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Implementation of STEM in Preschool Education

Abstract

It is a controversial issue that magnetism is an interesting topic for children but also the concept is too abstract for the preschoolers. In this study, an action research is conducted that examines whether the designed intervention program based on STEM can be beneficial for 5-6 years old children to learn more about the specific features of the magnets. The program consists of several activities including reading story, playing a tablet game and designing a product from different shaped magnets. Findings underline the importance of STEM activities, as an interdisciplined approach, can foster the children to engage more actively in learning, inquiring, designing and reflecting processes. Besides, this study confirms the claim that preschool children are capable of developing conceptual understanding in 'magnetism'

Keywords: STEM in Preschool; Magnetism, STEM Activities in Early Childhood Education

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An Example Implementation of STEM in Preschool Education

In the globalizing world, for an education system that meets the necessities of the age, countries are concerned about gaining a place in international comparisons. For this reason, the countries have seen adopting revised education policies as a top priority. These policies prompt scientists to produce different approaches and practices and bring to mind the idea that the necessary gains can be achieved through effective and qualified science education at all educational levels, including preschool. In this way, it is aimed to develop students' inquiry, scientific thinking and rational decision making skills i the early ages. So, innovative teaching approaches based on interdisciplinery holistic perspectives gain prominence. At this point, STEM education, a program that aims to blend the fields of science, technology, engineering and mathematics in relation with each other, comes to mind.

STEM, which incorporates the gains aimed at coping with the new economic order as well (Surma et al., 2019), has been recognized as a powerful driving force in the growth of national economies all over the world (Taylor, 2016). When it is considered the necessities of the age, STEM education aims to bring problem solving skills especially (Bagiati, 2011). Children who acquire this skill at an early age become adults who can easily overcome the difficulties they encounter (Akcanca, 2020a) and this provide added value both individually and socially.

STEM education appears to be an approach that improves individuals' knowledge and experience (Günşen, Fazlıoğlu & Bayır, 2017), predispose them to solve problems by making interdisciplinary connections for situations they encounter with in their daily lives (Tosmur-Bayazıt et al. 2018) and enhances their creativity (Tozlu et al., 2019). STEM education is getting more and more involved in the studies conducted in the preschool level (Çetin & Demircan, 2020; Dorouka et al., 2020). Based on the literature, preschool level is considered as the starting point of the STEM education (Katz, 2010). According to this issue, STEM is a seed for growing critical citizens for a digital tomorrow and the early childhood period is seen as perfect 'seed-time' (McClure et al., 2017). Children are born as scientists and every child wonders about surrounding objects and events that occured

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(Aktürk, 2019; Alan, 2020). Thus, curiousness, as a source of exploring, emerges since birth and children try to make sense of the outside world throughout the early years of age. So, it is valuable to apply innovative teaching techniques such as STEM in order to acquire the prominent skills at the preschool level (Akcanca, 2020a). Preplanned activities in science education help children acquire scientific process skills such as observing, asking questions, experimenting, grouping, problem solving and communicating (Karademir et al. 2020; Karamustafaoğlu & Kandaz, 2006). Specific skills such as scientific thinking and generating hypotheses, analyzing data, and interpreting data can be acquired at a very young age, and young children can show interest in statistical data and even interpret these data for their own hypotheses (Gopnik, 2012). Therefore, STEM activities are structured by a content build upon the integration of isolated pieces to the real life concepts and dynamics (Johnson, 2012). In this context, one of the effective ways of developing scientific skill processes in early childhood is STEM education. STEM education has a facilitating effect in giving children the opportunity to interact with their social environment, especially about their observations and predictions. It is important to note here that children's inquiry and reasoning skills should be cultivated by STEM activities in the early years so that their pre-existing knowledge about science becomes more accurate and preschoolers are initiated to scientific culture (Christidou et al., 2019). However, at the point of an effective implementation of STEM education in preschool; it is necessary to pay attention to design developmentally appropriate activities (Gomes & Fleer, 2014) that support children's engagement (Akman et al., 2010).

Technology emerges as an important tool in STEM education in preschool level. Aronin and Floyd (2013) stated that there are supportive tablet applications can be integrated to STEM concerning the fields of science, engineering and mathematics. In a study conducted by Alade et al. in 2016, it was revealed that the use of tablets in the context of games and video display had positive effects on the acquisition of science concepts in preschool children. When the studies conducted in Turkey are examined, a study taking advantage of tablets in pre-school STEM education has not been encountered.

While *science* enables us to understand the outside world, the field of *engineering* serves to change the outside world in line with our needs.

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Therefore, science and engineering are seen in an inseparable integrity (Dilek et al., 2020). In a research conducted by Başaran (2018) it was determined that STEM activities had a permanent positive effect on preschool children's engineering and product design skills. In addition, DeJarnette (2018) stated that simple engineering skills can be gained effectively in the preschool period through STEM activities, and it is important to consider the environment as a third teacher within the scope of material supply and physical equipment.

Similar to science, *mathematics* is also a crucial part of the daily lives of preschool children. For example, they can observe the size and shape of an object they examine or make a comparison with another object in terms of its features (Ültay & Aktaş, 2020). Studies about STEM education in preschool level suggest that mathematical terms and concepts can be easily integrated into tablet applications (Aronin & Floyd, 2013), story reading (Kalogiannakis et al., 2018) or product design activities (Torres-Crespo et al., 2014). At the same time, mathematical outputs can be considered as a natural phase of STEM education. In other words, mathematical conversations can be heard from children at each sub-stage or mathematical concepts can be included in the preplanned activities by the teacher in an improvised way.

Considering that STEM education is carried out within the scope of science and the concepts are abstract; picture storybooks come to mind as one of the effective methods by which preschool children can embody abstract concepts. It is possible to embody abstract concepts in storybooks. For example; mathematical numbers and concepts are visualized and thus learning becomes more permanent (Shatzer, 2008). In addition, it is emphasized that learning becomes more permanent when activities such as story reading and drawing are combined (Hu et al., 2020). In a research about the concept of astronomy; the teaching of the subjects such as the formation of the solar system, the layers of the Earth and how the fossils were formed, was carried out through story reading and drawing activities. At the end of the activities, the preschool children's learning in astronomy (as an abstract science concept) is found at a high level (Hu et al., 2020). In another study conducted by Kalogiannakis et al. (2018), the concept of magnetism and the features of the magnets were tried to be taught to preschool children through

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story reading. Research findings show that reading relevant picturebooks are an effective way of teaching preschool children the concept of magnetism.

Many researchers state that preschool children generate theories about objects or situations through their intuition (Gopnik, 2012; Bonawitz, 2019; Wilkening & Sodian, 2005). For example, some conducted studies show that children explain the pulling behavior of the magnet as an 'invisible force' (Selman et al., 1982) and use the expression 'gluing' (Piaget & Chollet, 1973) (cited in Kalogiannakis et al., 2018). According to Barrow (2000), children mostly have perceptions of only the pulling behavior of magnets and they think that the pulling power of the magnets will increase according to their sizes. The fact that the children state that the magnet has 'miraculous' features and use incorrect conceptual expressions shows us that the certain invisible situations must be explained correctly and clearly to get preschool children understand the nature of science (Kalogiannakis et al., 2018). The solution of the above problems may be achieved through developing innovative programs aimed at preventing young children's misconceptions about magnets. In fact, a STEM-based program promises to be more beneficial for preschool children to learn abstract science concepts (Akcanca, 2020b). This is further supported by recent evidence coming from research with preschool children and STEM activities pointing to the importance of developing scientific skills (Akcanca, 2020a), curious thinking (Aktürk, 2019) and math 'talk' as prior knowledge for deeper understanding of concepts (McClure, 2017).

According to the relevant literature, the interaction of magnets with objects and with each other (push and pull behavior) can be taught effectively to young children (Van Hook & Huziak-Clark, 2007). In addition, the limited thoughts of preschool children about the shapes of magnets can be enriched with activities (Kalogiannakis et al., 2018). Studies on teaching the concept of magnet with STEM activities in the preschool education have been found to be quite insufficient (Büyüktaşkapu et al., 2012). In the light of all these informations, the aim of the present study is to evaluate the effectiveness of STEM activities designed in teaching the two mentioned features of the magnets to preschool children. In this context, it is expected that the research will support children to think scientifically and learn the concept of magnets in a more concrete way, give suggestions in terms of the sample activities within the scope of STEM education to practitioners and will provide

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researchers detailed information about the activity processes and results. Based on the above literature review the following sub-questions guided the research:

1. Are the designed STEM activities effective in teaching preschool children the concept of magnet?
    a. Effectiveness in learning that magnet has push and pull behaviors due to the plus and minus poles of it
    b. Effectiveness in learning that magnets have different shapes.
2. Is the use of technology in STEM activities effective in teaching the conept of magnet to preschool children?
3. Are the designed STEM activities effective in developing the engineering skills of preschool children?
4. Do the STEM activities increase children's mathematical talk in the course of reflecting/expressing the features of magnets?

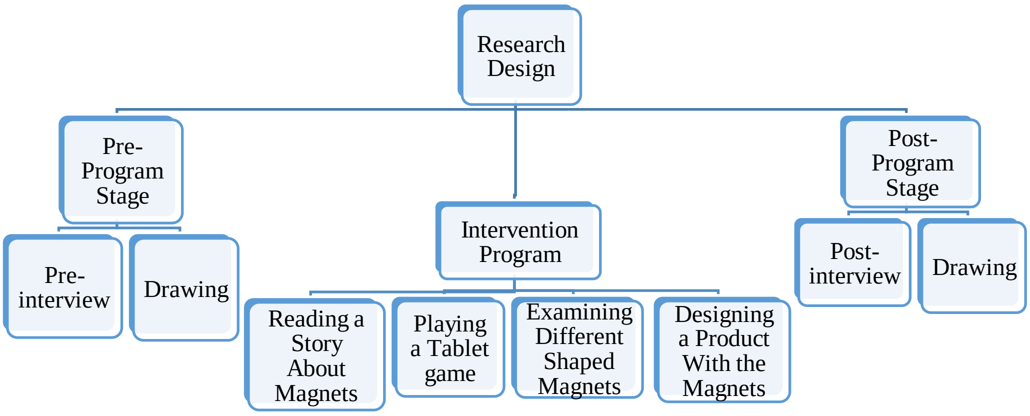
Method

Research Model

Action research model was used in the study. Action research, mostly known as 'teacher study', is not a widely used method. It is an implication-oriented method and based on problem-solving issue in scientific fields (Artvinli, 2010). Also, it is believed that the action research can serve as a tool for developing new educational programs (Köklü, 2001). To add, this method emphasizes increasing the teaching quality of the educators. According to this prespective; the current study is more eligible to use action research method to present detailed stages of the designed program. In this context, a program prepared by the researchers based on STEM education implemented and its effects had been examined. The situation of designing comprehensive and coordinated activities and arranging them according to the age level of children is explained with the concept of intervention program (Valanides et al., 2000; Hu et al., 2020). Details of the intervention program designed within the scope of the current research are shown in Figure 1.

Figure 1

The Research Design



Before the intervention program designed according to the aim of the study, pre-interviews were held with the children and they were asked to draw a picture about the magnets. In the intervention program, activities of reading picturebook involving the features of magnets, playing magnet game on tablet, examining different shaped magnets and designing a product with magnets were carried out with children. After the program, the children were interviewed again and they were asked to draw pictures about magnets again. In addition, students were observed throughout the intervention program and observation notes were taken.

Children Participants

The research was carried out in an independent kindergarten affiliated to the Ministry of National Education in Kocaeli in the academic year 2020-2021. The cluster sampling method was used in the study. The cluster sampling method involves taking groups that are clustered around a certain feature instead of taking individuals one by one (Şimşek, 2012). In the school, which has 11 branches, it was thought that the selection of children from each branch would hinder the education and training processes and a total of 15 children (8 girls, 7 boys) were selected from 2 randomly selected branches. During the implementation process of the study, a total of 5 groups

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of 3 people were formed and the intervention program was applied to all groups separately. The program was completed in 50 minutes in each group. Children were chosen from 60-72 months old groups and their average age was calculated as 68 months. Before the implementation of the program, necessary permissions were taken from the school administration and parents. Throughout the research, attention was paid to keeping the children's information confidential.

Data Collection Tools

Semi-Structured Interview

Preliminary and final interviews were conducted with the children in the study. It is stated that asking semi-structured questions is an effective technique, especially in measuring the knowledge of young children about concepts (Van-Hook & Huziak-Clark, 2007). In this context, three questions prepared by sticking to the sub-objectives of the research were asked to the children. Two experts who are a preschool educator and a science educator were consulted for the questions of ‘What do you know about magnets? Why do magnets push/pull objects? What can you say about shapes of magnets?’ The answers to these questions which were directed to children before and after the program were recorded by the researcher. Semi-structured interviews, implemented as pre and post interviews, lasted 30 minutes in total.

Children Drawings

In studies conducted with young children drawing is one of the most effective ways to measure information about a concept (Kalogiannakis et al., 2018). In this context, the children were asked to draw pictures about magnets in addition to the interviews in order to enable them to reflect their knowledge and ideas in a rich way. Before the program, the children were asked to draw free pictures about magnets by the researcher. After the intervention program, they were again asked to draw pictures about magnets without any instruction of the researcher. The drawing activity before and after the program lasted 20 minutes in each group. Within the scope of the research carried out during the pandemic process, the children were seated at a distance and they did not interfere with each other during the process.

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Classroom Observation and Observation Notes

Observation notes were taken by the researcher during the program process within the scope of the aim of the study. Children's dialogues were noted during the painting, story reading, tablet game and design process for mathematical conversations. In addition, within the scope of engineering skills, data were collected by the researcher with observation notes containing the statements of the children in the process of product designing and product presentation and the expressions of the pictures they made before and after the program.

Data Collection Process

The intervention program carried out within the scope of the aim of the research was designed to last 90 minutes. The program includes the processes of reading a picture story, playing a tablet game, exploring different shaped magnets and making designs.

The plot of the picture story was written by the researcher. In the drawings of the pictures, assistance was received from a specialist in the field. For the sub-goals of the story reading; it is designed in a way to include mathematical concepts (plus and minus poles, large-small-ellipse magnets, etc.), to explain the interaction of magnets (push and pull behavior), and to cover the knowledge that they can be in different shapes (horseshoe or elliptical shape). The plot in the written story includes a father with a horseshoe-shaped head and an ellipse-shaped child (both are magnet). The child wants to jump on his father's shoulder, but the same poles push each other and the child falls to the ground. Then the child asks his father "Why did I fall, why am I different from you?" and gets answers from his father. When he finally goes to school, he realizes that his friends are in the same shape (ellipse). Children with the same poles greet each other from a far, and children with opposite poles are first surprised when they pull each other, but then they hug each other. Sample visuals of the picturebook are presented in Figure 2.

Figure 2

Sample visuals of the picturebook

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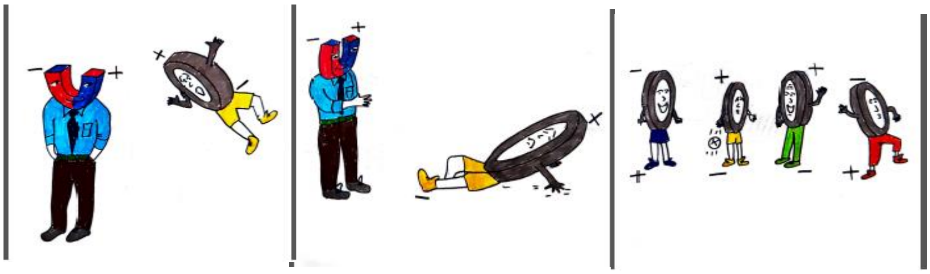

After the 10-minute story reading activity, the children played a tablet game about magnets that was downloaded by the researcher to use in the program. Within the scope of the game as a round magnet advances, it tries to open its own way by approaching and pushing other magnets in front of it. The focus concern about the game is comprising different shaped magnet figures and showing how the magnets act when they come closer. During the game, the researcher asked children about which shapes do they recognize and why they think magnets are pushing each other. The questions serve the achievements as part of 'establishing cause and effect relationships' and 'evaluates the details and different characteristics of the situations/objects'. The game activity was implemented in a total of 10 minutes, taking into account that each child plays for an equal time. After tablet activity, by giving the children magnets of different shapes and sizes they were given the opportunity to both observe the magnets and talk to each other about their observations for 5 minutes. As the literature suggested, hands-on activities facilitates minds-on activities, after the exploration stage, different materials such as wooden cubes and ropes were added by the researcher and the children were asked to design a product using these different materials. The product design stage took 15 minutes. Basically; 'Makes three dimensional designs using different materials', 'Reflects the process and the designed product to their peers' and 'Finds alternative ways to solve problems' were the main achievements for this stage. According to the pandemic in the world, considering the contagiousness of the Covid-19, in compliance with the strict measures taken by the schools, it was ensured that each child designed individual products by protecting their social distance instead of working together. In addition, it was observed the pre-school education institution where the study was conducted did not have physical and

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technological infrastructure for STEM activities to be applied to gain the concept of magnets. In this context, the technological equipment needed for the program was also provided by the researcher. In order to prevent children from being exposed to distractions such as sound, an empty class was used that is far from other classes. All the necessary materials for the program were obtained by the researcher, and the physical environment was arranged before the program

Analysis of Data

Data Obtained from Interviews

It was examined in the light of research questions related to science, technology, engineering and mathematics. In this context, the answers given by the children to the interview questions before and after the program were presented comparatively. The scientific answers coding scheme used by Hu et al. (2020) for their research was used to encode the responses given by the children before and after the program (Table 1).

Table 1. Interview Data Coding Scheme

Code	Classificationof Children's Responses	Explanation
0	No answer	'*I don't know'* or not answering questions
1	Hypotheses, Misconceptions	'Pure' theories produced in line with daily life observations. For example, seeing that it pulls iron and thinks that the magnet is also made of iron.
2	Mature Scientific Answers	Simple judgments that contain scientific accuracy and are based on daily observations. For example, thinking that magnets can come in different shapes and colors.
3	Comparative Detailed Scientific Answers	Making inferences different from existing knowledge by thinking inquisitive rather than scientific correct knowledge. For example, thinking that the magnet sticks to the heater due to its ability to pull iron.

In the Table 1, the children's answers to the pre and post interview questions are analyzed and scored in four different categories (no answers, misconceptions, mature scientific answers and comparative detailed

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scientific answers). In addition to this, five different thinking skills in the field of engineering presented by Stone-MacDonald et al. were based on for analysis of gains in the field of engineering. In this direction, the coding of the obtained data is shown in Table 2.

Table 2. Classification of Data Obtained in Engineering Dimension

Code	Category (Thinking Skills)	Explanation
1	Curious Thinking	Willingness to observe, learn and explore (question)
2	Persistent Thinking	Continuing to work towards the same goal for a long time without giving up
3	Flexible Thinking	Thinking that there is more than one way to solve a problem, imitating other people's problem solving ways
4	Reflective Thinking	To be able to explain their own product and evaluate the design process
5	Collaborative Thinking	A tendency to interact with others and group work

The drawings of the children were analyzed by document analysis method. Document analysis aims to produce empirical information based on making sense (Kıral, 2020). In this context, in the present study, the effectiveness of STEM activities was examined by carefully analyzing and comparing the pictures children made before and after the intervention program. During the analysis process, the pictures made before the program were expressed with the abbreviations BP, and the pictures made after the program with the abbreviations AP. In the analysis of the pictures, the magnets of different shapes and the plus and minus poles drawn by the children were scored, sticking by the aim of the research.

In addition, data were obtained by making classroom observations and taking observation notes during the research process. In line with the observations made, the statements and behaviors of the children regarding the study subject are systematically recorded (Özdemir, 2010). In this context, observation notes were taken within the scope of children's

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mathematical conversations in painting, story reading, tablet game and design processes. Besides, the expressions used by the children in the product design process and their statements during the presentation phase of the products were noted and scored by the researcher.

Findings

Findings obtained from the research were examined under four sections as science, technology, engineering and mathematics dimensions.

Findings Obtained in Science Dimension

When the findings of the pre and post interviews with children regarding their knowledge of magnets were examined, it was observed that there were differences between the two interviews and the designed intervention program increased the knowledge of children about the magnet concept. The findings of the pre and post interviews with the children are presented in Table 3. The scientific answers of the children classified in the previous section are included in this table as categories.

Table 3. The Scores of the Children's Answers in the Pre and Post interviews

Question	Category 0		Category 1		Category 2		Category 3	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	0	0	3	2	13	15	0	3
2	7	4	5	2	2	12	0	3
3	6	5	7	0	2	10	0	1

As seen in Table 3, the children got higher scores in the last interview than in the first interview. Besides, all the children answered the first question of what they know about magnets. It is noteworthy in Category 1, which includes misconceptions, there is a decrease in the last interview compared to the pre-interview. Also the findings shows some children answered the questions in the pre-interview in line with the observations they made in their daily lives. Some of these answers are as follows:

P2: Magnets pull metal things. I have no idea why it pulls them. Their shapes are different.

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P12: Magnets pull each other. If you get them closer to each other, they will stick together. I have a magnetic photo and it can stick to the fridge. It sticks to iron things but I don't know why.

It was observed that some of the children also produced their own hypotheses and had misconceptions. Children's responses in this context are as follows:

P3: Magnets pull each other. Because they are strong. Where there is black is strong and it pulls.

P6: I know magnets, they pull gold. It is because the edges of the magnets are iron.

In particular, there is a marginal increase in the scores of the answers to questions 2 and 3 (Why do magnets push or pull other objects? / What can you say about the shape of the magnets?). This increase in question is mostly seen in Category 2, which includes mature scientific answers. When the answers given after the program were examined, it was seen that the children gave more accurate and detailed information than their previous answers.

P4: Magnet and items may stick together. The negative and positive poles pull each other, the positive and positive poles repel each other.

K5: If it is the same with its own poles, that is, plus and plus or minus and minus it pushes each other. If it comes to a plus minus, it pulls. It can be square, rectangular, triangular. It also happens in a U shape. They can be in many colors like red and white.

It was observed that the views of some children on the concept were limited to the information they acquired as a result of their daily observations after the program. For example, it was found that a child who said that he did not know why magnets pushed some objects before the intervention program gave the same answer in the interview held after the program.

It is observed that while there is no expression before the program in Category 3, which includes detailed and comparative answers, these expressions increased after the program. For example, before the program P9 said *'They are round shaped. They pull each other. Because there are pole*

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magnets.' It seems that there are misconceptions about both the cause of the magnet's push-pull behavior and the shapes of it. After the implementation, the same participant's answer is as follows; '*Magnets can come in many shapes, plus and minus poles pull each other. If they both are plus poles, they push. Some pull a lot, some pull a little.'*

After the program, the responses reflecting that the participants made comparisons and constructed new knowledge in addition to the previous information are as follows:

P11: Magnets can be round, like a horseshoe. If the positive and minus poles come together, they pull each other. Also, magnets pull iron. So if we bring it closer to the heater, it will stick.

K8: There are electricity at the ends of the magnets. So if the positive poles get closer together they push. It is like a semicircle. My shirt also has something that looks like a magnet (pointing to the letter U).

The findings also suggests the children actively engaged in the story reading activity. Comments such as '*Teacher, one is plus and one is minus so they can hug each other. Since others are also plus, they can throw a ball to each other from a distance. (K9)'* were made about the interactions of the child hero meeting with his other magnet friends at school. A child, drew a U shape by his finger on the table to describe the shapes of the magnets before the program, was heard shouting *'Look at the magnets. They are different. (K10)'* during the story reading. The same child answered the post-interview question about the shapes of the magnets as: *'Magnets can be round, elliptical, horseshoe.'* In this context, it is obvious that story reading makes learning permanent. One of the children (P1) drew the characters of the picturebook in the picture he made after the program (Figure 3).

Figure 3

After the Program; The drawing of P1.

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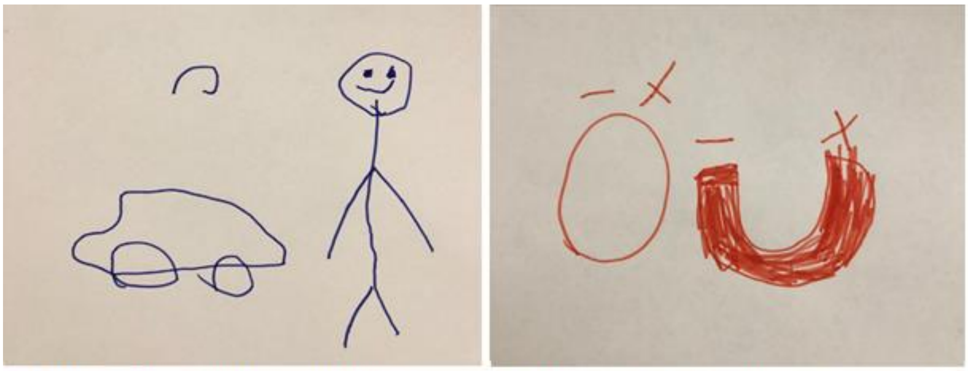
Figure 3 shows the child (P1) reflect his knowledge about the different shapes of the magnets and the drawing consists of the details like the pushing and pulling behaviors of magnets depend on its poles. Finally, it was seen in the pictures drawn by children before and after the program that the learning about the features of magnets took place effectively. Examples for the finding are presented in Figures 4, 5 and 6.

Figure 4



BP: Me, a car and a magnet. The magnet pulls the car.

AP: There are two magnets. They have plus and minus poles. They pull each other.

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Figure 5

BP: I did a lot of magnets.

AP: Magnets with different shapes. There can be even a fish-shaped magnet. I also drew an elliptic child.

Figure 6

BP: I drew two magnets. And there is a girl. Her hair is also a magnet.

AP: Different shaped magnets are pushing each other.

The figures reveal the knowledge of the children about the concept of magnet was limited before the program. After the program, the magnet drawings of children have diversified. Besides, the drawings prove that children gained awareness of the poles of magnets after the program. In addition, the children expressed the interactions of magnets with each other correctly.

Findings Obtained in Technology Dimension

In the technology dimension of the designed program, a game about magnets was played on the tablet (Figure 7). In the game, children easily understood that the magnet is pushing everything in its path and thus trying to make way to itself. All of the children engaged in this activity and it was

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observed that they had fun. While playing the game, 3 children stated that magnets push each other (20%). The number of children who stated that the shapes of the magnets are different is 13 (86.6%). But there haven't been any kids commenting on why the magnets in the game push each other. The researcher stated that during each participant's game, either the positive or negative poles come together and therefore push each other.

Figure 7. *The Tablet game*

Findings Obtained in Engineering Dimension

With the coding of thinking skills in the engineering field, each children observed regarding skills in the product design and presentation stages was scored (each expression or behavior = 1 point) and Table 4 was created for these calculated scores.

Table 4. Points of Engineering Skills

Thinking Skills in Engineering Fields	Points
Inquisitive Thinking	13
Persistent Thinking	3
Flexible Thinking	6
Reflective Thinking	12
Collaborative Thinking	-

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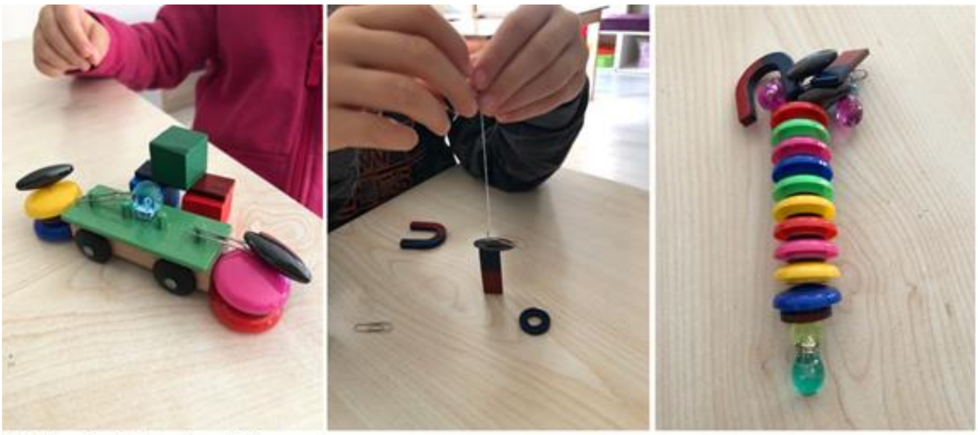
Considering the highest score in the engineering dimension of children in Table 4, they have inquisitive thinking skills (86.6%) and reflective thinking skills (80%). Also the children had a high desire to produce a product with magnets of different shapes and they considered the behavior and shapes of the magnets while making their designs. The situations in which these skills are observed are shown in Figure 8. In the examples where different designs draw attention, it was determined that the children have high skills of describing the product, talking about the details, and expressing what they experienced during the design process.

Figure 8

The Designing Stage of the Intervention Program



P5: One side of this train pulls the magnets and the other side pushes. So I tried to find plus and minus poles. I finally made a freight train and a station.

P11: I am fishing. I tied a paper clip to the rope. So I can catch magnets (fishes)

P12: I made a colorful caterpillar magnet. She glues everything in her way. Can we do this activity a little bit longer?

In addition to these, it can be said that the skills with the lowest scores are persistent thinking (20%) and collaborative thinking (0%). Flexible thinking skill is seen at medium level (40%). In this context, P1’s expression regarding the ability to think alternative ways of problem solving and observe others' ways, which was *‘Magnets were always sticking, I couldn’t do anything. I looked at my friends and he had put them away from each other. I did that too and it was easier to work that way.’*, is remarkable.

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Findings Obtained in Mathematics Dimension

In line with the observations made during the research and the observation notes taken, the frequency of mathematical expressions in the explanations of children about the shapes of the magnets (expressing the names of the figures representing mathematical speech and including them in their pictures) and the reason for the push-pull behavior (using plus and minus words and including them in their pictures) was calculated before and after the program. According to this, while the rate of including mathematical concepts in children's speech was 4% in interview responses, it was recorded as 41% after the program. Whereas the rate of including mathematical concepts before the program in the pictures was 21%, it increased to 56% after the program.

According to the findings of the current study; after the program, children gave more correct answers to the questions asked about the properties of magnets. While before the program, only 13.33% of the children gave correct answers to the question about in which situations the magnets show push and pull behaviors, the correct answer rate increased to 66.67% after the program. Besides, before the program the rate of the misconception such as magnets were only U-shaped was 33.33% and they were only round was 20%. After the program, the rate of children who think magnets can have very different shapes has increased to 66.67%. Finally, while the rate of children who correctly answer about the reason for the push-pull behaviors of magnets and their knowledge that they can have different shapes is 40% (n = 6), the analyse of the drawings indicate the rate of children who reflected both information is to be 60% (n = 9).

Discussion, Conclusion and Suggestions

When the answers and drawings are evaluated at the end of the program, obviously the drawings reflect the information are more detailed compared to the answers given to the interview questions. For example, in the interview, it was observed that a child who talked only about the pull and push feature of magnets, drew plus and minus poles in their picture and attributed the push / pull behavior to this feature. Similarly, Papandreou (2014), in her study with children aged 48-72 months, revealed that children use drawing as a communication tool and remember their experiences and

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knowledge more clearly through drawing. Einarsdottir, Dockett and Perry (2009) also proved that drawing and explaining the picture is a powerful combination when it comes to learning for children aged 4-6. In the present study, parallel to this statement, the finding that children's pictures are richer than their verbal answers in terms of mathematical expressions draws attention. As it is seen, young children can present what they know / learn in more detailed and different ways by means of drawing in which they can also use their creativity rather than verbally expressing it. Also, the use of picturebook as a tool to teach magnets may have increased young children's conceptual knowledge and children may have found the opportunity to reflect their accurate scientific answers during the drawing stage.

In line with the observations, the mathematical talk of the children before and after the program are compared and the findings suggest the STEM activities are effective to aquire mathematical skills. According to Zippert et al. (2019), during their play young children can engage in more verbal math explorations such as shapes, spatial relations and patterns. Based on this finding, the tablet game and exploration of magnet stage (as a *'play with magnets'* stage*)* in the current study may have enhance children's knowledge and expressions about 'shapes'. In the longitudinal study conducted by Wai et al. (2010), it is suggested that individualsexposed to STEM activities in early years of their lives would have had high math skills in adulthood. Visual presentation of mathematical concepts and educator's mathematical talk throughout the program may have enrich children's perceptions and expressions towards mathematical concepts, math skills become permanent and positively affect their developmental processes throughout their lives. At this point, it will be effective if educators integrate mathematical concepts both verbally and visually into the STEM education for preschoolers, as applied in the current study.

Moreover, the findings of the current study show the knowledge of some children was still limited to their daily life observations after the program and that they gave the same answers to the pre and post interview questions. Maybe the cause of that result was the subject did not attract the attention of the children, or that they may have been distracted in an environment other than their classroom they were in for the first time, and therefore their knowledge may have been limited.

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Besides, there were children who stated that they enjoyed the activities during the program. It is also noteworthy that after a long time of the program, children continued to talk about magnets among themselves. Similarly, in the study conducted by Dilek et al. (2020), it was determined that STEM activities gave preschool children a more positive perspective towards science and that children found STEM-based activities funnier and easier. In the current study, developmentally appropriate and enjoying program planned to engage children into the activities. So the program tends to give such a result that learning becomes more permanent depending on the interesting and planned presentation of a concept children encounter in their daily life.

It is a controversial issue that there are positive and negative effects of using tablets in science concepts in the preschool period. According to the results of the research conducted by Takacs et al. in 2015, it was stated that pre-school children's being intertwined with technology, especially the activities of reading books and playing games in digital environments related to the subject / concept has positive results in learning. Pila et al. (2020), on the other hand, tried to teach subjects on physics (weight and balance) to young children with STEM activities including haptic games on tablets. In conclusion, children in the experimental group and the control group got similar results as a result of the test. They emphasized that tablet games contain too many stimuli such as color and movement makes the games fun, so it may limit the inquiring process. Similarly, current study showed that while playing the tablet game, children put aside inquiry and focused on the game itself. In this context, entertaining games designed for children can be given at the end of the activities or inquiring (why / how) questions can be asked to the children at the end of the game without any intervention during the games, and answers may be asked from children in the context of games and concepts.

Many gains of applying STEM activities in pre-school age can be mentioned. For example, on one hand children are enabled to work on a concept, on the other hand the ability to use knowledge in different disciplines for 21st century skills can be supported. In his research in 2018, Başaran found that designing a product with different materials in the STEM activities improved young children's cognitive skills. Bagiati and Evangelou

(2018) revealed in their study that STEM activities support the active participation of children, thus improving engineering skills, including areas such as questioning and product design. These results are in line with the findings obtained from the present study. Children gained their engineering thinking skills during the product design stage of the intervention program. In this scope, while inquisitive thinking skills and reflective thinking skills were observed the most, persistent and collaborative thinking skills were observed the least. Due to curious nature of the young children, studying with interesting objects such as different magnets and toy materials may have promote their inquiry skills and as they are ‘new’ and ‘intriguing’ materials, the process of reflecting what and how they design may be supported. Based on the health measures taken in schools due to the Covid-19 disease experienced all over the world, the individual studies of the children were provided throughout the research and no group activity could be conducted. Therefore, it is thought that collaborative thinking skill is not observed during the activities. Persistent thinking skill, on the other hand, may have been observed at a low level due to the limited time for activities.

According to the results of the study, children that did not mention different shapes that magnets could have, stated that they could have different shapes such as horseshoe, ellipse, round, rectangle after the program. According to Trundle and Smith (2017), in early years of age, hands-on exploration move on to minds-on discussion. Based on this idea, as one of the stages of the current intervention program, the exploration of magnets may have let children to experience different shapes of them and gain accurate scientific knowledge about magnets. In addition, it has been noteworthy children who thinks magnets only pull objects at the very beginning, mentioned that magnets can push objects either.In a study conducted by Bonawitz et al. (2019), it was seen that children indicated the pulling behavior of the magnet rather than the pushing behavior. Similarly, Kalogiannakis et al. (2018) stated that after the program they implemented, there were children who stated that the magnet showed the pushing behavior as well as the pulling behavior. Another important detail in the results is that before the program the children, who thinks the magnets pull the objects because they are made of iron, stated that the magnets act to push or pull depending on the plus-minus poles at the end of the program. In this context, it can be said that the applied program became effective in correcting the

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misconceptions of children. Because all of the activities were designed based on to teach magnets pushing and pulling behaviors. The very details, such as exploring the magnet train toy which has both poles on it, may have lead the program to become more robust. In other words, the concretization of abstract concepts in science by bringing together different disciplines enables children to access accurate and detailed information.

In the process of experiencing and designing magnets, materials such as wooden lego and pompom were presented to children in addition to magnets in different shapes. Although the research focuses on the reasons and different forms of the push / pull behavior of magnets, the fact that some of the children, especially in the design dimension, stated that the magnet cannot pull wood or wool materials, shows us that children can make their own inferences through observation and it is a concrete evidence that children can access information when appropriate conditions are created. In parallel with this finding, Ültay and Aktaş (2020) gave children various materials in their study and asked them to design a product to carry the eggs without breaking them. As a result of the research, it was stated that if a rich material support is provided, different designs and ideas are encountered. In other words, giving importance to material richness in pre-school period will be beneficial in terms of richness of knowledge and experience.

In addition to all these results, the reactions and statements of children towards the shapes and behaviors of magnets during the picturebook stage has shown that story reading is an effective way to concretize science concepts at an early age. Furthermore, the drawings of children similar to the story images indicates that integrating the stories into STEM activities makes learning permanent. Kalogiannakis et al. (2018) stated that the story they created about magnets was highly effective in learning the features of magnets for young children. Similarly Christidou et al. (2009) found that the experimental interventions to teach young children the concept of magnets, such as storytelling, lead to noteworthy improvements on preschool children. Similar findings are considered as a proof that STEM activities with rich content and designed according to the developmental levels of children are effective process in teaching abstract concepts. Moreover, the motivation created in children through storytelling or picturebook reading may play an essential role to engage children actively in scientific thinking process and confirm their predictions about magnetic behaviors.

In the STEM activities designed in the light of the relevant literature, it was focused on the push / pull behavior and the possibility to be in different shapes of magnets rather than all the features of them. According to Bonawitz et al. (2019), waiting for children to make meaningful inferences by putting multiple data in front of them at once, ignores the critical components of conceptual changes. In the current research based on this view, beyond the two features taken into the center, a research can be carried out by designing a program for different features such as which objects magnets can and cannot pull. Thereafter research results can be evaluated in relation to each other. Educators can also make gradual activities by spreading science concepts over weekly or monthly processes.

When it is considered the differences in the expressions of children about magnets before and after the designed intervention program, STEM activities both corrected misconceptions and supported detailed analysis to be done. In this context, the concretization of abstract concepts with effective STEM activities has been supportive for young children in enriching their conceptual knowledge. With sustained gains for children, STEM education becomes more effective and thus, applicable on a wide scale. The most important factor should be emphasized here is that it is becoming increasingly important to apply holistic and interdisciplinary approachesin pre-school education in terms of bringing 21st century skills to young children.

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