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DESIGN ORIENTED STEM EDUCATION WITH PRESCHOOL CHILDREN

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ABSTRACT

In this study, the effects of design-oriented STEM activities on preschool children were examined. In the research conducted with case study in qualitative research designs, 20 preschool children aged five years in a kindergarten formed the participants of the study. Design Oriented STEM Activities were completed with 24 sessions of 8 weeks, 3 days a week. Within the scope of the research, data were collected through observations, interviews and research diaries and content analysis was made. As a result of the analysis of the data, it was concluded that the applied design-oriented STEM education increased the problem-solving, communication and cooperation skills of the children, and that the STEM education process; It has been concluded that it raises the awareness of children and gives them a sense of responsibility. In addition, it has been concluded that STEM activities encourage children to solve problems and generate ideas, make permanent behavioral changes in children, and increase children's social and adaptation skills.

Keywords: design thinking model, STEM, 21st-century skills, preschool education

INTRODUCTION

Brain development is not yet complete at birth, and 100 billion neurons are not yet connected in a network pattern. Studies show that our genetic code affects our brain development, but the main factor that shapes the brain experiences (Akdağ, 2015). A quality early childhood education allows children to experience basic skills such as researching, constructing knowledge and asking questions. Between the ages of 0-3, these neurons begin to connect with sound, vision, touch, taste and smell stimuli; this connection speed is around 700-1000 per second. The neurological process stems from this biology, and the natural curiosity about how the world works make early childhood the best time to introduce children to scientific research. There has been an increasing interest in research on science, technology, engineering and mathematics (STEM) in early childhood (Milford & Tippett, 2015; Moomaw, 2013; Tippett & Milford, 2017).

STEM Education

In early childhood, a critical stage in people's development, meeting children with STEM helps them learn from their experiences. In this respect, early childhood should be considered the right time for them to succeed in STEM education (Buchter et al., 2017). Studies show a strong and exciting relationship between early childhood education and science, technology, engineering and mathematics (STEM) disciplines (Chesloff, 2013). In addition, studies show that meaningful first-hand experiences in early childhood and primary school positively affect children's perceptions and tendencies about STEM education (Bybee & Fuchs, 2006; Dejarnette, 2012; Yalçın & Öztürk, 2022; Yalçın & Erden, 2021).

There are many benefits for preschool children to meet STEM education early (Yalçın, 2019). STEM activities provide preschool children with the opportunity to collaborate and communicate in a natural environment (Abanoz & Deniz, 2021). Integrated and exciting learning experiences support children's interest and learning in STEM education and raise children with the skills needed for the 21st century (Dejarnette, 2018; Uzun, 2019).

Design thinking refers to a process in which individuals understand, evaluate possible solutions, and redefine problems with the idea of developing new and creative solution proposals, which are not very visible at first glance (Dam & Siang 2018a).

In this study, the five-stage design thinking model created by Herbert Simon in the field of artificial sciences was used. These stages are; empathise, define, ideate, prototype and test phases. Figure 1 shows the stages of the design thinking model.

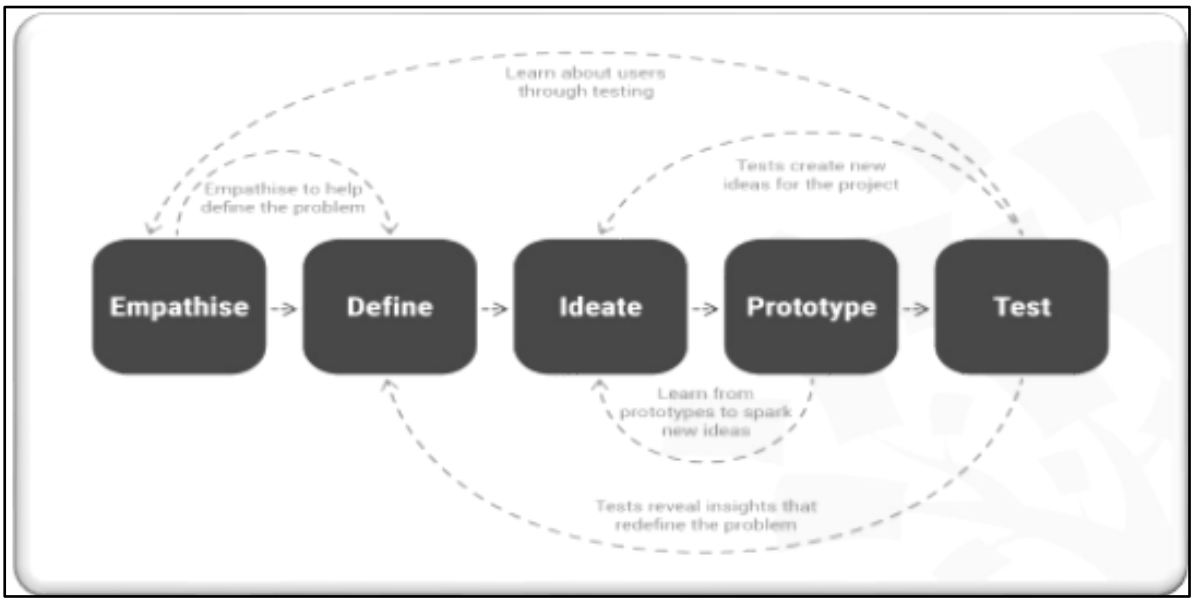

Figure 1. Design Thinking Model (Dam & Siang, 2018a)

The Problem and Rationale of the Research

STEM education is seen as the basis of countries' development, productivity, economic competition, and social welfare, so research on this subject is increasing globally. E.g.,

Germany, Finland and Switzerland are the countries with the highest student participation in STEM education programs (Freeman et al., 2015).

In the literature review about STEM in early childhood; It has been found that there are studies on cooperation and communication (Abanoz, & Deniz, 2021; Yalçın & Öztürk, 2022; Yalçın & Erden, 2021), scientific process (Abanoz & Deniz, 2019; Aydın, 2019), children's problem solving (Akçay, 2019; Yalçın, & Erden, 2021), skills. In addition, research has been conducted on integrating STEM into the preschool curriculum (Moomaw & Davis, 2010). In addition to these children's STEM activities; There are also studies examining the effects of creativity (Can Yaşar et al., 2022; Güldemir, 2019; Yalçın & Erden, 2021), problem-solving and cognitive thinking (Deniz Özgök, 2019). In addition, Öcal (2018) examined the effect of STEM on their children's scientific process skills.

In addition, the studies carried out have resulted in career planning (Gonzales & Fryer, 2014), scientific process skills (Büyüktaşkapu, 2010; Uysal & Cebesoy, 2020), intelligence (Özekin, 2006), product creation (Sağbaş, 2019), and academic success. (Çakır & Yalçın, 2020) It has been observed that its relationship with different contexts such as

The Current Study

The research is considered important since it is thought that preschool STEM education prepared according to the thinking model will be implemented. It is thought to increase children's universal literacy and skills in creating design-oriented products. In addition, the support of design-oriented STEM education to children's 4C skills, STEM education, and the design-oriented thinking model is frequently used in STEM education, especially in architecture and engineering. This study aims to examine the effects of preschool STEM activities on children.

METHOD

Model of the Research

This study, which examines the effects of preschool STEM activities on children, was conducted with a case study in qualitative research designs (Merriam, 2013). The main feature distinguishing case studies from other qualitative studies is that they are limited, and the case studied remains within a framework (Creswell, 2013; Yin, 2009).

Participants

The study's sample group consisted of five-year-old 20 children in a kindergarten, which was determined according to the easily accessible sampling method, which is one of the non-probability sampling methods. Within the scope of the research, after the necessary permissions were obtained from the Kilis Provincial Directorate of National Education, parental consent forms were obtained from the families of the children. In addition, attention was paid to the willingness of the classroom teacher in which the study was conducted to participate in the study (See Table 1).

Table 1
Demographic data of the children and of their parents in the participant group.

	Participants	
Mother's Educational Status	*f*	% (per cent)
Primary School	5	25
Secondary School	7	35
High School	6	30
Bachelor's Degree	2	10
Father's Educational Status		
Secondary School	1	5
High School	5	25
Bachelor's Degree	14	70
Gender		
Girl	8	40
Boy	12	60
Age		
5	20	100

Implementation Process of Design-Oriented STEM Education

In this study, design-oriented STEM activities in pre-school education took place three days a week, every other day for eight weeks, in 24 sessions. The practices started after the children's mealtime.

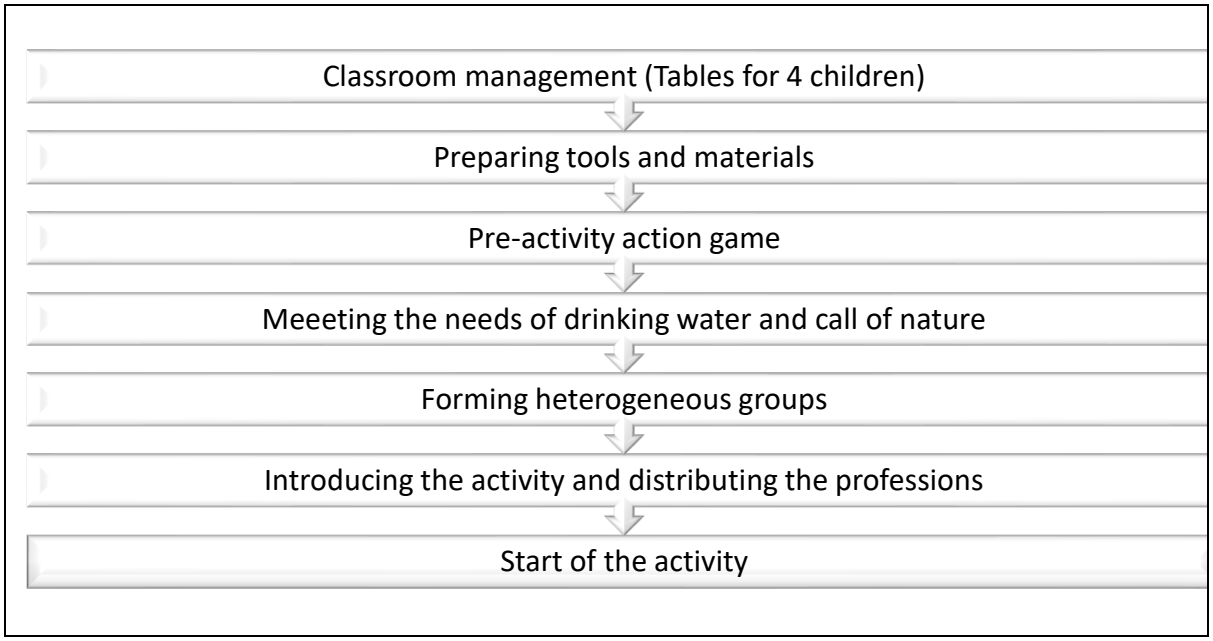

Figure 2. Preparation process prior to the design thinking STEM education.

Data Collection Tools

This study employed data triangulation, which is used in qualitative research. A semi-structured teacher interview form, a STEM education process observation form and a research diary were used in this study in order to obtain multiple perspectives to increase the accuracy of the data.

Teacher Interview Forms

The reliability of the present study was increased by evaluating the validity and suitability of the interview questions in the interview form prepared by the researchers in line with the opinions of seven experts, four of whom are professors (1 associate professor, 3 doctor lecturer) and three research assistants. The interview form consists of 10 basic questions and drilling questions. Through these interviews, it was aimed to reveal the possible changes and developments observed by the teacher who made non-participant observations during the design-oriented STEM implementation process. Some of the questions used in this semi-structured interview form are as follows: "Question 3- What kind of effects do you think the STEM activities have on children? What are the differences you have observed in children over the course of time?" Semi-structured interviews were conducted one by one in the teachers' room and lasted 23 minutes on average. In addition, the interviews were recorded with the permission of the teacher to prevent possible data loss.

STEM Education Process Observation Form

The STEM education process observation form was prepared based on the results obtained from the examination of relevant scientific studies in the literature. Figure 3 illustrates the main sources used in preparing the observation form.

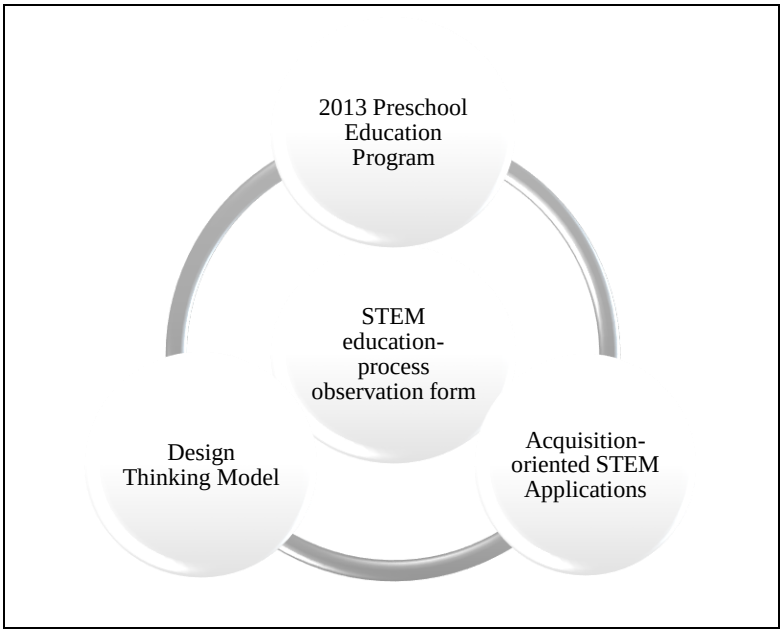

Figure 3. Basic resources used for preparing the STEM education process observation form.

Since it will not be possible to observe the whole process, researchers should determine the context, boundaries and scope of the observation. For this reason, the STEM education observation form (chekclist) was prepared by considering the steps of the Preschool Education Program, the "Acquisition-Centred STEM Applications" (2019), the "Tinkering Process Assessment Form", as well as the Design Thinking Model in addition to the relevant literature review.

During the implementation process, STEM education was handled in five dimensions: children's understanding of activities, task sharing, communication, implementation, and evaluation skills through the process observation form (chekclist) and carried out by the researcher and the classroom teacher for each activity. After eight weeks of STEM applications, a 90-minute meeting was held in the teachers' room on a specific date when both the researcher and the teacher were available in order to compare the observation forms.

Research Diary

In qualitative research, it is tried to observe the research process as naturally as possible through observations (Punch, 2011). The diary notes of the researcher were coded as the "researcher's diary and order of activity". For example, the eighth activity in the researchers' diary was coded as "RDA8". Similarly, the diary notes regarding the classroom teacher were coded as "teacher's diary and order of activity". For instance, the fifth activity in the teacher's diary was coded as "TDA5".

Data Collection

The researcher and the classroom teacher kept a research diary during the design thinking STEM education. In addition, they filled out the STEM education process observation forms. At the end of the process, the researcher made individual interviews with the teacher about the design thinking STEM education, taking an average of 23 minutes each. In order not to distract the teacher, the interview was conducted in the teachers' room of the school. In order to increase the reliability of the data obtained from the "STEM education process observation form", the STEM education process observation forms filled out by the researcher and the classroom teacher were compared to determine the rate of agreement between them as observers.

Validity and Reliability in Qualitative Research

Necessary permission was obtained from the Ministry of National Education for the research, and "informed consent forms" were obtained from the kindergarten principal, preschool teacher and parents of the children in the classroom where the study would be conducted in order to increase the validity and reliability of this study. Also, a "research diary" was kept and "STEM education process observation forms" were filled in. The researchers reported the research process objectively, clearly, and understandably. The reliability of the study was increased by explaining in detail the demographic data of the children participating in the study. The compatibility of the findings and results obtained from the data with the theoretical framework of the study and the support of the results with similar results of the related studies in the literature are the other factors that increase the reliability (Golafshani, 2003; Maxwell, 2008). In the current study, the results were supported by the findings of similar studies in the literature to increase the reliability. Some important steps that will help contribute to internal

reliability have been taken such as making systematic use of the data obtained with qualitative data collection techniques in the research, strengthening the research with different perspectives by including more than one observer, performing data triangulation by supporting qualitative data with observations, conducting interviews and keeping diaries, and including expert opinion with participant confirmation, determining the rate of conformity between observers in order to ensure consistency within the data, choosing the method of data collection and analysis by adhering to the theoretical framework prior to the applications (Merriam & Grenier, 2019; Neuman & Robson, 2014).

Data Analysis

NVivo 11 package program was used in the analysis of qualitative data. The data obtained from the interviews were analysed using the content analysis technique (Merriam & Grenier, 2019). The notes recorded in the diary by the researcher and the preschool teacher during the design thinking STEM education application were directly quoted in the results, conclusion and discussion sections of the study wherever necessary in order to support the data.

RESULTS

This article presented an observation chart regarding the design thinking STEM education, a semi-structured interview form with the preschool teacher who was an unattended observer during the design thinking STEM education, and finally, the findings from the data analysis on the research diaries kept by both the researcher and the preschool teacher during the application process.

The design thinking STEM education process observation form contains data pertaining to the weekly changes in the observations conducted for 5 dimensions, namely the ability of children to understand the activities and the process, task sharing, communication, application and evaluation skills for each activity in the design-oriented STEM education process. Observation forms were filled out by the researcher separately for each activity and added to the graph weekly. The main focus in the observation chart was to fully realize the application process in accordance with the design thinking model and to take notes on the progress observed in children throughout the process.

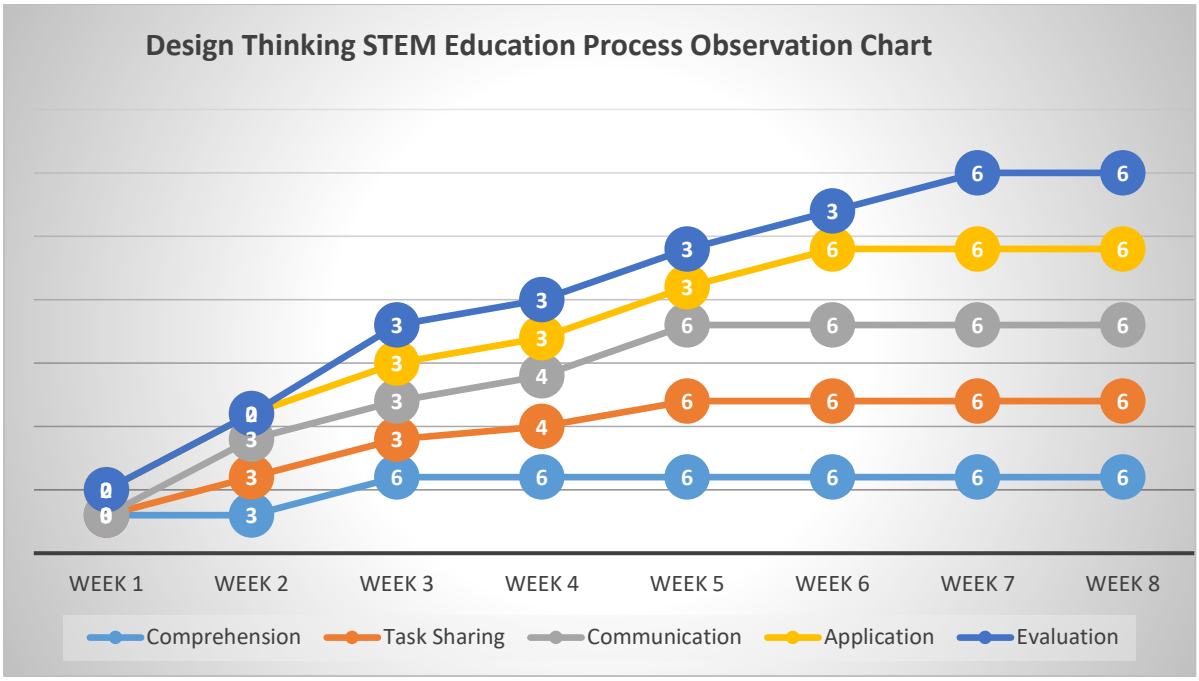

Figure 4. Design Thinking STEM Education Process Observation Chart

Figure 4 shows the weekly changes observed in the children participating in the application. The highest score to be obtained in a week is 30, while the lowest is 0. The total score in the graph indicates that the groups got 5 points in the first week, 11 points in the second week, 18 points in the third week, 20 points in the fourth week, 24 points in the fifth week, 27 points in the sixth week, and 30 points in the seventh and eighth weeks.

On page 1 of the interview form with the classroom teacher, it was stated that "… *the children were not active at first",* indicating that the children were not very actively involved at the beginning of the activities. Again, on page 1, the teacher said, "…*that was the case especially in the first few weeks, but later, they started to do the work consciously, knowing more about what they could do. For this reason, their participation in the process has increased over time*", indicating that children understood the process better and their participation in the activities improved in time. Furthermore, it is also understood from the findings obtained from the interview form and diaries that the development was not constant, but with pauses from time to time. The main reason for this may be that children fully grasped the activity process only over time and that the activities gradually became more difficult.

Analysing the diaries from the angle of the multidimensional development of children in the design thinking STEM education process, the researcher indicated in RDA14, "*The groups are remarkably good at understanding the problem, sharing tasks and fulfilling their responsibilities. They can also feel empathy and come up with creative solutions. Communication and interaction within and between groups is getting better*", and TDA18 said, "*Aluminium foil attracted the attention of children. They laughed when some of them couldn't say its name. They came up with different ideas about aluminium to protect the forest. Understanding and implementation phases went quite well*", emphasizing that children developed creative thinking, problem solving, communication, cooperation and empathy skills in the application process of design thinking STEM education. Similarly, RDA12 stated that *"children understand the problem and talk about how to find a solution within their groups.*

They came up with really good ideas. Almost every child from each group was involved in the process and expressed their opinions". Likewise, RDA16 said, "*They are very good at cooperation and communication especially during the application phase. They are able to establish a cause-and-effect relationship*. *They have achieved a good level in generating ideas for solutions and problem solving*", indicating that the children actively participated in the process, which can be considered to confirm the answers in the semi-structured interview form and the results obtained from the research diaries.

Results Obtained from the Interview

The table below presents the analysis results of the data obtained from the semi-structured teacher interview form that includes the classroom teacher's observations and evaluations regarding the implementation process of the research.

Table 2.
The teacher's views on the skills observed in children during the design thinking STEM education process.

Theme	Category	Code	F
Creativity	Awareness Imagination Cooperation Sociability	Changes in children during the process	6
		Children's willingness to participate in events	5
		Interesting activities suitable for their developmental characteristics	5
		Developing behaviour independent from the teacher	3
		Coming up with a different solution	3
		Using one's imagination	3
		Advantages of group activities	3
		Expressing one's opinion	2
		Parent feedback	2
		Listening	2
Problem Solving	Productivity Daily life problems	Gaining autonomy / Autonomous behaviour	5
		Self-confidence	3
		Improved skills	2
		Time management	2
Communication	Small-group activity Suitable environment / opportunity	Language use	4
		Communication problems	4
		The ability to take responsibility	2

Creativity: It was concluded that one of the differences observed in children participating in the STEM activity process is the change in their creativity skills. On page 4 of the interview, the teacher said, "*Some of the children were especially introverted and unable to come up with solutions. They used to sit down and cry when they encountered any problems, and retreated to a corner. I especially drew on the activities a lot about those children*". Moreover, on page 5, the teacher said, "*I heard a few parents say that their children started to do different stuff at home using different items and developed their creativity. After the STEM education, they stated that the children began to think of and express very different things*", indicating that the changes in the children's skills have also been noticed by their families.

In addition, the teacher explained the effects of small group activities on children by saying, "*They are more likely to talk in the process and decide with each other. I had students who had trouble expressing their feelings. I saw that STEM education was beneficial especially for them, as the change in them was clearer and more visible",* which is a statement that confirms the findings in the design thinking STEM education process observation form and the results obtained from the research diaries.

Problem solving: It was concluded that another difference observed in children in the design thinking STEM education process is the change in their problem-solving skills. On page 2 of the interview form, the teacher said, "*At the end of the STEM applications, we saw that the children started to come up with solutions themselves. They started to solve the problems among themselves. Most importantly, they do not ask for help from me anymore, which has reduced my work load*." On page 4 of the interview form, the teacher further said, "*I mean, a few of my students were especially introverted and unable to produce problem solutions. When faced with any problems, they sat down, cried, and retreated into a corner. I saw that it was especially helpful on those children*." In the relevant literature, problem behaviours are reported to be seen more in children with low language skills (Gilliam & Mesquita, 2000; Girard et al., 2017; Qi et al., 2019; Yew & O' Kearney, 2015; Zevenbergen & Ryan, 2010). In addition, on page 3 of the interview form, the teacher said, "*I have received very good feedback from the families in the process, as they said that their children ask 'How can we solve this problem? What can we do? with a solution-oriented and problem-solving attitude.*" Based on this, it can be assumed that families are also aware of the changes in their children in the process as children make use of the skills they have learned and acquired at school, as well as drawing on them out of school, and that activities increase children's language skills, thereby reducing the problem behaviours.

In addition, RDA19 said, "*When the children could not decide on their profession, they decided by playing a counting game. Definitely, their problem-solving skills have improved. Intra-group interactions were positive and constructive.*" On the other hand, TDA21 said, "*The children discussed the solutions to the problem with the other friends of theirs in the group and came up with many ideas*", which confirms the findings in the design thinking STEM education observation form and the results obtained from the answers in the semi-structured interview form.

Communication: It was concluded that the last difference detected in children during the design thinking STEM education process is the change in their communication skills. On page 3 of the interview form, the teacher said, "*… apart from that, their communication skills have also improved. As the study was carried out in small groups, their communication skills have particularly been developed. They talk and decide with each other*", and again on the

same page, the teacher further added, "*I have observed the development in the children… Those with adaptation problems have built better relations with their friends".*

In relation to this theme as covered in the research diary, RDA7 said, "*Even though there were children who insisted on their own opinions, in-group communication was quite positive, getting better day by day.*" RDA13 also said, "*They turned out to be a good group and share tasks among themselves very well. In-group communication was fine. They were able to find common solutions,"* and TDA 19 said, "*The groups worked collaboratively in the applications and fulfilled the tasks appropriate to their professions within the activity. The children in the groups helped each other in the process,"* which is statement to confirm the findings in the design thinking STEM education observation form and the results obtained from the answers in the semi-structured interview form.

DISCUSSION

Within the scope of the research, the effects of preschool STEM education applied according to the design thinking model on children were found based on the data obtained from observations, interviews and diaries. In this context, design-oriented STEM children contribute to essential skills such as creative problem solving, communication, cooperation, empathy, solution-oriented, being included in a group, productivity, and assertiveness. In addition, it is seen that the application steps and the activities done in small groups allow peer learning, give children a sense of responsibility self-confidence, and enable the formation of a child-centred process. When the literature is examined, it is seen that the results of this research on the subject are supportive (Abanoz & Deniz, 2019; Abanoz & Deniz, 2021; Moomaw & Davis, 2010; Noel & Liub, 2017; Yalçın & Öztürk, 2022; Yalçın & Erden, 2021).

Similarly, STEM increases problem solving skills (Akçay, 2019).and preschool children's cognitive thinking skills improve their skills to understand the problem, make logical inferences and interpret (Deniz Özgök, 2019). Bal (2018) states that STEM activities improve children's scientific process and problem-solving skills in his research on the subject. As can be seen, the results of the study conducted in the literature on the subject support the results of this study.

In addition, design-oriented activities are active in the steps of questioning, imagining, planning, creating and redesigning in the design-oriented thinking process of children (Cavas et al., 2013), while the participants in the design-oriented process observe, understand, produce ideas, make prototypes and test. Research on the fact that the stages of learning to increase their motivation and thus lead children to cooperation (Kröper et al., 2011), and also in this research, especially in life. The fact that STEM activities are prepared with problems, the activities are done in small groups, there is a distribution of tasks within the group, it activates the children in the process. It provides learning by doing and experiencing. Therefore, STEM education, which is applied with the design-oriented thinking model in this study, aims at children's multi-dimensional development. It can be interpreted that it is effective in the bookmarks.

In summary, it has been concluded that design-oriented STEM education contributes significantly to preschool children's skills such as creative problem solving, communication, cooperation, empathy, solution-orientedness, and idea generation. In addition, it is seen that the application steps and activities done in small groups allow peer learning, give children a sense of responsibility self-confidence, and enable the formation of a child-centred application

process. Similarly, it has been concluded that STEM activities increase children's problem-solving skills (Akçay, 2019), and preschool children's cognitive thinking skills improve their skills to understand the problem, make logical inferences and interpret (Deniz Özgök, 2019). Bal (2018) states that STEM activities improve children's scientific process and problem-solving skills in his research on the subject. As can be seen, the results of the study conducted in the literature on the subject support the results of this study.

Limitations

This study is limited to research diaries, observations and interviews.

Suggestions

According to the research results, the design-oriented STEM education of children; has been concluded that it contributes to the development of skills such as creative problem solving, communication, cooperation, empathy, being solution-oriented, being included in a group, productivity and assertiveness. From this point of view, teachers can add design-oriented STEM applications to activities in order to support children's versatile development. Teachers can be trained in design thinking model and STEM subjects, so that teachers can develop in accordance with theory and practice.

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