	G2	1	G1, G3, G6, G7, G8, G9, G10	7	G4, G5	2

According to Table 3, STEM-focused activities designed by preschool teacher candidates were planned to be conducted in a student-centered manner and also seemed appropriate for group work. However, the criteria prepared by preschool teacher candidates were not sufficient especially in the evaluation of designs. The attitude points that teacher candidates have developed against STEM are given in Table 4.

Table 4. Preschool Teacher Candidates' Attitude Points towards STEM

	Average	Minimum	Maximum	Range	Maximum/Minimum	Variance
Item average (pre test)	2.549	2.000	4.000	2.000	2.000	0.400
Item average (post test)	3.959	3.000	4.765	1.765	1.588	0.319

According to Table 4, the preschool teacher candidates' attitude score averages for pre test were 2.5 which meant 'rarely' and for the post test 3.9 which meant 'often' in Kaptan's chart. It is also noteworthy that the marked minimum value is 3.

Investigation of STEM-focused activities of the groups

1. Group. The preschool teacher candidates planned to start the lesson by watching a duck-themed animation that could not swim for the students. It was planned to ask the question of how we can have helped him to pass a duck that cannot swim with the animation across the lake. Thus, it was thought that a real life problem was presented to the students. After this stage, students tried to decide what product to design by generating ideas to help the duck. After reaching a group decision, students who were released free on choosing material began to design their products by taking their materials. Students who had the opportunity to try the product they had designed in a basin brought to class, redesigned their products if their designs had an inoperative point (such as sinking in water or deterioration of the carton when it is wet). The designs of the groups were evaluated as a result of the criteria determined by the teacher and the best design of the class was selected. Students' designing a product such as boats was associated with engineering, swimming or sinking of the boat they designed was associated with science.

2. Group. The STEM-focused activity planned by the preschool teacher candidates started with a slingshot in the hands of the teacher. First of all, the teacher explained what the sling did and how it was used, and then told a story. In this story, there were two kids playing with a slingshot, and one's sling brought while playing. The teacher presented the real life problem by asking how we can have helped the friend whose sling was broken. After that, the students decided to design a slingshot for this friend and started by choosing materials for their designs. After the students completed their designs, they experimented with putting stones or balls. If there were points that did not work in their designs (such as not being able to launch or reaching the desired distance), students were given the opportunity to redesign. Then, the best design was chosen according to the criteria determined by the teacher. Designing catapult, or etc. was considered as a relation to engineering discipline, the ability of the catapult they designed to balance, and the flexibility of the launcher can have been related to science discipline, and the estimation of the distance of the bottles to be hit with the designed catapult was considered as a relation to mathematics discipline.

3. Group. The STEM-focused activity planned by the preschool teacher candidates started with a cartoon. There was a cat in the tree in this cartoon and this cat cannot have got off the tree. The question of what tool we should have designed to help this cat was a real-life problem. Within the framework of this problem, students decided what kind of tool they would have designed and moved on to material selection. After designing their products, students discussed about the robustness and suitability of the products, and those with incomplete designs began to redesign. When the redesign process was finished, the designs were evaluated within the criteria determined by the teacher. Designing a product such as stairs etc. by students to save the cat from the tree was associated with engineering discipline, measuring whether the length of the tools made was sufficient for the length of the tree was associated with the field of mathematics.

4. Group. The STEM-focused activity planned by the preschool teacher candidates started with a story. This story talked about a group of children being together to fly a kite. A child without a kite joined the story later, and the story continued with that his friends decided to make a kite for the child without a kite. In this way, the real-life problem was passed on to the students, and the students decided to design a kite to help this child and determined their designs in a group. Then they chose the materials they wanted and revealed their designs. The teacher asked how we can have made these designs more robust and asked the students to rethink and correct the missing points. When this stage was over, the kites were evaluated in terms of predetermined criteria. The students' designing a kite was related to the field of engineering, the length of the rope used and the number and length of the materials used to ensure the air circulation (pipe, wooden rod, etc.) were related to the mathematics, and making experiments and observations made on whether it will fly in windy weather were associated with science.

5. Group. The STEM-focused activity planned by the preschool teacher candidates started with the teacher asking students to collect pet bottles for recycling. After the students had accumulated empty pet bottles for about a month, they brought them to the class. After watching an animation about recycling, the teacher asked what we can have done with these empty pet bottles and asked students to design a product that we can have used in daily life using empty pet bottles. Students who planned their designs by the group started their designs after getting the necessary materials. The teacher helped the students in the guide position. After talking about the usefulness and quality of the products made, the designs were evaluated. The students' designing products from pet bottles was associated with engineering, while the number of objects used and the geometric shapes of the products formed were associated with the field of mathematics.

6. Group. The STEM-focused activity planned by the preschool teacher candidates started with the story of a sparrow that had lost its home in the winter months. The teacher asked the students how we can have built a nest to help this sparrow, and the students decided their designs in groups. Then they started creating their designs by choosing their materials. When the designs were finished, their durability was checked by the teacher and the non-durable designs were redesigned by the students. At the last stage, these designs were evaluated with the criteria created by the teacher. Students' designing nests for birds was related to the field of engineering, the materials they used for designing, and the cameras placed inside the nests were related to the field of technology, the number of objects used and the correlation of the designs of the nests with geometric shapes were related to the mathematics.

7. Group. The STEM-focused activity planned by the preschool teacher candidates started with a question asked by the teacher from daily life. The teacher asked the students how to clean small crumbs spilled at home and then asked our class how to clean them if these crumbs were spilled. Thus, it directed the students to the question of what kind of product we should have designed to remove small crumbs. After students discussed in groups and decided their designs, they started their designs by choosing the appropriate materials for their designs. The teacher assisted the groups who wanted to use the engine in their designs during the installation of the engine. After the designs were finished, they were tested whether they pulled small papers to test the designs and if there was a point that did not work in the design, it was corrected. Designs were evaluated through the criteria that the teacher had previously determined. Students' designing a product such as vacuum cleaner etc. had been associated with engineering, and engine placement in the product they had designed had been associated with technology, the relation between pulling power of the engine and the length of the hose was associated with mathematics.

8. Group. The STEM-focused activity planned by the preschool teacher candidates started with the teacher's conversation about homeless cats on the street. Along with the question of how we can have helped street cats, the question of how we can have designed a home for them had been raised. After that, students decided on the nest they would have designed in groups and chose the necessary materials to get to work. After the designs were finished, they were checked by the teacher and asked students to redesign the nests that were not shockproof or cold protected. Designs were last evaluated by the teacher. Students' designs such as wooden hut etc. were associated with engineering, the construction of the hut equipped for heat loss was associated with science, camera, or electronic thermometer technology used by students were associated with technology, and the number and the geometric shapes of the objects they used were associated with mathematics.

9. Group. The STEM-focused activity planned by the teacher candidates started with a student's curiosity about stars and planets. Then the teacher hung mockups of celestial objects such as stars and planets in the class. The teacher asked how we can have seen the stars more closely, and after the students' answers, it presented the real-life problem that students had prepared as a tool to see more closely the celestial objects. After that, the activity continued with the students designing telescopes and similar tools. The designed vehicles were tested by looking at the stars on the ceiling of the class, and groups with problems in their design were given the chance to redesign. Finally, the designs were evaluated by the criteria determined by the teacher. Students' designing telescope etc. was related to the field of engineering, the examination of celestial bodies was related to science, and the calculation of the distance to keep the telescope in balance was related to mathematics.

10. Group. The STEM-focused activity planned by the teacher candidates started with a few students who came to class late and they explained their teachers why they came late. For the students who told that the bridge that the students had to use when they came to school was shaking too much and did not look very strong, the teacher turned to the class and revealed the real life problem by saying "how can you have helped your friends?" Students were divided into groups and tried to find solutions to this problem situation. After the students planned and made their designs, the robustness of the designs was tested with a hair dryer. Designs that were determined to be not robust were rearranged. Finally, the designs were evaluated by the criteria determined by the teacher. Students' designs such as bridge etc. were associated with engineering, and the balancing the bridge was related to science.

Discussion

In the research, it was determined the skills of preschool teacher candidates to design STEM-focused activities, and at the end of 14 weeks STEM education, the attitudes of teacher candidates towards STEM were tried to be determined. At the end of the research, it was seen that the STEM-focused activities designed by teacher candidates were generally collected in partially sufficient and sufficient categories and the scores they got as a result of this categorization were at a good level. However, when STEM-focused activities designed by preschool teacher candidates were examined in depth, the most important points that the activities were student-centered and required group work. This shows that in science education, the transition from a teacher-centered approach to a student-centered approach has been internalized in recent years. As it is known, the common point of all the programs (such as, Project 2061, AAAS Science, NGSS, Model-Based Analysis and Reasoning in Science) that have been developed in order to contribute to science education and to increase the number of science literate individuals in recent years (Ayas & Çepni, 2007; Ültay, 2017) have focused on student-centered learning. However, one of the most important points of the STEM education is that it is student-centered and enables group work (Kennedy & Odell, 2014). Guzey, Moore, and Harwell (2016) stated that the STEM activities should be student-centered while listing the important features that should be present in a STEM activity. It is also a known fact that group work and collaborative practices increase success and improve social emotions (Kovac, 1999; Sisovic & Bojovic, 2000).

When STEM-focused activities of preschool teacher candidates were examined, all activities started with a real life problem. Half of them (in the group who are partially sufficient) started with a story, animation, or cartoon. Based on a problem situation mentioned in the story, animation, or cartoon, students were planned to be directed to design a product. STEM activities in the group, which is found to be sufficient, started with the students coming to the agenda of a daily problem and developing a solution proposal for that problem. For example, in the activity that G10 had planned, it started with the problem of a bridge that many students had to use when coming to school and they were late for the class for a while because of shaking the bridge. Students started to develop solutions to solve this problem and wanted to help their friends. One of the most important points of STEM activities is that it contains a real life problem (Aydın-Günbatar, 2019). According to Moore et al. (2014), one of the most important indicators determining the quality of a STEM activity is the existence of activities that are meaningful and interesting for students and require them to use their personal knowledge and experience. This is possible by creating partially or completely realistic and meaningful situations (Brophy, Klein, Portsmore, & Rogers, 2008; Carlson & Sullivan, 2004).

When the STEM activities designed by teacher candidates are considered which STEM areas they contained, it was seen that all of the groups were focused on at least two STEM areas. However, while five groups planned an activity proposal for covering three STEM areas, only one group (G8) planned an activity that included all of the STEM areas. However, it is sufficient that a STEM activity addresses at least two STEM fields (Kennedy & Odell, 2014). The common preferred STEM field in all groups was engineering. The reason for this may be that the best way to integrate STEM activities in preschool education is to develop a product or to produce a tool (Çil, 2019), because the best way for preschool children to learn information is to present the information by concrete. Also, Moore et al. (2014) state that the common point to be found in STEM activities is engineering design homework.

When the suitability of STEM-focused activities designed by preschool teacher candidates to the characteristics of project and problem-based learning approaches were examined, it was seen that all of the prepared activities contained a problem situation. From this point of view, it can be said that they were prepared in accordance with the problem-based learning approach. There must be a problem situation for the integration of science fields in STEM activities (Sanders, 2009). Problem-based learning is a learning approach that involves collaborative work with the most general point of view that requires the student to face in real life and have multiple solutions, to face the student with an interdisciplinary problem and to review the existing information to solve it (Savery, 2006). STEM-focused activities designed by preschool teacher candidates addressed these points. In project-based learning, learning activity is organized around projects. However, a question that will motivate students in project-based learning needs to be asked, and students form plans, determine the process, develop solution suggestions, and share the results with the class by creating groups (Selvi & Yıldırım, 2018). It can be said that the activities designed by teacher candidates were prepared in accordance with project-based learning, because it contained the points that should be included in project-based learning. In addition, it can be said that the characteristics of STEM activities and project-based learning are largely similar (Selvi & Yıldırım, 2018).

When the STEM-focused activities designed by preschool teacher candidates were examined, it included the students' group work in accordance with the problem situation given, developing a solution proposal, turning it into a product, and then trying the product they designed. The majority of these trials had been carried out in accordance with the reality. In other words, for example G1 tried the product they designed to cross a non-floating duck in a basin full of water which was brought into the class. As a result, if the product they designed was submerged in water or deteriorated when it got into the water, they corrected the product they designed by questioning the reason. However, in the activity prepared by G4, the students who designed kites did not have the opportunity to make a real experiment. Only the teacher checked the kite and, if any, noted the missing points and told the students to redesign. However, in all activities, students were given the chance to redesign whether a real experience environment was presented or not. One of the important points of STEM activities is to give students a chance to redesign and to learn from failure (Moore et al., 2014; Wheeler, Whitworth & Gonczi, 2014).

It is seen that preschool teacher candidates had set criteria for evaluating the designs that students planned to do in STEM-focused activities. These criteria were determined in various dimensions such as easy availability of the material, harmless to health, and whether they were suitable for the purpose. Since the engineering design assignment at STEM activities can have more than one solution and also allows the design of different products in a variety of ways, these criteria must also be diverse. In this sense, the groups whose criteria were somewhat more limited are in "partially sufficient" and "should be developed" categories. The criteria can be given to students at the beginning of the activity or after the activity is over. Thus, students will see that there cannot be one correct design and that the best design depends on certain criteria (Aydın-Günbatar, 2019).

It can be said that preschool teacher candidates' attitudes towards STEM were very positive as a result of giving a 14-week STEM education to them. One of the most important bases in the emergence of STEM is that it develops a positive attitude towards the individual in STEM areas (Furner & Kumar, 2007). Guzey, Moore, Harwell, and Moreno (2016) stated that their STEM-based activities caused a positive change in students' attitudes. There are many studies in the literature having similar result (e.g., Alsup, 2015). However, it should be remembered that a long time is required for the change in attitude. As a matter of fact, Berlin and White (2010) stated that the attitudes of teacher candidates started to change positively only after three years in their studies on STEM integration with their teacher candidates. Al Salami, Makela, and Miranda (2017) reported that the 12-15 week education they provided to teachers did not cause a change in their attitudes towards STEM. Moreover, it is defended that if teachers have positive attitudes towards STEM, then they become good role models for developing positive attitudes of students towards STEM disciplines (Li, Forbes, & Yang, 2021; Wang, Choi, Benson, Eggleston, & Weber, 2020). According to

DeJarnette (2012), the majority of existing STEM education programs is for secondary and high school students, with fewer opportunities available to primary school students, preschool education students, classroom teachers, and preschool teachers.

Conclusions and Suggestions

As conclusion, it can be said that preschool teacher candidates could have designed STEM-focused activities in a manner of student-centered and including group works. It is also seen that STEM-focused activities included a real life problem. It was quite suitable for problem-based learning. Apart from this, all STEM-focused activities contained at least two STEM disciplines and engineering was the common discipline. Additionally, teacher candidates created evaluation criteria for STEM-focused activities. All in all, it can be said that preschool teacher candidates considered all the important points of STEM-focused activities. Furthermore, preschool teacher candidates developed positive attitudes towards STEM. By looking at the problem situations presented by teacher candidates, it can be suggested to prepare more realistic and problematic types that students can face in their daily lives. Preparing the criteria created to evaluate students' engineering design homework from a wider perspective can be suggested because it is important for them to be able to design more freely. In addition, it is seen that the 14-week training provided has a positive effect on their attitudes towards STEM. However, it should be taken into consideration that this period is not sufficient to develop attitudes. From this point of view, it can be suggested to examine attitudes towards STEM for longer periods. In the light of the importance of the research, the findings should be discussed with literature and author comments.

References

Al Salami, M. K., Makela, C. J., & de Miranda, M. A. (2017). Assessing Changes in Teachers' Attitudes toward Interdisciplinary STEM Teaching. *International Journal of Technology and Design Education, 27*(1), 63-88.

Aldemir, J., & Kermani, H. (2017). Integrated STEM Curriculum: Improving Educational Outcomes for Head Start Children. *Early Child Development and Care, 187*(11), 1694-1706.

Alsup, P. (2015). *The Effect of Video Interviews with STEM Professionals on STEM-Subject Attitude and STEM-Career Interest of Middle School Students in Conservative Protestant Christian Schools*. Doctoral Dissertation. Liberty University.

Atiles, J. T., Jones, J. L., & Anderson, J. A. (2013). More than a Read-Aloud: Preparing and Inspiring Early Childhood Teachers to Develop our Future Scientists. *Teacher Education and Practice, 26*(2), 285-299.

Ayas, A., & Çepni, S. (2007). Eğitimde program geliştirme ve bazı fen ve teknoloji programları (Curriculum Development in Education and Some Science and Technology Programs). In S. Çepni (ed.), *Kuramdan Uygulamaya Fen ve Teknoloji Öğretimi* (pp. 13-32). Ankara: Pegem Publishing.

Aydın-Günbatar, S. (2019). Fen, Teknoloji, Mühendislik ve Matematik (FeTeMM) Yaklaşımı Ve FeTeMM'e Uygun Etkinlik Hazırlama Rehberi (Science, Technology, Engineering and Mathematics (STEM) Approach and Guide for Preparing an Activity Suitable for STEM). In H. Artun, & S. Aydın-Günbatar (eds.), *Çağdaş Yaklaşımlarla Destekli Fen Öğretimi: Teoriden Uygulamaya Etkinlik Örnekleri* (pp. 2-23). Ankara: Pegem Publishing.

Azgın, A. O. (2019). *STEM in Primary School: Students' Career Interest and Attitudes and Orientation of Teachers*. Unpublished Master's Thesis. Turkey: Muğla Sıtkı Koçman University (In Turkish).

Bagiati, A., Yoon, S.Y., Evangelou, D., & Ngambe-ki, I. (2010). Engineering Curricula in Early Education: Describing the Landscape of Open Resources. *Early Childhood Research & Practice*, *12*(2), 1-22.

Berlin, D. F., & White, A. L. (2010). Preservice Mathematics and Science Teachers in an Integrated Teacher Preparation Program for Grades 7-12: A 3-Year Study of Attitudes and Perceptions Related to Integration. *International Journal of Science and Mathematics Education*, *8*(1), 97-115.

Bozkurt, E. (2014). *Mühendislik tasarım temelli fen eğitiminin fen bilgisi öğretmen adaylarının karar verme becerisi, bilimsel süreç becerileri ve sürece yönelik algılarına etkisi* (The Effect of Engineering Design-Based Science Instruction on Science Teacher Candidates' Decision Making Skills, Science Process Skills and Perceptions about the Process).Unpublished Doctoral Thesis. Ankara: Gazi University Educational Sciences Institute.

Brophy, S., Klein, S., Portsmore, M., & Rogers, C. (2008). Advancing Engineering Education in K–12 Classrooms. *Journal of Engineering Education 97*(3), 369-387.

Bybee, R. W., & Fuchs, B. (2006). Preparing the 21st Century Workforce: A New Reform in Science and Technology Education. *Journal of Research in Science Teaching, 43*(4), 349-352.

Campbell, C., Speldewinde, C., Howitt, C., & MacDonald, A. (2018). STEM Practice in the Early Years. *Creative Education Journal Special Edition Preschool Education Research, 9*(1), 11-25.

Carlson, L., & Sullivan, J. (2004). Exploiting Design to Inspire Interest in Engineering across the K–16 Engineering Curriculum. *International Journal of Engineering Education, 20*(3), 372-380.

Chen, Y. L., Huang, L. F., & Wu, P. C. (2021). Preservice Preschool Teachers' Self-Efficacy in and Need for STEM Education Professional Development: STEM Pedagogical Belief as a Mediator. *Early Childhood Education Journal, 49*(2), 137-147.

Chesloff, J. D. (2013). STEM Education Must Start in Early Childhood. *Education Week, 32*, 32-27.

Çil, E. (2019). Okul öncesi dönemde STEM eğitimi (STEM Education in Preschool Period). In S. Çepni (ed.), *Kuramdan Uygulamaya STEM eğitimi* (pp. 457-483). Ankara: Pegem Publishing.

Çınar, S., Pırasa, N., Uzun, N., & Erenler, S. (2016). The Effect of STEM Education on Pre-Service Science Teachers' Perception of Interdisciplinary Education. *Journal of Turkish Science Education, 13*(Jan), 118-142.

Cotabish, A. Dailey, D., Robinson, A., & Hughes, G. (2013). The Effects of a STEM Intervention on Elementary Students' Science Knowledge and Skills. *School Science and Mathematics, 113*(5), 215-226.

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative and Mixed Methods, Approaches.* 2nd Edition. SAGE Publications.

DeJarnette, N. K. (2012). America's Children: Providing Early Exposure to STEM (Science, Technology, Engineering and Math) İnitiatives. *Education, 133*(1)*,* 77-84.

Derin, G., Aydın, E., & Kırkıç, K.A. (2017). A Scale on the Attitudes towards STEM Education. *El-Cezerî Journal of Science and Engineering, 4*(3), 547-559.

Furner, J., & Kumar, D. (2007). The Mathematics and Science Integration Argument: A Stand for Teacher Education. *Eurasia Journal of Mathematics, Science and Technology, 3*(3), 185-189.

Guzey, S. S., Moore, T. J., & Harwell, M. (2016). Building up STEM: An Analysis of Teacher-Developed Engineering Design-Based STEM Integration Curricular Materials. *Journal of Pre-College Engineering Education Research (J-PEER)*, *6*(1), Article 2.

Guzey, S. S., Moore, J. T., Harwell, M., & Moreno, M., (2016). STEM Integration in Middle School Life Science: Student Learning and Attitudes. *Journal of Science Education and Technology, 25*(4), 550-560.

Hacıoğlu, Y. (2017). *Fen, teknoloji, mühendislik ve matematik (STEM) eğitimi temelli etkinliklerin fen bilgisi öğretmen adaylarının eleştirel ve yaratıcı düşünme becerilerine etkisi* (The Effect of Science, Technology, Engineering, and Mathematics (STEM) Education-Based Activities on Prospective Science Teachers' Critical and Creative Thinking Skills). Unpublished Doctoral Thesis. Ankara: Gazi University Educational Sciences Institute.

Hacıoglu, Y., & Donmez Usta, N. (2020). Digital Game Design-Based STEM Activity: Biodiversity Example. *Science Activities, 57*(1), 1-15.

Hacıömeroğlu, G. (2018). Examining Elementary Pre-Service Teachers' Science, Technology, Engineering, and Mathematics (STEM) Teaching Intention. *International Online Journal of Educational Sciences*, *10*(1), 183-194.

Hackman, S. T., Zhang, D., & He, J. (2021). Secondary School Science Teachers' Attitudes towards STEM Education in Liberia. *International Journal of Science Education, 43*(2), 1-24.

Herdem, K., & Ünal, İ. (2018). Analysis of Studies about STEM Education: A Meta-Synthesis Study. *Journal of Educational Sciences, 48*, 145-163.

Kaptan, S. (1998). *Bilimsel araştırma teknikleri ve istatistik yöntemleri* (Scientific Research Techniques and Statistical Methods). Ankara: Tekışık Publishing.

Karahan, E., Canbazoğlu Bilici, S., & Ünal, A. (2015). The Integration Media Design Processes in STEM Education. *Eurasia Journal of Educational Research*, *15*(60), 221-240.

Kennedy, T., & Odell, M. (2014). Engaging Students in STEM Education. *Science Education International, 25*(3), 246-258.

Kong, Y. T., & Huo, S. C., (2014). An effect of STEAM activity programs on science learning interest. *Advanced Science and Technology Letters, 59,* 41-45.

Kovac, J. (1999). Student Active Learning Methods in General Chemistry. *Journal of Chemical Education, 76*, 107-109.

Li, H., Forbes, A. & Yang, W. (2021). Developing Culturally and Developmentally Appropriate Early STEM Learning Experiences. *Early Education and Development, 32*(1), 1-6.

Moore, T. J., Stohlmann, M. S., Wang, H.-H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). Implementation and Integration of Engineering in K–12 STEM Education. In, S. Purzer, J. Strobel, & M. Cardella (eds.), *Engineering in Precollege Settings: Research into Practice* (pp. 35-60). West Lafayette, IN: Purdue University Press.

Reighard, C., Torres-Crespo, M. N., & Vogel, J. (2016). STEM Curiosity Academy: Building the Engineers of Tomorrow. *Children and Libraries, 14*(4), 32-35.

Sanders, M. (2009). STEM, STEM Education, STEMmania. *The Technology Teacher, 68*(4), 20-26.

Savery, J.R. (2006). Overview of Problem-Based Learning: Definitions and Distinctions. Interdisciplinary. *Journal of Problem-Based Learning. 1*(1), 73-76.

Selvi, M., & Yıldırım, B. (2018). STEM öğretme-öğrenme modelleri: 5E öğrenme modeli, proje tabanlı öğrenme yaklaşımı ve STEM SOS modeli (STEM Teaching-Learning Models: 5E Learning Model, Project-Based Learning Approach and STEM SOS Model). In S. Çepni (ed.), *Kuramdan Uygulamaya STEM Eğitimi* (pp. 205-239). Ankara: Pegem Publishing.

Sisovic, D., & Bojovic, S. (2000). Approaching the Concepts of Acids and Bases by Cooperative Learning. *Chemistry Education: Research and Practice, 1*(2), 263-275.

Sümen, Ö.Ö., & Çalışıcı, H. (2016). Pre-Service Teachers' Mind Maps and Opinions on STEM Education Implemented in an Environmental Literacy Course. *Educational Sciences: Theory and Practice, 16*(2), 459-476.

Tseng, K. H., Chang, C. C., Lou, S. J., & Chen, W. P. (2013). Attitudes towards Science, Technology, Engineering and Mathematics (STEM) in a Project-Based Learning (PJBL) Environment. *International Journal of Technology and Design Education, 23*(1), 87-102.

Tuncel, G. (2011). Sosyal bilgiler dersinde rubriklerin etkili kullanımı (Effective Use of Rubrics in Social Studies Lesson). *Marmara Geographical Journal, 23*, 213-233.

Ültay, E. (2017). Examination of Context-Based Problem-Solving Abilities of Pre-Service Physics Teachers. *Journal of Baltic Science Education, 16*(1), 113-122.

Ültay, N., & Aktaş, B. (2020). An Example Implementation of STEM in Preschool Education: Carrying Eggs without Breaking. *Science Activities, 57*(1), 16-24.

Ültay, N., & Ültay, E. (2020). A Comparative Investigation of the Views of Preschool Teachers and Teacher Candidates about STEM. *Journal of Science Learning, 3*(2), 67-78.

Ültay, E. Ültay, N., & Dönmez Usta, N. (2018). Examination of the Lesson Plans according to the 5E Learning Model and REACT Strategies for "Simple Electric Circuits" Prepared by the Classroom Teacher Candidates. *Kastamonu Education Journal*, *26*(3), 855-864.

Uştu, H. (2019). *Preparing and Implementing Successful STEM/STEAM Activities in Primary Schools: A Participatory Action Research with Primary School Teachers*. Unpublished Doctoral Dissertation. Turkey: Necmettin Erbakan University.

Wang, X. C., Choi, Y., Benson, K., Eggleston, C., & Weber, D. (2020). Teacher's Role in Fostering Preschoolers' Computational Thinking: An Exploratory Case Study. *Early Education and Development 32*(6), 1-23.

Wheeler, L. B., Whitworth, B. A., & L. Gonczi, A. (2014). Engineering Design Challenge: Building a Voltaic Cell in the High School Chemistry Classroom. *The Science Teacher*, *81*(9), 30-36.

Whitebook, M., & Ryan, S. (2011). *Degrees in Context: Asking the Right Questions about Preparing Skilled and Effective Teachers of Young Children*. Retrieved from: http://www.nieer.org/resources/policybriefs/23.pdf. [Accessed 1 April 2021]

Yamak, H., Bulut, N., & Dündar, S. (2014). 5. sınıf öğrencilerinin bilimsel süreç becerileri ile fene karşı tutumlarına FeTEMM etkinliklerinin etkisi (The Impact of STEM Activities on 5th Grade Students' Scientific Process Skills and their Attitudes Towards Science). *Gazi University Gazi Education Faculty Journal, 34*(2), 249-265.

Yıldırım, B., & Selvi, M. (2015). Adaptation of STEM Attitude Scale to Turkish. *Turkish Studies International Periodical for the Languages, Literature and History of Turkish or Turkic, 10*(3), 1117-1130.

Yılmaz, H., Yiğit Koyunkaya, M., Güler, F., & Güzey, S. (2017). Turkish Adaptation of the Attitudes toward Science, Technology, Engineering, and Mathematics (STEM) Education Scale. *Kastamonu Education Journal, 25*(5), 1787-1800.