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Preschool Children's Science Motivation and Process Skills during Inquiry-Based STEM Activities

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Abstract

STEM is an educational practice to integrate science, mathematics, engineering, and technology within the formal and informal context and it provides practical opportunities for the child to make sense of the world holistically. Moreover, the most important benefit of STEM activities for children, including engineering design, is to improve or support children's science and mathematics skills and social-emotional development. In this study, therefore, it was aimed to investigate children's science motivation as well as their usage of scientific process skills during inquiry-based STEM activities including engineering designs. Fourteen 5/6-years-old children included in the study and classroom observations, pre and post interviews were conducted to collect rich data. The findings revealed that children frequently engaged in STEM activities by employing at least one of the science process skills and they used engineering thinking apart from the science process skills. Moreover, following inquiry-based STEM activities, children have recognized science as an area of activity, and there have been positive changes in their motivation towards science.

Introduction

In educational policies, there are many ideas about critical times for students to increase their interest and success in STEM fields. Especially, a number of researchers have taken position that school levels including primary school and middle school (Wendell & Lee, 2010; Dabney, et al., 2012; King & English, 2016), high-school (Colakoğlu, 2016; Means, et al. 2017; Wang, 2013), college-level (Lai, 2018; Sass, 2015) have been influential for improving students' success and interest in STEM fields. However, in recent years, the idea STEM implementations should be started in early childhood education is increasingly accepted (Soylu, 2016; Tippett & Milford, 2017). Scientific findings, which show that children use their innate skills such as curiosity, questioning, and exploration to understand the world that they live in (French, 2004; Gelman & Brenneman, 2004; Katz, 2010; Schulz & Bonawitz, 2007), motivate policymakers, practitioners, and researchers to appreciate why STEM implementations should start at these ages. In fact, with these innate skills children offer a developmental potential for STEM education pedagogy. In other words, children already have a developmental trend or capacity which is an important requirement for STEM education pedagogy. Moreover, the early childhood education is appropriate to implement the academic subjects in STEM education by integrating since the integrated instruction, which is in the heart of STEM education, is an important learning standard for developmental appropriateness in early childhood education (Bredenkamp & Copple, 2006).

The academic subjects of science, technology, engineering, and mathematics integrate in STEM education when they are implemented in classroom contexts. Particularly, science and mathematics, which are two important components of STEM education, are crucial in improving these skills. For example, inquiry-based science activities can improve children's scientific process skills, including observing, discovering, and problem-solving (Eshach & Fred, 2005; French, 2004; Gelman, Brenneman, McDonald, & Roman, 2009). The preschool mathematics also plays an important role in children's future school achievement, literacy development, and cognitive processes (Clements, Sarama, & Germeroth, 2016; Duncan et al., 2007; Nguyen, et al., 2016; Purpura, Logan, Hassinger-Das, & Napoli, 2017; Watts, Duncan, Clements, & Sarama, 2018). In recent years, there has been also an increasing interest in the field of technology. Researchers proved that in the early years of children, technology can contribute to their problem solving, mathematical concepts, computational thinking, and sequencing skills (Fessakis, Gouli, & Mavroudi, 2013; Kazakoff, Sullivan, & Bers, 2013; Sullivan & Bers, 2016). In early STEM education, engineering activities should be understood. The engineering was defined as the process of designing the human-made world by Katehi, Pearson, and Feder, (2009a, p. 27). While science tries to understand the world in which we live, engineering aims to modify the world to satisfy human needs. The scientific knowledge guides the engineering process, and it is also not possible to make much scientific

progress without tools developed by engineers (Katehi, et al., 2009a, p. 27). In this respect, science and engineering cannot be separated from each other in learning environments. Engineering activities provide a natural context for children to experience scientific skills rather than abstractly learning concepts (Katehi, et al., 2009a; Schunn, 2009). These findings revealed that there is a lot to do about integrating the field of engineering into early childhood education environments to increase children's scientific gains. In this study, we expect that inquiry-based STEM activities including engineering designs present a learning environment that can help teachers to improve children's scientific process skills and their science motivation.

Science process skills are those that allow children to advance new information through concrete experiences. These skills are important in the daily lives of children as well as in their future lives (Charlesworth & Lind, 2010, p. 77). Young children's natural curiosity is crucial for learning science skills, and they not only learn skills but also build on a set of skills over time (Jirout & Zimmerman, 2014; Kuru & Akman, 2017). Moreover, these skills in the early years are also best predictors of children's science achievement in their next grades (Saçkes, 2013). Therefore, the researchers suggest that inquiry-based activities should be implemented in early childhood education to improve children's scientific skills and to increase their scientific achievement and their motivation (Alabay & Özdoğan, 2018; Saçkes, 2013; Samarapanguvan, Patrick, & Mantzicopoulos, 2011) because in inquiry-based activities, the child should take responsibility in the learning process by actively participating to obtain new knowledge (Pedaste, et al., 2015). Alfieri, Brooks, Aldrich, and Tenenbaum (2011) and Furtak, Seidel, Iverson, and Briggs (2012) reported that students' learning gains in the inquiry-based learning model were much more than traditional models.

This Study

The global economic competition has created the widely accepted STEM movement in the field of education (Katehi, et al. 2009b; Martín- Páez, Aguilera, Perales- Palacios & Vílchez- González, 2019; Soylu, 2016). STEM is an educational practice to integrate science, mathematics, engineering, and technology within formal and informal context and it provides practical opportunities for the child to make sense of the world holistically (Lantz, 2009; Marcus, Haden & Uttal, 2017; Marcus, Haden & Uttal, 2018). Moreover, the most important benefit of STEM activities for children, including engineering design, is to improve or support children's science and mathematics skills and social-emotional development (Katehi, et al. 2009b; Lippard et al., 2017). In recent years, thus, early STEM education has been a remarkable subject for researchers in Turkey and they have obtained various findings from their studies. For example, the findings of the study conducted by Akgündüz and Akpınar (2018) showed that STEM activities contribute to science, mathematics and 21st-century skills of children. Similarly, in another study, it was found that STEM activities improved children's 21st-century skills and STEM components (Günşen, Fazlıoğlu & Bayır, 2017). Uğraş (2017) also found that teachers emphasize the benefits, limitations, and practices of STEM in a study conducted to examine teachers' opinions about STEM education. However, there are not sufficient scientific data to support these findings. Martín- Páez, et al. (2019) in a literature review found that preschool was an educational stage when STEM studies were least conducted. Soylu (2016) also suggested that there should be more efforts to integrate STEM activities into the preschool education. This situation makes early STEM research particularly significant. The need for STEM activities in early education has been a point of inspiration for this study. Furthermore, the experts suggests that children acquire the scientific process skills at an early age and that this needs to be done through inquiry-based activities (Charlesworth & Lind, 2010; Jirout & Zimmerman, 2014; Saçkes, 2013; Samarapanguvan et al., 2011). To benefit from these activities, however, children need to participate in the educational process in a motivated way, as motivation is an important factor in children's academic success and school performance (Çeliker, Tokcan & Korkubilmez, 2015; Wigfield, Eccles & Rodriguez, 1998). Therefore, it is considered that this study is specifically important to determine whether inquiry-based STEM activities create a natural learning environment for the use of science process skills as well as the effects of these activities on children's science motivation. In this context, the following research questions were investigated:

- 1) Which science process skills were used by children at inquiry-based STEM activities including engineering design?
- 2) How did inquiry-based STEM activities influence children's science motivation?

Method

This qualitative study was designed following a case study methodology. The case study methodology (Moustakas, 1994) was used to explore how or why the actions occur within real-world contexts. Qualitative

inquiries are powerful tools for enhancing one's understanding of learning and teaching process (Creswell, 2007). Correspondingly, kindergarten children's engaging in the inquiry-based STEM activities were investigated considering those activities as a case. In this study, science process skills that children used during the inquiry-based STEM activities and influence of children's engagement in these activities on their science perceptions were explored.

Participants

The study group was created by using homogeneous sampling, which is a purposeful sampling method. Purposeful sampling methods are the techniques to determine and select information-rich cases for the most effective use of limited resources (Patton, 2002). The purpose of this process with homogeneous sampling was to understand and describe a particular group in-depth through the data in relation to the aims of this study.

Table 1. The demographic data of the children in the study group

| | | <i>f</i> | % |
|----------------------|---------|----------|----|
| Gender | Male | 7 | 50 |
| | Female | 7 | 50 |
| Age | 5 | 8 | 57 |
| | 6 | 6 | 43 |
| Attendance to school | 1 year | 7 | 57 |
| | 2 years | 4 | 28 |
| | 3 years | 2 | 14 |

This study was conducted in a public preschool in the center of Kırşehir. The school is located in the city center and families with an economic status range from low-to-high-level have their children enrolled in this school. There were ten groups in the school: five in the morning and five in the afternoon. The number of children in a classrooms varied between ten and sixteen. As the school was much in demand, teachers were eager to carry out the new practices. Moreover, the classes were less crowded. This was significant, because the small number of children in the classroom is very important for activities to be more effective and is an important element of the quality of education (Sheridan, Williams, & Samuelsson, 2014). Fourteen 5/6-years-old children (7 male and 7 female) and their teacher took part in the activities. Nearly half of the children were in their first year at school, four children were in school for two years, and two children were in school for three years. The teacher holds a bachelor's degree and gave her concept to implement Early Childhood Education Curriculum (MoNE, 2013) in the classroom. The classroom design was suitable for the Early Childhood Education curriculum and was adjusted according to the procedure of this study. Children were observed in small groups during the inquiry-based STEM activities.

Procedure

Three basic stages were followed when conducting this study. A general outline of the procedure was presented in Figure 1 below.

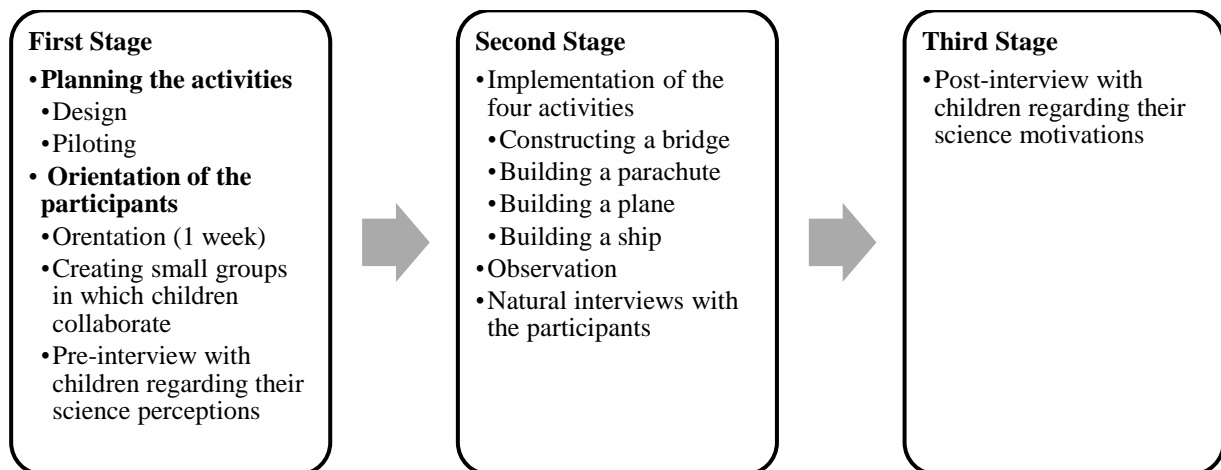


Figure 1. General Outline of the Procedure

In the first stage, four inquiry-based STEM activities were designed by the researchers. The activities were designed according to the inquiry-based learning framework of Llewellyn (2002). Besides, the activities were planned as integrated activities and satisfying properties of STEM activities. Moreover, the activities included “force” which is one of the contents to be taught in the preschool classrooms. In the process of creating activities, first of all, activities including the basic steps of the inquiry-cycle framework were arranged according to the subject of force in the solid, liquid, and gas. These activities were examined by three experts (two in the field of preschool education and one in the field of science education). Experts evaluated these activities according to content accuracy and developmentally appropriateness for preschoolers and then, activities were prepared for the pilot study by making arrangements according to experts’ feedback. The pilot study was conducted in a different classroom to improve the structure and timeline of the activities. At the end of the pilot study, arrangements were made and the activities became ready for implementation. Although integrated activities were emphasized by the MoNE curriculum (2013), the teacher, children, and design of the classroom were not completely ready for conducting inquiry-based STEM activities. In the first stage of classroom sessions, therefore, a one-week orientation was conducted by the researchers to familiarize the participants with the activities. In addition, pre-interviews with children were conducted. The pre-interviews aimed at determining children’s prior knowledge about science activities and their motivation towards science.

The second stage of this study included the implementation of the activities. While one researcher and the teacher conducted the activities, one researcher videotaped the classroom and collected data by recording field notes during the implementation of the activities. Engagement, exploration, explanation, elaboration, and evaluation (5E) processes were executed in each activity (*Figure II*). The third stage of this study consisted of conducting post-interviews with the children. These interviews were conducted to investigate how inquiry-based STEM activities influenced children’s motivation toward science.

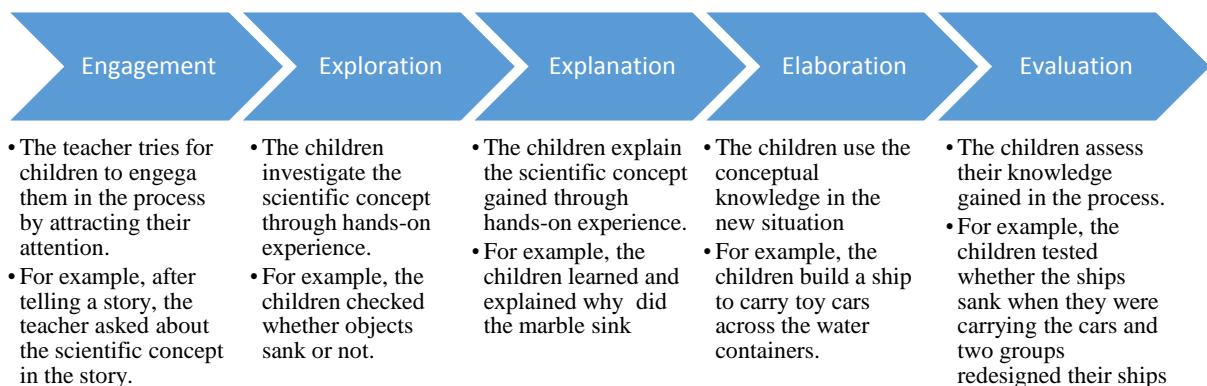


Figure 2. The inquiry-cycle with examples in the activities

Data Collection

Several data collection procedures were used in this study. Classroom observations, video recordings pre and post interviews were conducted to collect rich data. Although each data collection method had different characteristics, they provided useful information for understanding children’s engagement in inquiry-based STEM activities. Classroom observations constituted the main data of this study. As mentioned earlier, one researcher both video-recorded and observed the classroom during the activities. A second researcher conducted activities in the classroom by getting help from the teacher. The role of both researchers was part-participant. The researchers who attended to the fieldwork used an observation form to record children’s engagement in the activities. After conducting the activities, the video recordings were watched and analyzed by the remaining researchers. The observation form used in this study was developed by the researchers and was designed to record the activities performed by the children in each step of the inquiry cycle. After the initial version of the observation form was created, experts’ opinion (one in field of preschool and two in field of educational sciences) was taken to determine whether the form was appropriate for this study. Moreover, a researcher used this form during the pilot study to determine whether the form is appropriate for the aims of this study. The form was redesigned with changes made as a result of feedback on its appropriateness. The final form consisted of each step of the inquiry-cycle and the starting-ending time of these steps. The observer noted what the teacher and the children do in these steps. In this way, the form was arranged in a semi-structured observation form model which the observer descriptively noted what he/she heard, saw and understood. (Rozahegyi, 2019).

Semi-structured pre and post interviews with the children were conducted to explore the influence of the STEM activities on children's motivation towards science to obtain children's views more efficiently. The opinions of the three experts (one in the field of preschool education and two academicians in the field of educational sciences) were collected during the preparation of the draft of the interview form. Two questions were removed from the draft interview form by the feedback received from experts. Finally, the coefficient of agreement between the experts was calculated as .78 with the Fleiss Kappa coefficient. To reach the purpose of the study, the questions were asked to the children such as "Do you like science activities? What do you think of science activities? Do you think science activities are easy/difficult? Why?" During the interviews, additional questions were asked to children to broaden their answers.

Data Analysis

Observation notes, video recordings derived from the activities were collected to investigate children's use of science process skills during inquiry-based STEM activities. During the activities, the two researchers who participated in the fieldwork defined science process skills according to Charlesworth and Lind's (2010) categorization. Therefore, the collected data was coded around the following skills: observing, comparing, classifying, measuring, communicating, inferring, and predicting. These codes were used to analyze children's utilization of science process skills during the activities.

Additionally, the researchers were open to emerging new codes that were hidden in the data. During the analysis of observation notes and video recordings, apart from the science process skills, active engagement and emotion codes also emerged. These codes were used to interpret the influence of activities on children's science motivation. The data collected during pre and post interviews were analyzed according to Mantizicopolus, Patrick, and Samarapanguvan, (2008)'s categorization of science motivation of children. These codes were as follow;

- Don't know, no response, or irrelevant
- School activities or events not related to science
- Science content not included STEM activities
- Science content included STEM activities
- Science content and affect

Several procedures were used to eliminate validity and reliability issues. For the validity purpose, multiple sources of data were used for triangulation. Reliability and consistency of the results were also taken into consideration. The inter-rater reliability was calculated as .96 that showed acceptable reliability (Creswell, 2007) according to Miles and Huberman's (1994) formula. Besides, excerpts from video recordings, classroom observations, and interviews were presented in the related section. In the excerpts, pseudonyms were used to protect confidentiality.

Results

This section has two parts. The first part presented children's engagement in inquiry-based STEM activities and their use of science process skills during these activities. In the second part, the science concept of children was presented.

Children's Use of Science Process Skills during the STEM Activities

Children's engagement in STEM activities and their use of science process skills during these activities were analyzed in this part. We found that children frequently engaged in STEM activities by employing at least one of the science process skills. They actively participated in the activities and were motivated for reaching the goal of each activity cooperatively. However, children intended to use each skill in a different stage of the inquiry. The table below presented examples of children's use of science process skills in each stage.

Children used their observation skills in each stage of the activities. They frequently observed the teacher, their group-mates, and other group members. In the engagement stage, children observed the teacher. The teacher engaged them in the activities by telling a story, showing interesting pictures, and arranging a discrepant event to generate their interest. Children's observations of the discrepant event quickly attracted their attention. In the

exploration stage, children observed their group-mates and worked cooperatively with them. Furthermore, they observed members of other groups to imitate strategies that they used and to understand how they used different materials in the designing process. In the explanation stage, children observed the teacher's explanation regarding the designs and groups' products that were created in the exploration stage. Especially, when teacher exhibited each group's product, children focused on the explanation of the teacher. Children's observations in the elaboration stage were similar to their observations in the exploration stage. They observed both their group-mates and members of other groups when refining their designs and products. In the evaluation stage, children observed how their and other groups' final products functioned. To sum up, children consistently used their observation skills for gathering information about the activity within the group and across groups. That is, their observations established a base for each stage. The excerpt below presented a variety of children's observation. Children also used comparison skills during their activities. They began comparing real-life situations and scientific concepts in the engagement stage (i.e., sinking-floating objects). For example;

...After the attention of the children was drawn to the scientific concept, the children were given some real objects (ping-pong ball, sponge, marble, mandarin, key, and woods). The teacher instructed the children how to record their predictions about whether these objects would sink in the water. To do this, children used the prediction chart prepared for this activity. The children then put the objects into large water containers and checked whether they sank or not, and then they marked the sunken objects into a new chart. The children explained the reasons for their first predictions by comparing their previous and subsequent chart. For example, Ahmet explained his opinion as; "I thought marble would sink because it was small, but it doesn't.... (Observation note from activity "Let's build a ship").

Moreover, they compared materials according to their properties, sizes, and intended purposes in the exploration stage. Each group compared members' proposals for designing the product. Besides, children compared components and different perspectives of the designs. In the explanation stage, children compared designs and products of the groups under the guidance of the teacher. Children compared the properties of the designs and materials that were used in the products. Children compared their prior knowledge with present understanding in the elaboration stage of the activities. Thus, they refined their designs according to their observations. Finally, children had the opportunity to compare their initial design and last design in the evaluation stage. They compared their designs with other groups' designs. In the evaluation stage, children also compared their prior knowledge and final understanding of the concepts. The excerpt below included children's comparisons of cardboards and papers during the design of an aircraft.

Classifying was widely used by children both in the design and evaluation processes. First, children classified real-life objects or events during the engagement process provided by the teacher. Next, they classified materials to design their models. They sorted materials according to their possible usages in the model. However, some children were not successful at classifying materials since they had to lack prior experiment on some materials and concepts. The teacher explained the concepts and materials in the explanation stage. Children classified each group's design and model following the teacher's explanation. In the elaboration stage, children classified materials to re-design and refine their models. They were generally successful at classifying at this stage since they had experienced during the activity. In the evaluation stage, children evaluated all groups' products and designs according to the purpose of the activity. They classified models such as floating-sinking or as solid-unstable. The excerpts below were a good example of children's classification of materials. Besides, children sorted materials according to their possible usages in the model.

...Children chose materials themselves to design an airplane. They tended to use cardboards for their plane. They took cardboards and tried to put them onto other materials. Some children tried to fly cardboard by throwing. The teacher watched the children and groups for a while and instructed children how to design their airplanes... Children expressed their notions and drew their designs. Some groups drew more than one design, since children had different views... (Video note from activity "Let's build an airplane").

Measurement skill was another common science process skill that children used during the activities. When engaging children in the activities, the teacher provided children with opportunities to measure some concrete materials. In the exploration stage of the activity, children measured materials and collected data for their designs and models. They measured the length or weight of the materials for designing their models by using rulers, fingers, pencils, and so on. In the explanation stage, across groups, the teacher led children to measure some models' properties for comparison and classification purposes. Children used data from these measurements for refining their models in the elaboration stage of the activities. Finally, they measured some properties of the models when evaluating these properties. For example,

Table 2: Examples of children's use of science process skills during the STEM activities

| Science Process Skills | Stage | Example |
|------------------------|-------------|--|
| Observing | Engagement | Children's observations of discrepant events led them to quickly activate their attention and learning. |
| | Exploration | Children observed group-mates' behaviors, especially some children who did not have prior knowledge about the topic. |
| | Explanation | Children observed teacher's instruction and explanations. |
| | Elaboration | Children observed group members and other groups' modifying designs. |
| | Evaluation | Children observed how their products functioned. |
| Comparing | Engagement | Children compared real-life situations during discrepant events. |
| | Exploration | Children compared materials while designing. Comparing elements of the designs. |
| | Explanation | Children compared designs and materials created in the exploration stage. |
| | Elaboration | Children compared their prior knowledge and present understanding. |
| | Evaluation | Children compared their first and ultimate designs. |
| Classifying | Engagement | Children classified real-life situations through the help of a teacher. |
| | Exploration | Children sorted materials according to their intended use and intended parts of the design. |
| | Explanation | Children classified appropriate designs. |
| | Elaboration | Children classified materials according to the explanation of the teacher. |
| | Evaluation | Children evaluated models and classified them according to their properties. |
| Measuring | Engagement | Children conducted measurements during discrepant events. |
| | Exploration | Children measured materials and properties of designs and collecting data during the activities. |
| | Explanation | Children measured properties of designs to compare and classify. |
| | Elaboration | Children used their measurement skills to refine their designs. |
| | Evaluation | Children measured properties of final products. |
| Communicating | Engagement | Children explained prior knowledge. |
| | Exploration | Children shared observations and they communicated during the activities. |
| | Explanation | The teacher used a common language regarding scientific concepts. |
| | Elaboration | Children redesigned their products and discussed during the arrangement of materials. |
| | Evaluation | Children and teacher discussed the final products of the groups. |
| Inferring | Explanation | Children described their designs and investigations and deduced from teacher's comparison of the designs and materials. Children improved their understanding of using their experiences. |
| | Elaboration | Children observed explanation stage and made inference while redesigning their materials. |
| Predicting | Elaboration | Children made predictions about the properties of their designs such as floating in the water. |
| | Evaluation | Children evaluated products by predicting their properties. |

...The children tried to test how their parachutes landed when they threw them from a height. However, all groups saw that their parachutes did not work. The teacher also tried the parachute that he had prepared. The parachute slowly landed and the children were all excited and applauded teacher's parachute. After these trials, the teacher asked to the children, "Why did my parachute work, while yours didn't? I'm putting my parachute on the table so you can answer that question. Come and examine, compare it with your own". The children examined the teacher's parachute. The groups changed or reconstructed their parachutes. In a group, the children used a ruler to make the ropes the same length as the teacher's parachute ropes... (Observation note from activity "Let's build a parachute").

One of the common science process skills that children used was communication. It could be understood from the excerpts children frequently communicated with each other during the activities. Children frequently communicated with each other during their activities. Children shared their observations and ideas for the designs and products from the exploration to the evaluation stages. It should be noted that the teacher guided children for using their communication skills in the first activity. Therefore, it was ensured that each child collaboratively participated in the activities. They orally communicated ideas and directions. Children also drew figures of the designs so that other children could understand what they meant.

...The teacher showed the children the toy cars and asked how they could carry the toys cars across the water containers without sinking. One of the children (Berrak) said: "We could carry it by the ship". The teacher presented the children with a variety of materials to build a ship (ping-pong ball, pipette, cardboard, wood, paper, rope, sponge, bag, etc.). Children discussed in their group how to build a ship. The groups then took the materials they chose. They shared tasks. After building their ships, they tested whether the ships sank when they were carrying the cars. The teacher asked the children "Why did some ship sink at this stage". Furkan replied; "Because the cardboard was not water-resistant. If we had glued bags to our ship, it wouldn't have sunk". Two groups redesigned their ships by adding some materials such as bag, wood... (Observation note from activity "Let's build a ship").

Surprisingly, children used inference and prediction skills in the later stages of the activities. In the explanation stage, children began inferring when the teacher provided explanations of the events. For example, when the teacher provided information about how a ship could float, children inferred their designs' and products' properties regarding floating. Hence, they improved their knowledge of floating objects. Moreover, children used their inference skills while redesigning their products. Regarding the prediction skill, children made predictions in the elaboration and evaluation stages. As they gained scientific background through the activities, they predicted properties of the products and evaluated them in the evaluation stage.

The Effects of STEM Activities on Children's Science Motivation

In this section of results, we presented how inquiry-based STEM activities affected children's science motivation. Table 2 presents children's answers about science activities with examples in the pre and post interviews. The answers were arranged according to the coding scheme generated by Mantizocopolus et al. (2008). However, new categories including "science in-home and collaborative science" that are generated during the coding process are added to this coding scheme.

A comparison of the children's responses in the pre and post interviews showed that there were significant changes. Almost all of the children were not aware of their science activities before inquiry-based STEM activities were implemented. Children often considered science-related activities that were not relevant to science. For example, they talked about "cutting and painting activities" in art activities as a science activity. However, following inquiry-based STEM activities, children have recognized science as an academic subject, and there have been positive changes in their motivation towards science. Before the process, Berra had explained her view as;

We cut things and paint them at the science activities.

But after the process, her view changed as;

We built a ship and tried to see whether it was swimming.

Table 3: Children's answers and frequencies with examples by categories

| Categories | f (Pre) | f (Post) |
|--|------------|-------------|
| Don't know, No Response, or Irrelevant | 49 | 2 |
| School Activities or Events Not Related to Science | 50 | 1 |
| Science Content Not Included STEM activities | 16 | 5 |
| Science Content Included STEM activities | - | 88 |
| Science Content and Affect | | |
| I like science | 3 | 14 |
| Science is difficult | 3 | 1 |
| Science is easy | - | 9 |
| Science is fun | - | 13 |
| Science is exciting | - | 13 |
| Science in Home | 2 | 7 |
| Collaborative Science | 5 | 12 |

Children earlier reported that they don't like science activities as it is difficult. After the inquiry-based STEM activities, however, children thought that science is easy and they stated their reasons as;

I can do it.

For example, before the process, Furkan had expressed his view as;

I don't like science because it is difficult for children to cut over the line.

After the process, his view changed as;

I like science because I can do it and it was easy for me. I had so much fun at the ship activity. It was fun and exciting to watch whether it sank or not.

The answers revealed that children's self-efficacy being engaged in science was effective, which led them to perceive science as an easy academic subject.

Another important finding was that children were able to transfer STEM activities from classroom context to home context. Before the process, irrelevant activities such as drawing, gluing, and paint printing was mentioned as home science activities. Following the process, the content of the home science activities changed. Children stated that they tried what they had done in the classroom at their home or that they told their parents about activities. After the process, Rümeyza expressed her experience as;

I didn't do anything about science at the home, but I explained to my parents how to make a plane, ship, and bridge.

Also, Belinay expressed her experience as;

I did an activity at home. I made the plane and ship with my mother

Besides, children recognized the importance of collaborative work in a STEM process. Abdulhalim explained his view like that;

I like working in a group, because my friends help me and then, the tasks get much easier

Discussion and Conclusion

In this study, the purpose was to understand how inquiry-based STEM activities, including engineering designs, affect young children's scientific motivation and to determine which science process skills that they use in the activity settings. A purpose of the present study is to examine the effects of inquiry-based STEM activities on children's science motivation. Children's experiences in an academic subject are effective in terms of their motivation, and these experiences are crucial in the choice of future careers and interests (Caspi et al., 2019;

Eshach & Fried, 2005; Mantizicopolus et al. 2008). Motivation is an important field of study for social psychologists. They explained the psychological determinants effective in the motivation as follow: the individual's perception, beliefs and attitudes of the task or behavior (such as fun, exciting, useful), their self-competence (the individual feels competent of any task or behavior), perceived control of task or behavior (it refers to an individual's assessment of how easy a task or behavior is), and collaboration with others (the presence of people to help when the individual needs them) (Azjen, 1991; Wigfield, et al. 1998; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006). In this perspective, STEM activities in this study positively affected the children's science motivation, as the findings revealed that there were significant changes in the psychological determinants of children's science motivation after STEM activities. For example, when children were engaged in the STEM process, their perceptions toward science changed positively. Children hadn't developed any idea of what was done in science activity or they hadn't thought science as an academic subject before the implementation process. However, their views on science changed after implementation. Moreover, the children began perceiving science as fun, exciting, and easy after the STEM process. While these findings are similar to the findings of studies reporting that children's science motivation increase when they are exposed to science activities (Mantizicopolus et al. 2008; Patrick, Mantizicopolus, Samarapanguvan, & French, 2008), they also reveal that inquiry-based STEM activities have positive effects on children's perceptions of science. This might be because when children engaged in developmentally appropriate and inquiry-based engineering designs, they perceived science as an academic subject and science became fun for them. Self-competence is also one of the psychological determinants of motivation. As children were exposed to activities, they considered themselves as competent (Samarapungavan et al. 2011). In this study, it was understood that children felt sufficient about activities after the STEM process. Furthermore, this study suggested that children's preference to work in collaboration with their group mates is also an important factor in their motivation.

The findings based on classroom observations revealed that children actively used their science process skills including observation, comparison, classification, communication, measurement, prediction, and inference. STEM activities provided an environment for children to experience these skills in a collaborative atmosphere. Children used these skills in each stage of the inquiry-based activities. However, in each stage, their intentions for using these skills were varied. Moreover, while children used their observation, comparison, classification, measurement, and communication skills across all activities, they used inference and prediction skills mainly in explanation, elaboration, and evaluation stages. Inquiry-based learning aims to involve students in a real scientific discovery process (Pedaste et al., 2015). Thus, researchers suggest that inquiry-based learning process should be performed in a classroom context for children to improve their gains (Saçkes, 2013; Samarapanguvan et al., 2011). The findings of this study proved that these suggestions were justified. In early childhood education, besides, science process skills have been highlighted as promoting children's understanding of science as a way of knowing (Sackes, 2013). Therefore, children should be provided with opportunities for experiencing science process skills in a collaborative and inquiry-based atmosphere. Moreover, inquiry-based STEM activities could be developmentally appropriate for ensuring this atmosphere.

The current study revealed that children designed, tested, refined, and evaluated their designs and products within the circle of inquiry-based STEM activities. We observed that children used engineering thinking apart from the science process skills while engaging in the activities and understood that inquiry-based STEM activities provided useful opportunities for supporting children's engineering thinking. Our finding suggested that inquiry-based STEM activities could provide suitable and rich opportunities for enhancing children's engineering skills in early education as it required the correct direction for its introduction (Bagiati & Evangelou, 2009). This finding also extended the findings of Bagiati and Evangelou's (2016) and Lippard et al. (2018) by showing that children use engineering skills when they are actively involved in activities. The activities required both the inquiry of the preschool teacher and children's active engagement, motivation and collaboration. In this way, the activities will provide useful opportunities for supporting children's engineering thinking.

Parents are important partners and children's home environments can be rich resources for STEM in early childhood education. Therefore, the link between school and home environments is a significant factor for early STEM education. In this study, the findings showed that STEM activities were naturally transferred to the home by children. In the interviews, some of the children mentioned that they told their parents about the activities they conducted in the classroom, while others also mentioned that they repeated what they have done in the classroom in their homes. This finding was surprising for us since we did not attempt to express or imply the using of STEM in their home environments. It was well understood that inquiry-based STEM activities were effective in establishing a natural connection between school and home. A great deal of effort is needed to establish a link between school and home in early science education. The finding of this study may, in part, shed

light on how to establish this connection. However, it should be noted that this study did not focus on what was done in children's home environments.

Recommendations

The findings of this study provided important information on the implementation of STEM activities in preschool education. Based on these findings, we provide the following recommendations. Since early STEM education provides the best opportunities for children to develop their 21st century and science process skills, policymakers in education, teachers and trainers may work collaboratively to integrate the engineering practices into preschool. Although STEM has been seriously taken up in preschool education, more information is needed on how to integrate STEM disciplines and how to implement engineering practices in the classroom context. Accordingly, professional development sessions including pedagogical information on the implementation of STEM disciplines can be planned for teachers. In particular, relevant courses may be integrate the curriculum of universities for teacher candidates to acquire their knowledge and skills for STEM during the pre-service years. Opportunities may be created for implementing STEM applications in informal contexts as well as formal contexts. Teachers may also generate "STEM activities in-home" by engaging families in the process. Moreover, STEM activities in formal context were implemented in this study. The studies may be planned to implement STEM in informal contexts such as museums, play-ground, laboratory. The finding that children reflect activities in various ways in the home environment may encourage researchers to investigate STEM practices in the home environment, their contributions to children, and parents' beliefs, attitudes and skills about STEM. This study was conducted over four weeks. However, future studies may be conducted to investigate how long-term STEM activities contribute to children's social, emotional, and language development.

Notes

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