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A sample STEM activity based on the engineering design process: A study on prospective preschool teachers' views

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This research aimed to introduce a STEM activity specifically prepared in accordance with the engineering design process and to examine a group of prospective preschool teachers' views about the activity. A total of 16 prospective teachers studying in the final year of a public university in the West Black Sea Region, Turkey, during the fall semester of the 2021/22 academic year were the participants of the study. The STEM activity was based on the problem of making a fish model that can sink, swim and float in water. At the end of the activity, an open-ended activity opinion form was used to gather the prospective teachers' views about the activity. The data were analyzed using the descriptive analysis method by taking into consideration the themes related to STEM, as specified in the theoretical framework. The results of the study show that the prospective teachers took the opportunity to experience how a STEM activity is held, that they found the activity fun and interesting, as well as conducive to learning science concepts and higher-order thinking skills. As for the negative aspects of the activity, the respondents stated that the activity was time-consuming, and that it was difficult to decide on and build the design. We believe that this study will provide theoretical and practical contributions to both researchers and preschool teachers.

Introduction

Recent developments in science and technology have triggered a need for individuals who are capable of coming up with creative ideas in solving complex problems. Without a doubt, education systems play a major role in raising such individuals. Skills such as responsibility, communication, creativity, critical thinking, cooperation, and problem solving (Partnership for 21st Century Skills, 2009), also known as 21st century skills, should be included in education systems. Yet, it does not seem possible for students to acquire these defined 21st century skills with traditional learning approaches (Roberts, 2012). In this regard, the STEM (Science, Technology, Engineering, Mathematics) education approach that contributes to the development of the mentioned skills has gained prominence as it is an approach that integrates the disciplines of science, technology, engineering, and mathematics to solve a problem encountered in everyday life. STEM education is the most up-to-date educational approach that includes knowledge, skills and beliefs formed by the intersection of

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more than one of the fields of science, technology, engineering and mathematics, and where interdisciplinary studies are applied holistically (Corlu, Capraro, & Capraro, 2014; Gonzalez & Kuenzi, 2012).

Still, there are arguments indicating that STEM education is not suitable for preschool children despite being an interdisciplinary approach that covers the entire education process from preschool to higher education. In particular, such opinions often stress that STEM education is not suitable for preschool curriculum, that teachers are not knowledgeable enough to teach in STEM fields, and that teaching materials prepared within the framework of STEM approach are not suitable for preschool children (Atiles, Jones, & Anderson, 2013; Bagiati & Evangelou, 2015; DiPerna, Lei, & Reid, 2007). STEM education is, however, implemented at all levels, including preschool education, in many countries. Preschool STEM education is of great importance for children to acquire basic skills and concepts so that they will not experience any related problems in the later stages of their lives (Riniker, 2021; Yıldırım, 2021).

Early childhood is a period in which children develop in every aspect of their lives. Many higher-order thinking skills, such as problem solving, creativity, cooperation, and communication, which are the target skills to instill in children through STEM education, should be taught to them, starting from an early age. In this way, students can have the opportunity to use the skills they have gained in preschool later in life (Locuniak & Jordan, 2008). STEM education is of particular importance in preschool (Moomaw & Davis, 2010). The relevant literature on STEM studies conducted in relation to preschool, indicate that STEM is effective in the development of students' positive attitudes towards the fields of STEM (Gonzalez & Freyer, 2014; Şişman, Küçük, &, Yaman; 2021), provides students with the opportunity of acquiring STEM-related skills and concepts (Milford & Tippet, 2015; Sullivan & Bers, 2016; Tank, Rynearson, & Moore, 2018), develops both social and psycho-motor skills such as assessment and communication (Alede, Lauricella, Beaudoin-Ryan, & Wartella, 2016; Clements & Sarama, 2016; Miller, 2018), and develop students' skills such as critical thinking and problem solving (The Early Childhood STEM Working Group, 2017). Tank et al. (2018) conducted STEM activities with 32 preschool students, with the focus on the engineering design process, and observed that the conceptual understanding of preschool students about science and engineering increased as a result of the study. Similarly, having worked with preschool students for 10 weeks, Aldemir and Kermani (2017) found that combined STEM education was effective in students' acquisition of science and engineering concepts.

STEM education denotes teaching the disciplines of science and mathematics through the combination of scientific inquiry, technology and engineering design, mathematical analysis and 21st century interdisciplinary themes and skills (Johnson, 2013). STEM education is introduced with a problem from everyday life and continues with finding the best ways to solve it. Although STEM education focuses on teaching the four disciplines in an integrated manner, the engineering dimension with the abbreviation "E" appears to be the least recognized and understood aspect when it comes to K-12 education (Basham & Marino, 2013). This dimension can be integrated with other disciplines of STEM to provide engineering education (National Research Council, [NRC], 2010). The most appropriate way to achieve this integration is to carry out the activities in accordance with the engineering design process (EDP) (Felix, Bandstra, & Strosnider, 2010). In the engineering design process, engineers, while producing effective solutions to daily life problems and needs test their solutions, review and retest these solutions in line with trial and error. Preschool children, who are very curious about the names of the objects they see around them, what they do, and why and how things happen, just like real engineers, identify the needs and problems of the engineering design process and think about them, produce solutions to these problems, test the solutions they produce. They are highly skilled in carrying out the steps such as working collaboratively with their peers and exchanging ideas on the appearance and functionality of their designs (Christenson & James, 2015).

Although the EDP does not reflect a linear process that clearly states which application steps should be followed in which order, it includes the processes of defining and solving the problem (NRC, 2010). For this reason, many EDP steps are mentioned in the studies in the literature. The EDP varies according to the level of the students (Corbett & Coriell, 2014; Engineering is Elementary, 2013; Hynes et al., 2011). The eight-step EDP, developed by the "Engineering is Elementary" (2013) project, is mostly preferred for preschool, primary, and secondary school students. The design process is given in Figure 1.

Figure 1. Engineering Design Process (Engineering is Elementary, 2013)

As can be seen in Figure 1, the EDP begins with the definition of the problem, followed by the process in which students conduct research on the given problem and imagine the product to develop for the purpose of solving the problem. The students then decide on the product they will design and move on to the creation phase. They also test the products they have designed according to the limitations and criteria indicated for the problem and re-develop the parts they consider are missing. Finally, the students complete the EDP by presenting the products they have designed. Since the EDP steps developed by Engineering is Elementary (2013) are followed in the STEM activity developed in this study, this model is explained in detail in the Practice section of the activity.

The integration of design-based science and engineering practices comprised within the integrated STEM education practices is gradually becoming more and more important day by day (Ring, 2017). Enabling children to deal with engineering design problems from an early age exert a strong and positive impact on them to learn science-related concepts (Cantrell, Pekcan, Itani, & Velasquez-Bryant, 2006). The engineering design process provides students with the necessary practice environment that includes relevant science concepts, insights into the engineering world, and 21st century skills such as innovation, problem solving, critical thinking, communication, and collaboration (Schnittka, Bell, & Richards, 2010).

The relevant literature shows that the activity-oriented STEM education has a limited use in preschool education (Brophy et al., 2008; Tippett & Milford, 2017). As an example, Malone et al. (2018), focused on preschool students' capacity to understand engineering and technology in the study, in which they employed the EDP model. As a result of the study, the researchers concluded that the EDP had a positive impact on students' capacity of understanding. It is fact that the implementers of the activities to be carried out in the preschool period are preschool teachers. For this reason, it is necessary that the prospective preschool teachers become familiar with STEM activities so that they can make use of them and express their opinions about them. By working like engineers in accordance with engineering and design skills during the STEM activity, the participants in our study were encouraged to integrate the STEM fields by involving both mathematics and science knowledge in this process, a technique indicating the importance of this study. Mathematics and science activities should be included in the preschool period, where the foundations of scientific process skills are laid (Özbey & Alisinanoğlu, 2008). It is important that these activities are carried out in learning environments enriched with concepts related to students' daily lives (Temel, Kandır, Erdemir, & Koçer Çifçibaşı, 2005). In the education program called "Great Explorations in Mathematics and Science (GEMS)", the importance of addressing subjects such as ladybugs, penguins, butterflies, ants and fishes, which attract children's attention, exist in nature or in their immediate environment, with which they can directly interact and observe (Yalçın & Tekbıyık, 2013). In this study, one of the important issues for the preschool period is to make an activity about how the fish swim. Developing sample lessons has always been a critical issue for teachers in our country. This study is, therefore, believed to contribute to the field as it sets an example for teachers about how a STEM activity is planned and held in conformity with the EDP. From this standpoint, we have aimed to introduce an activity prepared, in detail, in accordance with the STEM education approach, in line with the EDP, and to examine the prospective preschool teachers' views about the activity. The research main question acting as a guide in the study is given as follows:

What are the prospective preschool teachers' views about a STEM activity based on the EDP?

The sub-problems of the study are as follows:

(1) How are the views of prospective preschools teachers about the STEM activity?
(2) What are the suggestions of prospective preschools teachers about the STEM activity?

Method

In this study one of the qualitative research method case study method was employed about the STEM activity to collect prospective preschool teachers' opinions. The aim of the case study is not to generalize; to be able to understand and explain the distinctive features of a person, community or situation (Yıldırım & Simsek, 2008). A case study is a type of study in which a subject is defined and customized depending on space and time, (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2019), the most basic feature of which is the in-depth investigation of one or more situations.

Participants

The activity was carried out with the participation of 16 prospective preschool teachers (who identified as 14 females, 2 males) with an age range of 20-23, who were still studying in the final year of the Department of Preschool Education at a public university in the West Black Sea Region in the fall semester of the 2021/22 academic year. It took 180 minutes to complete the activity. Convenience sampling method was used in the current study. Researchers choose this method since it provides speed and practicality to the research (Fraenkel, Wallen, & Hyun, 2012).

Implementation of the activity

Developed by Kaya and Avan (2020), as an inquiry-based activity, the activity called "Let the Fish Swim" was adapted to the EDP and administered as an activity to the prospective preschool teachers in our study. The reason for choosing the subject of "floating fish" in the study is the thought that the subject is suitable for the pre-school period. In the preschool period, children are curious about what is going on around them. How fish swim is also one of the subjects of curiosity. While the adapted activity is related to science subjects such as swimming, sinking, floating, buoyancy, and respiratory system, it is related to balance and rhythmic counting in the field of mathematics. In terms of technology, on the other hand, the participants needed to use certain materials such as scissors and tape that could facilitate their designs while making them. The engineering dimension consisted of the processes in which the participants needed to think and implement together through the discussions they had with each other so that they could take the most appropriate decision about their models by working in groups while making their fish models. This STEM activity prepared in accordance with the EDP was based on the problem of making a fish model that can both sink, swim, and float in water. The prospective teachers were asked to produce a solution to the problem by following the worksheet provided.

The activity was carried out in conformity with the EDP steps (Engineering is Elementary, 2013). A detailed description of each step is presented in Table 1.

Table 1. Steps Followed in the Study in Accordance with the EDP

Steps	Explanation
Description	Prospective teachers define the problem situation. To do this, they are given a daily life-related problem to increase their interest and motivation. The problem is then presented in the form of a case study.
Research	They conduct research on science and mathematics concepts to be used in the activity. They work on the problem in groups of 4 each. They are then asked to watch a video, namely, "How do fish swim?", and asked some questions about the video, so that they can feel encouraged to develop solutions for their designs.
Imagining	They develop a number of solutions to the problem. They can use their creativity, making this stage a critical one. They are then asked to draw the fish model they intend to design.
Planning	They decide on their designs. They choose the necessary materials for the model they will design as a group.
Creation	They build their products. They design fish models with the materials they choose.
Testing	They test the product developed for the solution, in relation to the limitations and criteria given in the case of the problem. Their designs are also tested and evaluated according to the pre-prepared evaluation rubric.
Development	They discuss their design, and correct the deficiencies, if any, about the product, on paper, or rebuild the product. In this context, after the products are evaluated, the participants are asked to fill in the questions in the development section of the worksheets. They are expected to think about the products they have designed as to whether they have worked well or not, and they specify the aspects they want to improve in their products.
Communication	They present their designs by making reference to science and mathematics concepts. During the presentation, other groups can ask questions to the presenting group.

The implementation stages of the activity are explained in detail below, taking into account the expressions in Table 1.

Description (20 min)

First of all, the prospective teachers are provided with an introductory presentation about STEM education. They are informed that STEM education is an integrated approach consisting of the fields of science, technology, engineering and mathematics, between which the boundaries are removed. It is emphasized that daily life problems could be solved more effectively, that mathematics and science concepts be learned in a more fun way, and that the concepts be taught by concretizing them. In addition to these, the steps of the EDP are addressed, after which the activity called, "My Friend is a Fish" is introduced. Within the scope of this activity, prospective teachers are asked to design a fish model that could swim, sink, and float in water by using various materials.

The problem situation is given to the participants in the form of a scenario. This problem situation should be related to daily life and enable students to use STEM disciplines for its solution. The participants are asked to form groups of four, each of which is given the worksheet to follow and the materials to use during the activity. Figure 2 presents the scenario in which the problem situation is presented.

Since the start of the pandemic, Umut's best friend has been his tiny fish, Orange. Umut is considering designing a fish model that his little fish Orange can play and befriend with. The fish he intends to design should be able to float on water like a fish, sink under water, and stay in water. Well, guys, "Can we design such a fish model?"

Figure 2. Problem situation

The prospective teachers are required to identify the problem based on the scenario in Figure 2 and write the problem situation on the worksheets.

Research (20 min)

The prospective teachers conduct research as a group for the solution of the problem situation. They are presented with a video to watch about "How do fish swim?" to enable them to come up with ideas. The video is an example of an experiment performed with children in preschool. After watching the video, the participants are asked: "How do fish swim?", "How do divers sink to the bottom of the water?", "How can a submarine sometimes stay under the water and sometimes come to the surface?", so as to encourage them to think over the possible answers. The aim here is to motivate the participants in relation to solution proposals for their designs, by using science and mathematics concepts.

Imagining and Planning (30 min)

The prospective teachers are asked to draw the fish model they have thought to design using their imaginations. A sample student drawing is shown in Figure 3.

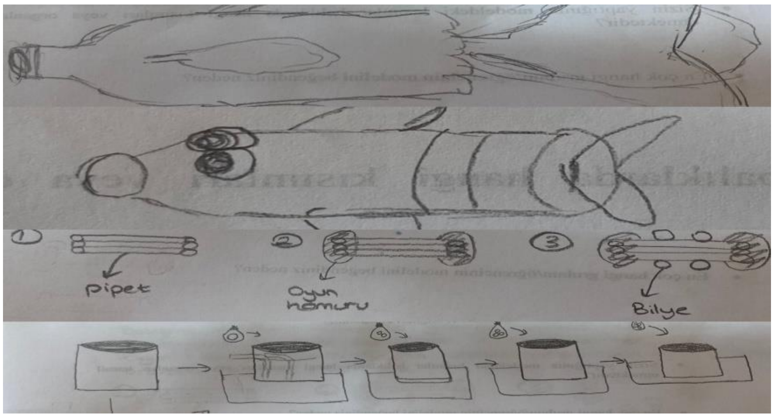

Figure 3. A design drawn by a prospective teacher

Upon completing their drawings, the participants decide on their designs, choose their materials and start to build their designs.

Creation (60 min)

The participants build the products they have already designed with the materials they choose. They are also asked to write down what they are doing while building their products, along with their reasons, on their worksheets. Below are the photographs of the models designed by the prospective teachers.

Photo 1. Examples of fish models designed by prospective teachers

Testing and Developing (20 min)

The swimming, floating, and sinking fish models are tested and evaluated according to the prepared evaluation rubric. The prepared assessment rubric is given in Figure 4.

Categories	You did an excellent job (3 points)	You did quite a good job (2 points)	You failed to do a good job (1 point)
Problem Situation	Students describe the problem situation completely	Students partially describe the problem situation	Students cannot describe the problem situation
Group Work	Work is divided by group members and all group members work	Division of work is done by group members, but some of the group members work	There is no division of labor by group members and the same people always work.
Creativity	The designed product is completely original	The designed product is partially original.	The designed product is ordinary.
Communication	Design is explained with science concepts	The design is partially explained	Design not disclosed
Functionality	The designed product is functional and satisfies all three rules	The designed product is functional but provides two rules	The designed product is not functional

Figure 4. Activity Evaluation Rubric

After each group has tested their fish models, the participants are asked the following question: "If you wanted to change your design, what would you change?". In the event that any participant wishes to modify or improve the model, additional time is given so that they can sketch their new product. However, none of the participants wanted to improve their design during the activity in our study.

Communication (30 min)

The participants present their designs to other groups. Groups can ask each other questions about their designs. After the building and testing processes are completed, the results are discussed. At this stage, the major issue is that the participants should make mention of science and mathematics concepts while presenting their products. In order to achieve this, they are required to answer a number of questions included in the worksheets such as: "Which science concepts did you use while designing the model?", "Which parts or organs of a fish do the parts in the model you made represent?" etc.

Finally, the STEM gains are discussed and the activity is concluded.

Data Collection Tools

Data were obtained from the open-ended activity opinion form administered to all prospective teachers. The form consisting of 7 open-ended questions was prepared by the researcher as a data collection tool. In order to ensure the content validity of the interview questions, two STEM education experts as well as an assessment and evaluation expert were consulted. The experts made suggestions about the way the questions were asked rather than the content. The form was finalized in the presence of expert opinion, and aimed to obtain the opinions of prospective teachers about the activity called, "My Friend is a Fish". The content validity of the form was also provided by taking the opinions of 2 field experts. Some examples of questions in the open-ended activity opinion form are as follows:

(1) What do you think you gained by doing this activity? Do you think it is important to do this activity, why?
(2) What kind of problems and difficulties did you encounter during the carrying out of the activity and how did you solve them?
(3) Would you like to use this activity in your classroom when you become a teacher? What would you change if you wanted to use it?

The prospective teachers were administered the activity opinion form immediately after the activity was completed. The average response time for the opinion form was 20-25 minutes.

Data Analysis

The data were analyzed using the descriptive analysis method, which is based on the summarization and interpretation of the obtained data in conformity with the predetermined themes. The purpose of a descriptive analysis is to present the readers with direct quotations taken from the individuals interviewed or observed in order to reflect their views of the in a striking way (Yıldırım & Şimşek, 2008). The data obtained through the prospective teachers' views reflected in the activity opinion form, consisting of open-ended questions, were gathered under three themes: "Positive views about the activity", "Negative views about the activity", and "Suggestions about the activity". Figure 5 illustrates the themes, sub-themes, and codes.

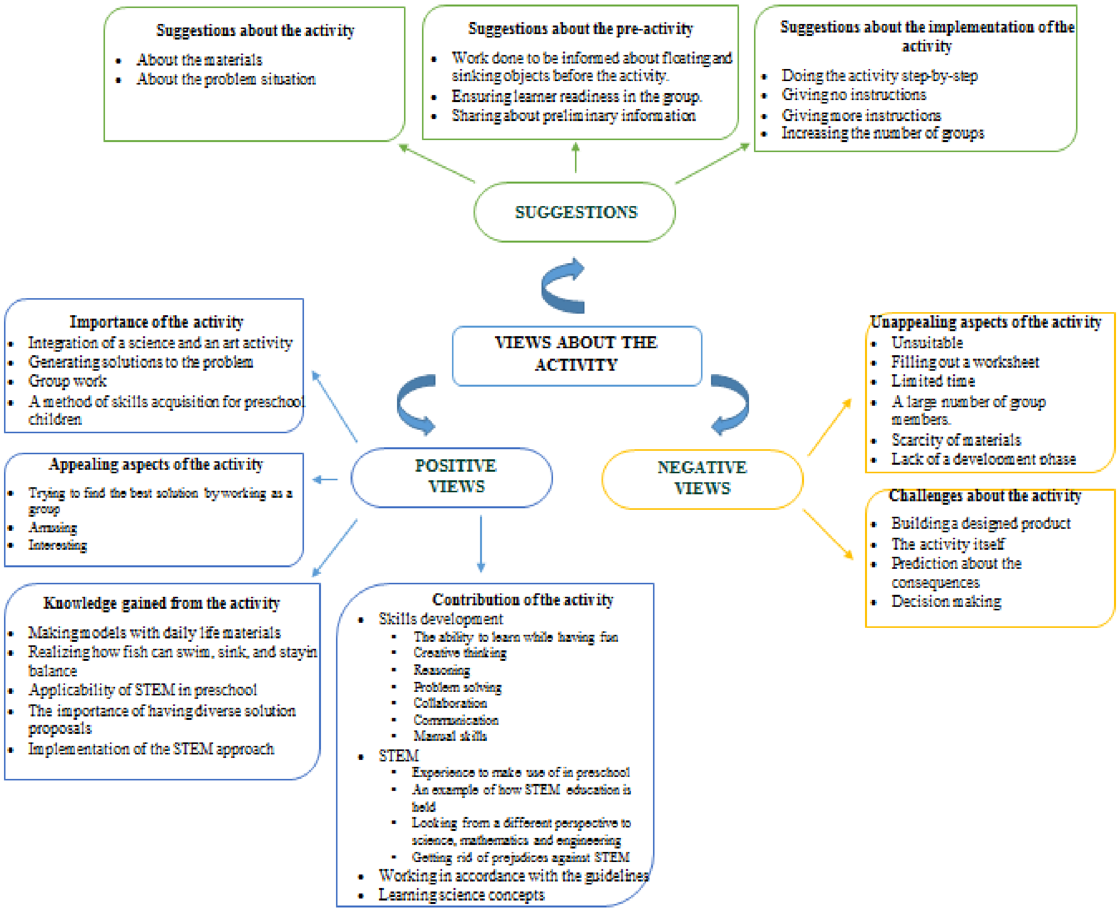

Figure 5. Themes, sub-themes, and codes

As can be seen in Figure 5, a total of 3 themes have been specified within the scope of the sub-problems of this study. Under the theme of "Positive views about the activity" are four sub-themes, namely, "the importance of the activity, appealing aspects of the activity, knowledge gained from the activity, and the contribution of the activity". Moreover, under the theme of "negative views about the activity" are two themes, namely, "the unappealing aspects of the activity and the challenging aspects of the activity". Similarly, the last theme, namely "Suggestions about the activity", consists of three sub-themes which have been identified such as "suggestions about the activity, the pre-activity, and the implementation of the activity".

The data transcripts were read by the researcher and an expert, independently of one another, and the themes were compared by taking into consideration the consensus and disagreement. For consistency calculation, the reliability of the data analysis was calculated by using Miles and Huberman's (1994) percentage of agreement formula "Percent agreement = [Agreement / (Agreement + Disagreement)] x 100". Reliability calculations over 70% in a qualitative study are considered reliable for the research (Miles & Huberman, 1994). In our study, the percent agreement between the two evaluators was found to be 96%, making it accepted as reliable for the study. The findings in this study were obtained by quoting directly from the data obtained according to the research categories. The prospective teachers whose views were taken were anonymized by giving them code names, i.e., Prospective Teacher 1 (PT1), Prospective Teacher 2 (PT2), and alike.

Results

The data obtained from the activity opinion form are presented in this section according to the determined themes.

Results on the positive views about the activity

The prospective teachers' positive views about the activity called, "My Friend is a Fish" were evaluated in relation to four sub-themes: the importance of the activity, the appealing aspects of the activity, knowledge gained from the activity, and the contribution of the activity. The sub-themes and codes created are shown in Table 2 in detail.

Table 2. Codes Obtained According to the Theme of Positive Views

Sub-Themes	Codes
Importance of the activity	• Integration of a science and an art activity • Generating solutions to the problem • Group work • A method of skills acquisition for preschool children
Appealing aspects of the activity	• Trying to find the best solution by working as a group • Amusing • Interesting
Knowledge gained from the activity	• Making models with daily life materials • Realizing how fish can swim, sink, and stay in balance • Applicability of STEM in preschool • The importance of having diverse solution proposals • Implementation of the STEM approach
Contribution of the activity	• Skills development • STEM • Working in accordance with the guidelines • Learning science concepts

The sub-theme of the importance of the study consisted of the participant comments about the activity which were also coded under such elements as integration of science and art activities, problem solving, group work, and skill acquisition for preschool children. PT10 attributed the importance of the activity to both its interdisciplinary nature and the fact that it could provide preschool children with numerous skills, saying that "*It helps to create a science activity to show what will sink and what will float. We also made use of art, etc., while decorating the fish. It is necessary to do such an activity in terms of instilling in children many skills.*" The following comments of PT16 support those of PT10's: "*The* *activity is important as it integrates science with art, and provides the ability to learn while having fun*". PT3, on the other hand, emphasized another significance of the activity, which is the group work. Likewise, PT6 made mention of doing group work, by saying: "*As a group, we presented our ideas and created our fish after coming to a common agreement. The activity actually reminded us the importance of group work*". Some prospective teachers found the activity important since it required coming up with a solution to a particular problem. Regarding this, PT4 stated that "*It is a good activity that I can apply with children, and it is important in that it produces a solution to the problem*".

Another subject in which the prospective teachers expressed their positive opinions about the activity is the appealing aspects of the activity. They liked the fact that the activity was fun, interesting and encouraging to find the best solution by working as a group. Most of them found the activity entertaining. As an example, PT4 stated that the activity was both more fun and interesting than the activities they already knew, by saying "*It was a fun and interesting activity*." PT5 also found it fun to do the activity as a group work, by saying: "*It was also a very enjoyable process to evaluate everyone's ideas as a group and find the best solution.*"

In general, the prospective teachers stated that the activity helped them learn how to build models with daily life materials, as well as the way fish swim, the applicability of STEM in preschool education, or how to apply STEM, and that thinking over numerous solution proposals is indeed important for any design. From among the topics learned about throughout the activity, the sub-theme of how fish swim stood out as the one on which most of the views were given. Regarding this sub-theme, PT13 pointed out what she learned about how to apply STEM education in her comment that reads, "*I learned about the STEM education in practical terms while doing the activity*". PT15, on the other hand, emphasized that she learned how to apply STEM activities and to build a model with daily life materials within the STEM activities, and said, "*Simple materials we have around us to solve the problem situation can actually be used as STEM activities*". Furthermore, PT2, PT3 and PT4 mentioned that they learned how to apply STEM effectively in preschool. Regarding this, PT2 remarked, "*I learned that STEM activity can be applied to children and that children's curiosity and willingness to learn could be nurtured to a higher level*." Unlike other prospective teachers, PT5, mentioned that she became aware of the fact that many solution-related suggestions generated in the activity were effective in creating a good design, saying: "*Multiple solutions have been proposed by more than one mind, which showed that we can create much better things*."

The prospective teachers' views classified under the sub-theme of the contribution of the activity were examined in four dimensions. Most of those participants said that the activity developed many personal skills such as creative thinking, reasoning, problem solving, communication, and cooperation. In this framework, PT5 said, "*First of all, it was an activity that greatly improved problem solving and creativity skills.*" Supporting this view, PT6 and PT7 similarly indicated that the activity especially improved creative thinking and problem-solving skills. PT12, on the other hand, referred to higher-order thinking skills in particular, by saying "*This activity absolutely develops higher-order thinking skills*".

On the whole, the prospective teachers participating in our study mentioned that they were prejudiced against STEM before the activity. They also stated that the activity gave them an essential experience in implementing a STEM activity in their classroom to take its advantage in their future profession as teachers, besides setting an example for a STEM activity, changing their perspectives on science, mathematics, and engineering, and enabling them to get rid of their prejudices against the STEM approach. Moreover, PT3, PT7 and PT10 emphasized that they gained experience as regards making use of the activity with preschool children. In this respect, PT3 particularly said, "*Through this activity, I experienced that it was very satisfying to be able to apply the STEM approach very easily while teaching preschool children*." PT11 said that the activity was a very effective exemplary STEM activity for them, and PT13 said, "*It brought a new idea to the activity. While doing the activity, I saw the STEM education in a practical way*" and expressed the same opinion with PT11, who stressed that the activity set a very effective example for the STEM approach, and likewise, PT13 said, "*It brought a brand-new idea to use as an in-class activity. While doing the activity, I found the opportunity to observe the STEM education in an applied way*" and expressed a similar view with PT11. Also, in this connection, PT2 said that she was prejudiced against STEM before, but her fears disappeared with this activity, whereas PT15 mentioned a different aspect of the contribution of the activity, saying "*Science, mathematics and engineering actually gave me a different perspective in every part of our lives and made me notice my surroundings more*", stated that the activity was instructive for purposes of looking at STEM fields from a different perspective. In addition to these, the prospective teachers stated that being provided with a worksheet in the activity helped them to study in accordance with the instructions, enabling them to learn some science concepts through the activity. They further indicated that they had learned certain science concepts with the activity, saying that they generally learned how fish swim, as well as the features regarding swimming and sinking. In the same context, PT2 said, "*Thanks to this activity, I recalled my knowledge of science and I learned how fish maintain balance in the water*" to imply that the activity enabled her to learn some science-related concepts. In parallel to this view, PT15 also expressed her thoughts on the contribution of the activity by saying, "*It gave us information about the air, the buoyancy in water, as well as the sinking and floating objects*".

Results on the theme of negative views about the activity

The negative opinions of the prospective teachers about the activity "My Friend is a Fish" were examined in two sub-themes, namely, the unappealing aspects of the activity and the challenging aspects of the activity. The sub-themes and codes created are shown in Table 3 in detail.

Table 3. Codes Obtained According to the Theme of Negative Views

Sub-Themes	Codes
Unappealing aspects of the activity	• Unsuitable • Filling out a worksheet • Limited time • A large number of group members. • Scarcity of materials • Lack of a development phase
Challenges about the activity	• Building a designed product • The activity itself • Prediction about the consequences • Decision making

According to what the prospective teachers wrote in the opinion form, the unappealing aspects of the activity were that it was not convenient to apply, in addition to the necessity of using a worksheet, the time limit, the high number of group members, the scarcity of necessary materials, and the absence of a development phase in the activity. Although the majority of the participants did not express any negative opinions about the activity, PT9 expressed her dislike for the activity and stressed that it was not suitable for her, saying: "*The study did not appeal to me. I did not like it much, at least it is not my thing*". PT3 and PT16, on the other hand, stated that the limited duration of the activity was the unappealing aspect of the activity. In addition, in the same statement, PT3 expressed the disadvantage of a high number of group members and the scarcity of materials during the activity as the unpopular aspects of the activity. PT7, on the other hand, expressed that she did not like the worksheet, they filled out during the activity, in her following comment: "*Filling out forms has always been boring to me.*"

Most of the prospective teachers' negative views about the activities revolve around the difficulties they experienced due to the process, such as building the design, the activity itself, as well as estimating and decision making. Most of the prospective teachers further stated that they had difficulties while building their designs. Regarding this, PT1 said, "*We had difficulties in how to balance the fish and then in attaching the fin and tail parts to the fish, but then we figured it out*." PT9 expressed that she did not enjoy the activity, but still, she said, "*I tried the activity, but I could not do it, since it was difficult at every stage while doing the activity. That is why I left it mostly to my friends*".

Another challenging aspect of the activity is about prediction. The respondents mentioned the difficulty of predicting whether the fish would swim or not while building their models. Regarding this, PT5 said, "*At the beginning, we started the stage of thinking from a different perspective. As different ideas came out, we wondered if any of them would work. We had a hard time predicting the outcome.*"

Results on the theme of suggestions for the activity

The prospective teachers in our study were asked the following questions: "What are your suggestions for the activity and the way it is implemented? If you wanted to implement this activity in your classroom when you become a teacher, what would you change?" in order to take their relevant suggestions. In line with the responses, the suggestions for the activity were classified under three sub-themes as those "for the activity", "for the implementation of the activity", and "for the pre-activity". The sub-themes and codes created are shown in Table 4 in detail.

Table 4. Codes Obtained According to the Theme of Suggestions

Sub-Themes	Codes
Suggestions about the activity	• About the materials • About the problem situation
Suggestions about the pre-activity	• Work done to be informed about floating and sinking objects before the activity. • Ensuring learner readiness in the group. • Sharing about preliminary information
Suggestions about the implementation of the activity	• Doing the activity step-by-step • Giving no instructions • Giving more instructions • Increasing the number of groups

Based on the responses given by the prospective teachers, the suggestions about the activity were determined as those related to the materials and to the problem situation. In this framework, PT10, PT12, PT13 and PT16 made suggestions about the materials used in the activity. In particular, PT10 made a suggestion that the variety of materials could be increased by indicating, "*I would like to use this activity by adding some more teaching materials to be* *used in the classroom*". A few other respondents also made suggestions regarding the problem situation. The problem case in the activity consisted of three different situations that need to be solved. PT6 and PT9 expressed the idea of limiting this situation so that the activity could be carried out on one or two problems. PT6 personally said, "*We can remove the swimming part according to the age group and turn it into two problems*". PT5, on the other hand, expressed an opinion on a different dimension of the problem situation and made a suggestion about the scenario, in which the problem situation was presented, as follow: "*By diversifying the subject more, I would present the problem in a way that children would be most interested in*".

As regards the implementation of the activity, the suggestions appeared to focus mostly on the way the activity was performed as well as the number of groups. Only PT16 made a suggestion for the number of groups in her comment that reads "*I would have kept the number of groups more during the activity*". PT3 and PT8, on the other hand, stated that there should be more instructions in order to make the activity more descriptive when it is carried out in younger age groups. PT3 personally suggested that "*I would give the younger age group more instructions during the application. I would have the activity carried out more openly*".

Given the suggestions before the activity, it appears that some respondents were of the opinion that a preliminary study should be conducted on the subject matter prior to the activity so that the chosen group should have preliminary information about the subject, since the group's readiness is also important in such activities. PT15 expressed this suggestion in her comment that reads, "*I would have a study done on sinking and floating objects before the actual activity*". PT12, on the other hand, suggested that planning should be done before the activity according to the sample group. "*The readiness of the sample group is important. In the case that the activity is carried out with a group of students who are not familiar with these concepts from before, it is likely that there will be difficulties in the implementation phase of the activity. In such a case, it may be a good idea to provide them with subject-related information prior to the activity*" PT12 remarked.

PT11 and PT14 did not make any suggestions about the application. Despite this, PT14 expressed her satisfaction with the activity in her comment that reads, "I think my students would be more creative than me and they could cooperate better, so I would not have to change anything".

Discussion, Conclusion and Recommendations

In line with the results obtained in the study, the prospective teachers' views about the activity were discussed under three headings, namely, the positive aspects of the activity, the negative aspects of the activity, and the suggestions about the activity.

The respondents appeared to find the STEM activity named "My Friend is a Fish", which was prepared according to the engineering design process, as a fun and interesting activity. A review of the relevant literature shows that there are results that support those of this study (Çiftçi & Topçu, 2021; Simoncini & Lasen, 2018). As an example, the prospective teachers who expressed their opinions in a study conducted by Çiftçi and Topçu, which examined the mental images formed by and opinions of prospective preschool teachers on STEM education, openly stated that they were able to be learned by having fun with STEM education. They further stated that the activity may help students develop some 21st century skills such as creative thinking, problem solving, reasoning, cooperation, and communication skills. The reason why STEM education is believed to be necessary is the fact that it helps to develop students' communication skills, curiosity, and imagination, as well as the 21st century skills (Wagner, 2008). The results of some studies in the literature support this particular view of the respondents about developing 21st century skills (Jamali, Md Zain, Samsudin & Ebrahim, 2017; Parno, Yuliati, Munfaridah, Ali, Rosyidah & Indrasari, 2020; Pekbay & Yılmaz-Tığılı, 2021; Yıldırım, 2020). For example Pekbay and Yılmaz-Tığılı (2021) in their work with high school students, students stated that activities were educational and funny, providing opportunities to promote group work and improve higher thinking skills. Scientific reasoning is one of the basic building blocks of STEM education (Jamali et al., 2017). In addition, Parno et al. (2020) created the PjBL-STEM by integrating project-based learning (PjBL) and STEM and conducted a quasi-experimental study on physics education with PjBL-STEM. The results of that study indicated that the problem-solving skills of the students who were trained with PjBL-STEM appeared to develop more than those of the students who were trained only through the PjBL method, with the presence of a difference at a very high effect size.

Another skill frequently emphasized by the respondents is the creative-thinking ability, to which, they believed, the activity contributed in terms of its development. Similarly, a study by Yıldırım (2020) concluded that preschool teachers were mainly of the opinion that STEM activities improved their creative thinking skills. Such a result can be clearly explained by the fact that a design process consists of similar steps with other processes such as problem solving, creative thinking, and engineering design (Doppelt, 2009). Research shows that many studies conducted with a focus on STEM-based activities concluded that such activities tend to lead students to cooperative learning and develop students' effective communication skills (Eroğlu & Bektaş, 2016; Kahraman & Doğan, 2020; Şahin, Ayar, & Adıgüzel, 2014). In this study, most of the respondents stated that working as a group during the activity and working by sharing the tasks with their teammates were both conducive to them personally and also a remarkable aspect which pointed to the importance of the activity. In the study of Ültay and Ültay (2020), both preschool teachers' and prospective preschool teachers' views as regards cooperation support the result of this study.

Another result of the study shows that prospective teachers had prejudices and fears against STEM earlier, but such emotions disappeared with this activity. The prospective teachers stated that the activity enabled them to gain experience to apply the STEM method. Research shows that there are other opinions indicating that STEM education is not suitable especially for preschool curriculum, that teachers lack sufficient knowledge and experience with respect to teaching about STEM-related fields, and that teaching materials prepared within the framework of STEM approach are not proper for preschool children (Atiles, Jones, & Anderson, 2013; Bagiati & Evangelou, 2015; DiPerna, Lei, & Reid, 2007). In a study by Yıldırım (2020) conducted with preschool teachers, the respondents stated that they felt inadequate about STEM fields and had difficulty in planning the lesson due to the lack of time, materials and resources. In the current study, likewise, the prospective teachers were also found to have similar views before the activity was implemented.

The results of the study show that the participants learned various science concepts, besides the implementation and building in a STEM activity. The participants specifically stated that they learned the concepts of sinking and swimming, and how fish swim, which are directly related to the activity. Some other studies conducted with teachers and prospective teachers present similar results to those of ours (Ültay & Ültay, 2020; Venville et al., 2000). Revealing that there was an improvement in the students' knowledge of science concepts at the end of the study, Riskowski et al. (2009), likewise, reported that the courses taught according to the engineering design process led to an improvement in the students' science concepts. The respondents also mentioned that they learned how to build models using materials from daily life via the STEM activity, “My Friend is a Fish”. Similarly, Thibaut et al. (2018) concluded that STEM education is a design-based approach which allows creating models or products to generate solutions to problems. Uğraş and Genç (2018) also found that STEM education creates the necessary basis so that original designs can emerge, a result, which is similar to those of the current study.

Despite some negative opinions and suggestions about the activity at some points, the majority of the prospective teachers commented that they would definitely like such activities to be carried out again in the future. By contrast, one of the strikingly negative comments made by the respondents is about having experienced some difficulties in the activity, mainly while building the design, deciding on the design, and predicting whether the product would work or not. This could be due to the fact that they may have encountered that type of activity for the first time. Another negative view is about the unappealing aspects of the activity. The respondents drew attention to the short length of the activity, the excessive number of group members, the scarcity of materials, and the necessity to fill out the worksheets as its unappealing aspects. The national and international literature review shows that prospective teachers tend to comment not only on the negative aspects of the activities but also the positive ones (Erdoğan & Çiftçi, 2017; Özçakır-Sümen & Çalışıcı, 2016; Uğraş & Genç, 2018). The most emphasized negative views seem to focus on the inadequacy of time and crowded study groups. In the study conducted by Özçakır-Sümen and Çalışıcı (2016), the prospective teachers claimed that the activities took a lot of time and applying them in large classes was difficult. Suchman (2014) also reported that the STEM education process takes a considerable amount time. For this reason, the number of students in the groups formed during the implementation of the activity can be adjusted considering the level of the group in order to ensure an efficient group work. In addition, the blank spaces to be written on the worksheet and the duration of the activity may be arranged by taking into consideration the level to which the activity will be applied.

Last of all, we discussed the prospective teachers’ suggestions regarding the activity, the implementation of the activity and a possible preliminary study prior to the activity. It also turned out that the suggestions of the respondents mostly focus on the parts where they had the most difficulty. The respondents also made suggestions about the variety of materials and problem situations related to the activity. They further noted that the instructions should be clearer especially for preschool children while applying the activity, and that information about the subject should be given before the activity according to the level of the study group.

The results of the study are limited to prospective preschool teachers studying in the final year of a public university. A STEM activity was carried out with them for three hours and their views about this activity were examined. The activity can also be applied at different grade levels to examine varying student views ranging from secondary school level to those of postgraduate level. The activities prepared based on the STEM education approach seem to have many contributions to the students. Depending on these results, STEM activities can be benefited from at all levels from preschool to higher education. Researchers to work in the field of STEM can better design their studies by considering the disadvantages mentioned in this study.

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