THE EFFECT OF STEM-BASED EDUCATION PROGRAM ON PROBLEM SOLVING SKILLS OF FIVE YEAR OLD CHILDREN*

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ABSTRACT

With STEM education, children obtain 21st-century skills, such as systematic thinking, problem-solving, being able to see the relationships between events and creative thinking skills, etc. and as for the development of problem-solving skills, it is included in 21st century skills in connection with STEM education. In parallel with the abovementioned, this study aims to examine the effect of a STEM-Based Education Program on the problem-solving skills of children aged five. The research group was determined by the purposive sampling method; the experimental group was composed of 19 five-year-old children of a private kindergarten from Ankara's Çankaya province, and the control group included 18 children from the 2017–18 academic year. The General Information Form and Problem Solving Skills Scale were used as data collection tools in the study. The STEM-Based Education Program prepared by the researcher was applied to children in the experimental group two days a week for a period of eight weeks. It was determined that there was a significant difference in the problem-solving skills of children in the experimental group who received the STEM-Based Education Program ($p< 0.05$). It was observed that the effect of the training was preserved with the permanence test applied to the experimental group three weeks after the last test. It has been determined that educational programs with STEM-based activities significantly affect children's problem-solving skills.

Keywords: *Preschool education, STEM, problem-solving skills*

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INTRODUCTION

In the changing education paradigm in the world and in our country in the current century, it can be observed that individuals approach educational goals with a holistic perspective (Bybee, 2010). Nowadays, economic and technological innovations have gained great importance in order to catch up with the developments in the world and to use the world's resources more efficiently (Maryland, 2012). In this context, these innovations have been used in many areas and have become a necessity for development (White, 2014).

In the 21st century, countries aim to raise their citizens as mentally, physically, and emotionally healthy; socially compatible with their environment; being able to solve their problems; entrepreneurial; productive; creative; and self-confident individuals (Koray et al., 2007). With the rapid development of science and technology, and the social changes that are being experienced, individuals and societies have to constantly renew themselves (Şanlı, 2005).

In order to be successful, individuals must incorporate themselves with 21st-century skills such as critical thinking, creativity, collaboration, communication, information literacy, media literacy, technology literacy, flexibility, leadership, entrepreneurship, productivity and social skills (Davies & Ryan, 2011). These skills are designed to help them keep up with the pace of today's modern job market and technology (Beers, 2011; Maryland, 2012).

The most popular learning strategies covering 21st-century skills are "critical thinking—problem-solving, creativity—innovation, collaboration and communication" skills (AES, 2019). Critical thinking is about approaching problems from different angles and solving all the problems (Gooderham, 2015). Collaboration refers to how students will work together to achieve a common goal and take responsibility while working. Communication enables students to learn how to effectively communicate their ideas. Creativity teaches students to think with new and different perspectives (AES, 2019; Beers, 2011; Fulton-Archer et al., 2011).

One of the educational approaches that aim to raise individuals equipped with the 21st-century skills listed above is the interdisciplinary approach (Bingimlas, 2009). Training methods established with the interdisciplinary approaches are extremely effective in terms of the complementary or supportive function of one discipline to another (Beers, 2011). The Science, Technology, Engineering and Mathematics (STEM) is one of these approaches, which is based on the combination of the four streams of learning in terms of purpose–process–output and has been at the forefront of the agenda of some countries, especially since the 2000s. (Bybee, 2013). It is emphasized that this approach should be disseminated from preschool education to secondary education and higher education levels (Davies & Ryan, 2011; Polat & Bardak, 2019).

STEM presents a contemporary and innovative approach to learning and teaching in the fields of science, technology, engineering, and mathematics. It is an educational approach that encourages and supports children to use their creative skills in their first years, enables them to think in terms of problem-solving, and focuses on finding solutions to problems by using the sense of "curiosity" in children (Guide, 2013; Hernandez et al., 2014).

The STEM approach and the 21st-century skills basically include learning processes used in "Research-Based Learning, Problem-Based Learning, and Project-Based Learning" approaches (Breiner et al., 2012). However, all learning conditions occurring in the 21st-century require the use of STEM skills, especially basic skills that help students' academic development (Wang et al., 2011). In order to accelerate the acquisition of these skills, although science was thought to be the most neglected field in the early periods, it should enter into education in these disciplines in the early stages such as early childhood education (Beers, 2011; Moomaw & Sally, 2013).

In consideration of all these developments, the abbreviation SMET was used by The National Science Foundation for the disciplines of science, mathematics, engineering, and technology in the early 90s (Sanders, 2009). However, this abbreviation, which is similar to other terms, changed over time and started to be referred to as STEM in 2001 (Breiner et al., 2012). The main fact in STEM education is that the individual produces solutions toward engineering problems by using their knowledge of science and mathematics and getting the corresponding support from technology (Kennedy & Odell, 2014). In this context, STEM elements enable new inventions, especially in the industry (White, 2014).

STEAM, on the other hand, is the integration of STEM with the addition of (A) for art. In addition, a concept called STREAM has emerged with the addition of (R) to STEAM by some education reformers. The R in STREAM refers to learning, where the proponents of this approach believe that students should be able to communicate effectively, which is an important aspect of human interactions, and that acquiring critical and creative thinking skills should basically be obtained through literacy. Therefore, they argue that this field should be added to the current STEM education (Duriansquare, 2019). As indicated in the literature, the philosophy of STEM education has evolved over time and new disciplines have been included with the questioning of its philosophy (Kılıç & Ertekin, 2017).

If two of the four disciplinary areas are deliberately emphasized, according to the perspective of early childhood specialists, these activities could be entitled STEM (Tippett & Milford, 2017). Nebraska, Illinois, and Massachusetts indicated that children aged 0–5 acquire learning standards with an early STEM emphasis. Nevada has published its own early learning standards for 4–5-year-olds (Nevada Preschool Standards, 2010).

These standards, which include mathematics and science, are presented as separate fields in addition to other academic and developmental areas. Many states have specific STEM learning standards and guidelines, by including them in early childhood education for children up to age 3 (Buchter et al., 2017).

Early Learning STEM Australia (ELSA) was started as a pilot study in Australia in which 300 teachers and 3300 children were included across 100 kindergartens (Earp, 2018). ELSA is a game-based digital learning program for preschool children to introduce STEM (ELSA, 2019). The game-based program is compatible with the Early Years Learning Framework and includes digital applications that support students, educators, and families. The ELSA's STEM Applications encourage children to question, speculate, solve problems, experiment, and think about what happens and why (ELSA, 2019).

With STEM, students can identify concepts by generating innovative solutions to understand and solve complex problems; it enables them to apply and combine their knowledge from various fields to come up with unique solutions. The 21st-century skills are undoubtedly effective in preparing the individual for life and the job market in this very complex and competitive environment (Khalil & Osman, 2017).

Problem-solving skills are one of the most important skills in STEM education (Banks & Barlex, 2014) because children who receive STEM education are able to ask questions about daily life problems and come up with solutions to solve them. They can take advantage of their knowledge based on science, technology, engineering, and mathematics (Bybee, 2010), which enables their development of problem-solving skills (Roberts, 2016; Aldan, 2019; MEB, 2016).

In addition to the relationship between STEM education and problem-solving skills, there is an important relationship between STEM education, the engineering design cycle used in STEM education, and the problem-solving skills because, with the engineering design process, children are able to solve daily life problems by using basic mathematics and science knowledge, solutions which they can further apply in real life (Basham & Marino, 2013). Additionally, the problem-solving skills in STEM education are also effective in the engineering processes that include planning, designing, building, and evaluating for a specific problem (English & King, 2015).

The concept of problem-solving includes processes such as defining the problem, revealing effective solutions, choosing the appropriate solution, and decision-making, as well as efforts to look at a situation from multiple points of view to close the gap, meet the need, overcome the difficulties, and remove the obstacles that include cognitive and behavioral processes (Philips & Soltis, 2005; Şahin, 2015).

Problem-solving is the process of overcoming difficulties in achieving one's goal. During this process, ways to comply with the conditions or to get rid of tension by reducing obstacles and bringing an internal balance are sought (Gonzalez & Kuenzi, 2012). Problem-solving is a skill that needs to be learned, acquired, and constantly improved, which requires time, effort, energy, and practice; in terms of its multiform, it combines creative thinking with intelligence, emotions, will, and action with the self at the same time. It is related to need, goal, value, belief, skill, habit, and attitude (Başaran, 1994; Bingham, 2004).

Problem-solving is such a complex process that certain steps must be followed (Şahin, 2015). However, there were no clearly defined steps related to the problem-solving process. Bingham (2004) defines problem-solving in six steps: recognizing the problem, explaining the problem, collecting information about the problem, data selection and regulation, identifying possible solutions, and evaluating those solutions. Gelbal (1991) defines the problem-solving steps as being aware of the problem, defining the problem, generating alternative solutions, and implementing those solutions. According to Başaran (1994), the problem-solving stages include hearing the problem, recognizing the problem, looking for solutions, deciding, implementing the decision, and evaluating the solution. Polya (1997) derived the guidelines of problem-solving with the steps of understanding the problem, making a plan, implementing the plan, and evaluating the result of the plan. Jonassen (2011) defines the steps of problem-solving as defining the problem, searching for possible solutions, implementing the solutions, and looking for and evaluating the solutions.

Models that are used for problem-solving processes, in general, are in some degree the modified versions of John Dewey's model that have been used since 1910 (Philips & Soltis, 2005). It is seen that Dewey's (1910) problem-solving steps are similar to the steps of noticing the problem, defining the problem, collecting information for the solution of the problem, determining the solutions for the problem, choosing the most appropriate solution to solve the problem, and reaching the result by solving the problem. It is also underlined that the problem-solving steps determined in this context are model steps. It is not certain that each step will be applied all the time or in the same order. Steps can either be associated or even skipped (Bingham, 2004; Yiğitalp, 2014).

In order for the individual to present their problem-solving behavior, first, the individual must encounter a situation and perceive this situation as a problem (Öğülmüş, 2006). The most important step in the problem-solving process is to define the problem. Defining the problem is the first step to understanding it. Defining the problem clearly uncovers many options for solving the problem. With the correct definition of the problem, the right resources are reached in data collection for the solution of the problem (Kneeland, 2001; Sullivan & Decker, 2001).

After the problem is recognized and defined, it is necessary to conduct multidimensional research about the problem before solving it (Bingham, 2004; Şahin, 2015). During the solution process of a problem, necessary information about the cause, limitations, and importance of the problem needs to be collected and a suitable environment is prepared to find correct solutions to the problem. Moreover, collecting necessary information about the problem allows the individual to organize ideas for the solution and approach the problem from different points of view (Bingham, 2004; Yılmaz & Tepeli, 2013).

While collecting information about the problem, ideas and possibilities about how to solve the problem also emerge. All these can be expressed as hypotheses and then a correct solution can occur from these hypotheses. It is stated that the value of these possible solutions largely depends on the originality and creativity of the person who is attempting to solve the problem. Before deciding how to start solving a problem, it is necessary to find the main facts that constitute the problem, which can go a long way in solving the problem (Kneeland, 2001; Zembat & Unutkan, 2003; Nite et al., 2014).

After determining a couple of solutions for the problem, the idea that can help to reach a solution in the fastest and most effective way among all the solutions should be considered and implemented (Başaran, 1994). In this step, information about the problem should be carefully collected and solutions should be determined in order to avoid indecisions (Bingham, 2004; Cotabish et al., 2013).

During the implementation of the solution determined for the problem, no logical solution should be overlooked. This condition gives the individual the opportunity to choose (Bingham, 2004). The problem is solved after the decision is effectively put into practice, the results are observed, and the problem is reevaluated (Kneeland, 2001; Zembat & Unutkan, 2003).

The solution and evaluation of the problem are expressed as the individual gaining the logic of the process. The individual needs to determine whether the problem-solving system is working or not; if not, they should look for where there is an error and ways to correct it. Problem-solving is a highly variable process, so it will not be possible for a person to use all of the above steps for every problem they are trying to solve, and the solution may not be determined in the same order. However, knowing about various aspects of the process and conscious attention is essential to develop problem-solving abilities. Development of the process leads to the emergence of more effective solutions (Bingham, 2004; Cooper & Heaverlo, 2013).

Considering the innovations brought by technology, it is necessary to prepare early childhood education programs for future professions, where children will gain skills, such as research, questioning, and finding different solutions to problems, using knowledge from fields such as engineering, science, technology, and mathematics (Katz, 2010).

In some studies, it has been seen that STEM education has positive effects on children's academic success, problem-solving, scientific process skills, conceptual knowledge, and self-efficacy at all education levels (Cooper & Heaverlo, 2013; Cotabish et al., 2013; Moomaw, 2013; Nite et al., 2014; Gülhan & Şahin, 2016; Yıldırım & Selvi, 2017; Başaran, 2018).

Upon the review of the literature, limited findings were observed relating to the preschool dimension of STEM education. In Turkey, studies on this field are small in number, relatively new, and are mostly compilation research. Considering all the conditions mentioned above, it is obvious that there is a need for experimental studies that examine the effect of STEM education. Based on this need, the relationship between STEM education and problem-solving skills in the early years was examined in this research. In view of all this information, the problem statement of the study has been determined as follows "What is the effect of STEM-Based Education Program on the problem-solving skills of five-year-old children?"

Purpose of the Study

The aim of this study is to reveal the effect of the STEM-Based Education Program on the problem-solving skills of five-year-old children attending kindergarten. In line with the purpose, answers to the following questions have been sought:

Does the STEM-Based Education Program prepared for children attending kindergarten have an effect on their problem-solving skills?

Does the STEM-Based Education Program prepared for children attending kindergarten show persistence in children's problem solving skills depending on the effect of education?.

RESEARCH METHOD

This section contains information about the research model, study group, measurement tools, data collection, preparation/implementation of the training program, application of the scales, and data analysis.

Research Model

The experimental design with the pretest–posttest control group was used in the study. In addition, the permanence test was also applied within the scope of the study. In experimental designs, the researcher aimed to test whether their intervention makes a difference on the dependent variable. Moreover, one of the purposes was to determine the cause–effect relationship between the variables in the experimental studies (Büyüköztürk et al., 2018; Creswell, 2013). The dependent variable in the study, which was performed with the experimental model, was the problem-solving skills of five-year-old children and the independent variable was the STEM activities. While the children selected in the study for the experimental group received the STEM activities in addition to their experiences in the environment they were in, the children in the control group continued to implement the Ministry of National Education's Pre-School Education Program for 36–72 Months-Old Children.

Participants/Study Group

The research group was determined by the method of homogeneous sampling, where 19 five-year-old children of a private kindergarten in Ankara's Çankaya province formed the experimental group and 18 children from the 2017–18 academic year formed the control group. While designating the experimental and control groups, it was observed that all the children had not previously received STEM education.

Data Collection Tools

The General Information Form and Problem Solving Skills Scale (PSSS) were used as the data collection tools in the study.

General Information Form

The general information form was prepared by the researcher in order to obtain information about the demographic characteristics of the children and their parents. The form was filled by the child's parents under the supervision of the researcher. The form includes questions about the children's age, gender, birth order, number of siblings, educational status, and age of their parents.

Problem Solving Skills Scale

The PSSS was published by Aydoğan et al. (2012) as a Guidebook; it consists of two forms, for children aged 4–7 years and 8–11 years. For the purposes of this study, the form for preschool and primary school, 1st-grade children, aged 4–7 years, was used. The PSSS form for 4–7 years old children consists of 10 subscales, including 50 + 2 (sample) items that include specific, observable, and measurable behaviors. The subscales are as follows: Recognizing the Problem, Defining the Problem, Asking Questions About the

Problem, Predicting the Cause of the Problem, Deciding on the Efficiency of Information for Solving the Problem, Identifying Factors of the Problem, Using Objects Differently than its Known, Predicting the Outcome of a Set of Actions, Finding the Most Appropriate Solution, and Choosing the Most Unusual Solution from Many Possible Solutions. Further, the internal consistency coefficients for the reliability inventory, KR−20 = 0.78, and Spearman–Brown two half-test correlation = 0.76 were recorded. The average complexity level of the inventory is 0.63. In order to evaluate the consistency of the inventory over time, the test–retest reliability was checked and the test–retest correlation was calculated as r = 0.93 (Aydoğan et al., 2012).

The KR-20 reliability coefficient was calculated as 0.79 in the 4–7 age group for the pilot program data. The same reliability coefficient for the normative sample is 0.81 in the 4–7 age group. The test–retest reliability calculated for the data sets obtained only from the pilot sampling is r = 0.75 for the 4–7 age group (Aydoğan et al., 2012).

Data Collection

Questions containing demographic information were filled in by the parents under the supervision of the researcher. The results were obtained by applying the PSSS to children face-to-face.

Preparation of the Training Program

Related literature has been scanned during the preparation of the STEM-Based Education Program. The purpose was to enable children to observe science, technology, mathematics, and engineering disciplines in an interdisciplinary way through the activities that were prepared. In this context, activities based on the engineering design cycle used in STEM education were prepared within the scope of this study. The engineering design cycle is explained as basic design skills that will provide children with engineering skills. In this research, activities consisting of solving problems, coming up with possible solutions, designing the possible solutions, deciding on the materials to be used, drafting the solutions, testing the draft, consolidating and testing the draft were prepared based on the engineering design cycle and its steps. While preparing the activities, the Ministry of National Education's (MEB, 2013) Pre-School Education Program was taken into consideration and the learning outcomes of the program were used in the activities. Twelve acquisitions related to cognitive development, nine related to language development, six related to social and emotional development, and three achievements related to motor development and indicators of the learning outcome were used in preparing the activity plans. The activities, concepts, and achievements prepared by the researcher were ordered from simple to difficult, such as car, bridge, air–water, tower, propeller, hydraulic, reel, and robot activities were distributed as 16 activities over eight weeks. Particular attention was paid to ensure that the materials that are used in the activities are not harmful to children, are hygienic, secure, and useful, and suitable for the developmental characteristics of children. In the evaluation part, questions were asked about the achievements and indicators, and at the end of the day, an evaluation activity was conducted and questions were asked about the achievements, indicators, and activities that were carried out. While preparing the evaluation questions, the order of descriptive questions, affective questions, questions about the concepts and achievements, and questions related to life have been taken into consideration.

Implementation of the Scales and the Training Programs

Implementation of the Pretests

Before the implementation of the training program, a meeting was held with the children's parents participating in both the experiment and control groups. At the meeting, the researcher introduced himself and gave information to the parents about the purpose, content, and days of the training program. During the implementation, pictures in the PSSS were shown in order, the questions and answers behind the pictures were read one by one, the child was asked to choose the most appropriate option, and this process was repeated for each question. The implementation took an average of 20 min for each child.

Implementation of the Training Program

Following the application of the pretests, the activities included in the STEM-Based Education Program were applied to the experimental group for eight weeks, in 16 sessions and two half days a week after breakfast on Tuesday and Thursday. For the children in the control group, the Ministry of National Education's (MEB, 2013) Pre-School Education Program for 36–72 Months-Old Children was continued by the classroom teachers. The training program was carried out in the classrooms where the children continued their education. Before starting the training, the researcher had individual interviews with the teachers and provided necessary explanations so that the children's arrival and departure to the training programs would not be interrupted. The teachers were asked not to discuss the training program of the children in the classroom and not to do it on other days, with the thought that they would threaten the external validity. In particular, the experimental group teacher was informed to not discuss the training program in the classroom with the control group teacher. The training environment was prepared so that the activities will start the moment the children entered the classroom after breakfast. The training environment was prepared in such a way that children could comfortably participate in the activities and feel safe. In the implementation of the activities in the STEM-Based Education Program, activities based on the engineering design cycle were applied. In this context, this cycle consists of nine steps: defining the need or the problem; identifying the needs; developing possible solutions; choosing the best possible solution; drafting, testing, and evaluating the solution; presenting the solution; redesigning; and deciding (Hynes et al., 2011). Activities based on this cycle were performed for a period of two weeks. During the evaluation, questions were asked about the learning outcome and indicators in the activity, and at the end of the day, an evaluation activity was conducted and questions were asked about the learning outcome, indicators, and activities performed. While asking questions to evaluate the activity and the day, particular attention was paid to the order of the descriptive questions, affective questions, questions about concepts and the learning outcome, and questions related to life.

Implementation of the Posttests

After the completion of the training, the PSSS was applied to the experimental and control groups as a posttest in the same environment and conditions where the pretests were performed.

Implementation of the Permanency Test

The scales were reapplied to the experimental group three weeks after the posttest in the same environment and conditions where the pretest and posttests were performed and whether the training was permanent was checked.

Data Analysis

In the analysis of the data collected with the general information form and PSSS, in addition to the descriptive statistics, such as frequency, percentage, and arithmetic mean, the nonparametric statistics were used to test the aim of the research.

The Shapiro–Wilk test is a test of normality used in cases where the sample size is less than 50 (Büyüköztürk, 2017). Because of the number of units, Shapiro–Wilk's test was used while examining the normal distribution of the variables in this study. While interpreting the results, 0.05 was used as the level of significance; it's stated that if $p < 0.05$, the variables are not from the normal distribution, and if $p > 0.05$, the variables are from the normal distribution. While examining the differences between the groups and two dependent variables, the Mann–Whitney U test and Wilcoxon test were used, respectively, because the variables were not from a normal distribution. While interpreting the results, 0.05 was used as the significance level; it was indicated that there was a significant difference in the case of $p < 0.05$, and there was no significant difference when $p > 0.05$.

FINDINGS

It was determined that 58% of children in the experimental group included in the study are girls and 42% are boys; 45% of the children in the control group are girls and 55% are boys; 53% of the children in the experimental group do not have siblings while 37% have a sibling(s), and 45% of the children in the control group do not have siblings while 55% have a sibling(s); 68% of those in the experimental group are the firstborn and 32% are the second or third child while 83% of those in the control group are firstborn and 17% are the second or third child; all children were observed to be five-years-old.

Table 1. *Distribution of Demographic Information of Children and Their Parents in the Experimental and Control Groups*

		Experimental Group		Control Group		Total	
		N	%	N	%	N	%
Gender	Girl	11	57.89	8	44.44	19	51.35
	Boy	8	42.11	10	55.56	18	48.65
	Total	19	100	18	100.00	37	100.00
Number of Sibilngs	No sibling	10	52.63	8	44.44	18	48.65
	Sibling(s)	9	47.37	10	55.56	19	51.35
	Total	19	100.00	18	100.00	37	100.00
Birth Order	Firstborn	13	68.42	15	83.33	28	75.68
	Second/third child	6	31.58	3	16.67	9	25.32
	Total	19	100.00	18	100.00	37	100.00
Mother's Education	Primary school	2	10.53	1	5.56	3	8.11
	High school	7	36.84	5	27.78	12	32.43
	Associate degree	2	10.53	3	16.67	5	13.51
	Undergraduate	8	42.11	6	33.33	14	37.84
	Postgraduate	0	0.00	3	16.67	3	8.11
Father's Education	Primary school	4	21.05	0	0.00	4	10.81
	High school	7	36.84	9	50.00	16	43.24
	Associate degree	3	15.79	1	5.56	4	10.81
	Undergraduate	5	26.32	8	44.44	13	35.14
	Total	19	100.00	18	100.00	37	100.00
Monthly Income	Less than 1500 TL[a]	10	52.63	3	16.67	13	35.14
	Between 1500–4435 TL	6	31.58	7	38.89	13	35.14
	Between 4435–10000 TL	3	15.79	8	44.44	11	29.73
	Total	19	100.00	18	100.00	37	100.00
	Less than 1500 TL	10	52.63	3	16.67	13	35.14

[a]Turkish lira

It was determined that 10% of mothers of the children in the experimental group are primary school graduates, 37% are high school graduates, 11% have associate degrees, and 42% are undergraduates; 21% of their fathers are primary school graduates, 37% are high school graduates, 16% have associate degrees, and 26% are undergraduates. It was also observed that 53% of their family's monthly income was less than 1500 Turkish lira (TL), 31% had a monthly income between 1500–4435 TL, and 16% had a monthly income between 4435–10000 TL.

It was determined that 5% of mothers of the children in the control group are primary school graduates, 28% are high school graduates, 16% have associate degrees, 33% are undergraduates, 18% are graduates; 50% of their fathers are high school graduate graduates, 5% have associate degrees, and 45% are undergraduates. It was observed that 17% of their family's monthly income was less than 1500 TL, 39% had a monthly income between 1500–4435 TL, and 44% had a monthly income between 4435–10000 TL.

In Table 2, as a result of analysis of the PSSS pretest scores of the experimental and control groups with the Mann–Whitney U test, it was observed that there was no statistically significant difference between the experimental and control groups in the total PSSS and its subscales' pretest scores ($p > 0.05$).

Table 2. *Mann–Whitney U Test Results Regarding Differences in the Problem Solving Skills Scale Pretest Scores between the Experimental And Control Groups*

Pretest		N	$\bar{x}$	Median	Min	Max	SS	Mean	z	p
Recognizing the problem	Experimental group	19	3.26	3	1	5	1.05	18.34	−0.395	0.693
	Control group	18	3.39	3.5	1	5	1.14	19.69		
Identifying the problem	Experimental group	19	3.79	4	0	5	1.18	20.03	−0.625	0.532
	Control group	18	3.72	4	2	5	0.89	17.92		
Asking questions about the problem	Experimental group	19	1.63	2	0	4	1.07	19.26	−0.161	0.872
	Control group	18	1.56	2	0	3	0.86	18.72		
Estimating the cause of the problem	Experimental group	19	3.26	3	0	5	1.19	17.45	−0.943	0.346
	Control group	18	3.61	4	1	5	1.04	20.64		
Deciding the efficiency of information for solving the problem	Experimental group	19	3.16	3	1	5	1.01	18.66	−0.215	0.830
	Control group	18	3.11	3	0	4	0.96	19.36		
Identifying factors of the Problem	Experimental group	19	3.32	3	2	5	1.06	19.42	−0.253	0.801
	Control group	18	3.22	3	2	5	1.06	18.56		
Using objects differently than its known	Experimental group	19	2.63	3	2	4	0.6	19.32	−0.200	0.841
	Control group	18	2.56	3	1	4	0.86	18.67		
Predicting the outcome of a set of actions	Experimental group	19	3.53	4	2	5	1.07	17.32	−1.010	0.312
	Control group	18	3.83	4	1	5	1.20	20.78		
Finding the most appropriate solution	Experimental group	19	3.79	4	2	5	0.98	19.55	−0.332	0.740
	Control group	18	3.67	4	2	5	1.08	18.42		
Choosing the most unusual solution from many possible solutions	Experimental group	19	1.74	1	0	5	1.15	16.61	−1.437	0.151
	Control group	18	2.11	2	0	4	1.08	21.53		
Total of Problem Solving Skills Scale	Experimental group	19	30.11	30	19	40	5.08	18.24	−0.442	0.659
	Control group	18	30.78	31	21	38	4.75	19.81		

$p > 0.05$

The PSSS total and subscale scores of the children in the experimental and control groups are close to each other and it is considered important in terms of revealing the effect of the training program. In studies with a controlled pretest–posttest model, the pretest scores of the experimental and control groups should be as close as possible (Kaptan, 1998).

In Table 3, as a result of the analysis of PSSS posttest scores of the experimental and control groups with the Mann–Whitney U test, while the problem recognition subscale of the posttest mean score of children in the experimental group was 3.79, the posttest mean score of the children in the control group was 3.89 ($z = -0.424$; $p = 0.672$; $p > 0.05$). While the posttest mean score subscale of children in identifying the problem was 4.53 in the experimental group, the posttest mean score of children in the control group was 4 ($z = -1.979$; $p = 0.048$; $p < 0.05$). While the posttest mean score subscale of children in asking questions about problems subscale was 3 in the control group the posttest mean score in the control group in children was 2.17 ($z = -2.024$, $p = 0.043$; $p <0.05$). While the posttest means score subscale of children in estimating the cause of the problem in the experimental group was 4.53, the posttest mean score of children in the control group was 4 ($z = -1.591$; $p = 0.112$; $p > 0.05$). While the posttest mean score of children in deciding the efficiency of information for solving the problem subscale in the experimental group was 3.84, the posttest mean score of children in the control group was 3.56 ($z = -1.093$; $p = 0.275$; $p > 0.05$). While the posttest mean score of children in identifying factors of the problem subscale was 4 in the experimental group, the posttest mean score of the children in the control group was 3.33 ($z = -2.25$; $p = 0.024$; $p < 0.05$). While the posttest mean score of children in the using objects differently than its known subscale was 3.11 in the experimental group, the posttest mean score of children in the control group was 2.67 ($z = -1.402$; $p = 0.161$;

p > 0.05). While the posttest mean score of children in predicting the outcome of a set of actions subscale was 4.42 in the experimental group, the posttest mean score of children in the control group was 3.61 (z = −2.54; p = 0.011; p < 0.05). While the posttest mean score of children in finding the most appropriate solution subscale was 3.45 in the experimental group, the posttest mean score of children in the control group was 2.20 (z = −3.381; p = 0.001; p < 0.05). While the subscale of choosing the most unusual solution among many possible solutions was 2.89 in the posttest mean score of the children in the experimental group, the posttest mean score of the children in the control group was 2.08 (z = −2.26; p = 0.043; p < 0.05). In terms of the total PSSS, while the posttest mean score of the children in the experimental group was 38.37, the posttest mean score of children in the control group was observed to be 32.83 (z = −3.584; p = 0.001; p < 0.05).

Table 3. *Mann–Whitney U Test Results Related to Differences in the Problem Solving Skills Scale Posttest Scores between the Experimental and the Control Groups*

		N	$\bar{x}$	Median	Min	Max	SS	Mean	z	p
Recognizing the problem	Experimental group	19	3.79	4	2	5	0.71	18.34	−0.424	0.672
	Control group	18	3.89	4	2	5	0.83	19.69		
Identifying the problem	Experimental group	19	4.53	5	4	5	0.51	22.16	−1.979	**0.048***
	Control group	18	4.00	4	3	5	0.84	15.67		
Asking questions about the problem	Experimental group	19	3.00	3	0	5	1.37	22. 42	−2.024	**0.043***
	Control group	18	2.17	2	0	4	1.10	15.39		
Predicting the cause of the problem	Experimental group	19	4.53	5	3	5	0.61	21.53	−1.591	0.112
	Control group	18	4.00	4	2	5	1.03	16.33		
Deciding the efficiency of information for solving the problem	Experimental group	19	3.84	4	2	5	0.76	20.74	−1.093	0.275
	Control group	18	3.56	4	2	5	0.86	17.17		
Identifying elements of the problem	Experimental group	19	4.00	4	2	5	0.75	22.63	−2.250	**0.024***
	Control group	18	3.33	3	2	5	0.97	15.17		
Using objects differently than its known	Experimental group	19	3.11	3	2	5	0.74	21.21	−1.402	0.161
	Control group	18	2.67	3	1	4	0.91	16.67		
Predicting the outcome of a set of actions	Experimental group	19	4.42	5	3	5	0.77	23.16	−2.540	**0.011***
	Control group	18	3.61	4	1	5	1.04	14.61		
Finding the most appropriate solution	Experimental group	19	4.26	5	1	5	1.05	23.39	−2.645	**0.008***
	Control group	18	3.33	3	1	5	1.14	14.36		
Choosing the most unusual solution from many possible solutions	Experimental group	19	2.89	3	1	5	1.05	22.05	−2.260	**0.043***
	Control group	18	2.08	2	1	5	1.13	13.78		
Total of Problem Solving Skills Scale	Experimental group	19	38.37	39	29	45	4.25	25.18	−3.584	**0.001***
	Control group	18	32.83	33.5	25	39	3.91	12.47		

*p < 0.05

The PSSS total and subscales in Defining the Problem, Asking Questions About the Problem, Identifying the Elements of the Problem, Predicting the Result of a Set of Actions, Finding the Most Appropriate Solution, Choosing the Most Unusual Solution from Many Possible Solutions, Problem Solving Among the Groups, there is a statistically significant difference in favor of the experimental group in terms of total posttest scores.

Although there is no statistically significant difference in the posttest mean scores of the experimental and control groups in Recognizing the Problem, Predicting the Cause of the Problem, Deciding on the Efficiency of Information for Solving the Problem, and Using Objects Differently than its Known, the posttest mean scores of the experimental group are higher than that of the control group.

Table 4. *Wilcoxon Sign Test Results Regarding the Difference between the Experimental Group's Problem Solving Skills Scale Pretest and Posttest Scores*

		N	$\bar{x}$	Median	Min	Max	SS	Mean	z	p
Recognizing the problem	Pretest	19	3.26	3	1	5	1.05	3.50	−2.153	**0.031***
	Posttest	19	3.79	4	2	5	0.71	6.00		
Identifying the problem	Pretest	19	3.79	4	0	5	1.18	6.50	−2.446	**0.014***
	Posttest	19	4.53	5	4	5	0.51	8.38		
Asking questions about the problem	Pretest	19	1.63	2	0	4	1.07	2.50	−3.047	**0.002***
	Posttest	19	3.00	3	0	5	1.37	7.38		
Estimating the cause of the problem	Pretest	19	3.26	3	0	5	1.19	0.00	−3.223	**0.001***
	Posttest	19	4.53	5	3	5	0.61	7.00		
Deciding the efficiency of information for solving the problem	Pretest	19	3.16	3	1	5	1.01	5.00	−2.804	**0.005***
	Posttest	19	3.84	4	2	5	0.76	6.64		
Identifying factors of the problem	Pretest	19	3.32	3	2	5	1.06	5.00	−2.092	**0.036***
	Posttest	19	4.00	4	2	5	0.75	6.22		
Using objects differently than its known	Pretest	19	2.63	3	2	4	0.60	5.00	−2.496	**0.013***
	Posttest	19	3.11	3	2	5	0.74	5.56		
Predicting the outcome of a set of actions	Pretest	19	3.53	4	2	5	1.07	5.00	−2.754	**0.006***
	Posttest	19	4.42	5	3	5	0.77	7.92		
Finding the most appropriate solution	Pretest	19	3.79	4	2	5	0.98	6.33	−1.625	0.104
	Posttest	19	4.26	5	1	5	1.05	6.56		
Choosing the most unusual solution from many possible solutions	Pretest	19	1.74	1	0	5	1.15	10.50	−2.864	**0.004***
	Posttest	19	2.89	3	1	5	1.05	7.82		
Total Problem Solving Skills Scale	Pretest	19	30.11	30	19	40	5.08	0.00	−3.836	**0.001***
	Posttest	19	38.37	39	29	45	4.25	10.00		

***p < 0.05**

In Table 4, as a result of the analysis of the experimental group PSSS pretest and posttest scores with the Wilcoxon sign test, while the subscale of recognizing the problem in the pretest mean score of the children in the experimental group was 3.26, the posttest mean score was 3.79 ($z = −2.153$; $p = 0.031$; $p < 0.05$). While the pretest mean score of the children in the problem description subscale experimental group was 3.79, the posttest mean score was 4.53 ($z = −2.446$; $p = 0.014$; $p < 0.05$). While the pretest mean score of the children in the experimental group was 1.63 in asking questions about the problem subscale, their posttest mean score was 3 ($z = −3.047$; $p = 0.002$; $p < 0.05$). While the pretest mean score of the children in the experimental group was 3.26 about estimating the cause of the problem subscale, the posttest mean score was 4.53 ($z = −3.223$; $p = 0.001$; $p < 0.05$). While the pretest mean score of the children in the experimental group was 3.32 about identifying factors of the problem, the posttest mean score of the children in the control group was 4 ($z = −2092$; $p = 0.013$; $p < 0.05$). While the pretest mean score of the children in the experimental group was 2.63 about using objects differently than its known subscale, the posttest mean score was 3.11 ($z = −2.492$; $p = 0.013$; $p < 0.05$). While the pretest mean score of the children in the experimental group was 3.53 about predicting the result of a set of actions subscale, their posttest mean score was 4.422 ($z = −2.754$; $p = 0.006$; $p < 0.05$). While the pretest mean score of the children in the experimental group was 3.79 about finding the most appropriate solution subscale, the posttest mean score was 4.26 ($z = −1.612$; $p = 0.104$; $p > 0.05$). While the pretest mean score of the children in the experimental group was 1.74 about choosing the most unusual solution from many possible solution subscale, the posttest mean score was 2.89 ($z = −2.864$; $p = 0.004$; $p < 0.05$). In terms of the total PSSS, while the pretest mean score of the children in the experimental group was 30.11, the posttest mean score was observed to be 38.37 ($z = −3.836$; $p = 0.001$; $p < 0.05$).

The problem-solving skills' subscales of the experimental group, Defining the Problem, Asking Questions About the Problem, Estimating the Cause of the Problem, Deciding on the Sufficiency of Information for the Solution of the Problem, Identifying the Elements of the Problem, Using Objects Differently than its known, Predicting the Result of a Set of Actions, and Choosing the most Unusual Solution from Many Possible

Solutions and Solving Problem's posttest scores are significantly higher, statistically, than the pretest scores. Although there is no statistically significant difference from the pretest mean scores in finding the most appropriate solution, the posttest mean scores are observed to be higher than the pretest mean scores.

Table 5. *Wilcoxon Sign Test Results Related to the Difference between the Control Group's Problem Solving Skills Scale Pretest and Posttest Score*

		N	$\bar{x}$	Median	Min	Max	SS	Mean	z	p
Recognizing the problem	Pretest	18	3.39	3,5	1	5	1.14	6.33	−1.625	0.104
	Posttest	18	3.89	4	2	5	0.83	6.56		
Identifying the problem	Pretest	18	3.72	4	2	5	0.89	7.40	−1.032	0.302
	Posttest	18	4.00	4	3	5	0.84	7.56		
Asking questions about the problem	Pretest	18	1.56	2	0	3	0.86	6.75	−1.768	0.077
	Posttest	18	2.17	2	0	4	1.10	5.83		
Predicting the cause of the problem	Pretest	18	3.61	4	1	5	1.04	6.83	−1.137	0.256
	Posttest	18	4.00	4	2	5	1.03	5.69		
Deciding the efficiency of information for solving the problem	Pretest	18	3.11	3	0	4	0.96	4.50	−1.814	0.070
	Posttest	18	3.56	4	2	5	0.86	6.56		
Identifying elements of the problem	Pretest	18	3.22	3	2	5	1.06	7.10	−0.282	0.778
	Posttest	18	3.33	3	2	5	0.97	6.07		
Predicting the outcome of a set of actions	Pretest	18	2.56	3	1	4	0.86	4.50	−0.540	0.589
	Posttest	18	2.67	3	1	4	0.91	6.50		
Using objects differently than its known	Pretest	18	3.83	4	1	5	1.20	7.07	−0.855	0.392
	Posttest	18	3.61	4	1	5	1.04	5.70		
Finding the most appropriate solution	Pretest	18	3.67	4	2	5	1.08	6.17	−1.386	0.166
	Posttest	18	3.33	3	1	5	1.14	7.50		
Choosing the most unusual solution from many possible solution	Pretest	18	2.11	2	0	4	1.08	5.50	−0.511	0.609
	Posttest	18	2.08	2	1	5	1.13	6.42		
Total Problem Solving Skills Scale	Pretest	18	30.78	31.00	21	38	4.75	4.75	−2.892	**0.004***
	Posttest	18	32.83	33.50	25	39	3.91	8.50		

*p < 0.05

In Table 5, as a result of the analysis of the control group PSSS pretest and posttest scores with the Wilcoxon sign test,

In terms of the total PSSS, while the pretest mean score of the children in the control group was 30.78, the posttest mean score was observed to be 32.83 ($z = -2.892$; $p = 0.004$; $p < 0.05$). There is a statistically significant difference in favor of the posttest in terms of the total pretest and posttest scores of the PSSS.

There is no statistically significant difference between the pretest and posttest scores in the problem-solving skills' subscales of the control group, Recognizing the Problem, Defining the Problem, Asking Questions About the Problem, Predicting the Cause of the Problem, Deciding on the Efficiency of Information for the Solution of the Problem, Identifying Elements of the Problem, Using Objects Differently than its Known, Predicting the Results of a Set of Actions, Finding the Most Appropriate Solution, and Choosing the Most Unusual Solution from Many Possible Solutions.

In Table 6, as a result of the analysis of the PSSS posttest and permanence test scores of the experimental group with the Wilcoxon sign test, it was determined that there is no statistically significant difference between the PSSS total score and its subscales in terms of posttest and permanence.

Table 6. *Wilcoxon Sign Test Results Related to the Difference between the Experimental Group's Problem Solving Skills Scale Posttest and Permanence Scores*

		N	$\overline{x}$	Median	Min	Max	SS	Mean	Z	p
Recognizing the problem	Posttest	19	3.79	4	2	5	0.71	5	−1.000	0.317
	Permanence test	19	3.95	4	3	5	0.71	5		
Identifying the problem	Posttest	19	4.53	5	4	5	0.51	4	−0.378	0.705
	Permanence test	19	4.58	5	4	5	0.51	4		
Asking questions about the problem	Posttest	19	3.00	3	0	5	1.37	2.5	−1.960	0.051
	Permanence test	19	3.68	4	1	5	0.89	7.38		
Predicting the cause of the problem	Posttest	19	4.53	5	3	5	0.61	3	−1.342	0.180
	Permanence test	19	4.37	4	3	5	0.60	3		
Deciding the efficiency of information for solving the problem	Posttest	19	3.84	4	2	5	0.76	3	−1.933	0.053
	Permanence test	19	4.21	4	2	5	0.79	4.17		
Identifying factors of the problem	Posttest	19	4.00	4	2	5	0.75	3	−1.406	0.160
	Permanence test	19	4.26	4	3	5	0.73	4.4		
Using objects differently than its known	Posttest	19	3.11	3	2	5	0.74	4	−0.378	0.705
	Permanence test	19	3.05	3	2	4	0.62	4		
Predicting the outcome of a set of actions	Posttest	19	4.42	5	3	5	0.77	4.4	−1.406	0.160
	Permanence test	19	4.16	4	3	5	0.76	3		
Finding the most appropriate solution	Posttest	19	4.26	5	1	5	1.05	4.79	−1.350	0.177
	Permanence test	19	3.95	4	3	5	0.71	5.75		
Choosing the most unusual solution from many possible solutions	Son-test	19	2.89	3	1	5	1.05	7.4	−1.032	0.302
	Permanence test	19	3.16	3	1	5	0.96	7.56		
Total Problem Solving Skills Scale	Posttest	19	38.37	39	29	45	4.25	9.2	−1.743	0.081
	Permanence test	19	39.37	39	34	45	3.13	9.62		

In Table 7, as a result of the analysis of the experimental group PSSS pretest–permanence test scores with the Wilcoxon sign test, while the pretest mean score of the children in the experimental group was 3.26 in recognizing the problem subscale, the permanence test mean score was observed to be 3.95 ($z = −2.365$; $p = 0.018$; $p < 0.05$). While the pretest mean score of the children in identifying the problem subscale in the experimental group was 3.79, the permanence test mean score was observed to be 4.58 ($z = −2.433$; $p = 0.015$; $p < 0.05$). While the pretest mean score of the children in the experimental group in asking questions about the problem subscale was 1.63, the permanence test mean score of the children in the control group was observed to be 3.68 ($z = −3.626$; $p = 0.001$; $p < 0.05$). While the pretest mean score of the children in the experimental group was 3.26 in predicting the cause of the problem subscale, the permanence test mean score of the children in the control group was observed to be 4.37 ($z = −3.104$; $p = 0.002$; $p < 0.05$). While the pretest mean score of the children in the experimental group was 3.16 in deciding the efficiency of information for solving the problem, the permanence test mean score of the children in the control group was observed to be 4.21 ($z = −2.882$; $p = 0.004$; $p < 0.05$). While the pretest mean score of the children in the experiment group was 3.32 in identifying elements of the problem subscale, the permanence test mean score was observed to be 4.26 ($z = −2.716$; $p = 0.007$; $p < 0.05$). While the pretest mean score of the children in the experimental group was 2.63 in the subscale of using objects differently than its known, the permanence test mean score was observed to be 3.05 ($z = −2.309$; $p = 0.021$; $p < 0.021$). While the pretest mean score of the children in the experimental group was 3.53 in the subscale of predicting the result of a set of actions, the permanence test mean score was observed to be 4.16 (z = −2.053; p = 0.004; p < 0.05). While the pretest mean score of the children in the experimental group was 3.79 in the subscale of finding the most appropriate solution, the permanence test mean score was observed to be 3.95 (z = −1.612; p = 0.504; p > 0.05). While the pretest mean score of the children in the experimental group was 1.74 in the subscale of choosing the most unusual solution from many possible solutions, the permanence test mean score was observed to be 3.16 (z = −3.043; p = 0.002; p < 0.05). In terms of the total PSSS, while the pretest mean score of the children in the experimental group was 30.11, the permanence test mean score was observed to be 39.17 (z = −3.83; p = 0.001; p < 0.05).

Table 7. *Wilcoxon Sign Test Results Regarding the Difference between the Experimental Group's Problem Solving Skills Scale Pretest and Permanence Scores*

		N	$\bar{x}$	Median	Min	Max	SS	Mean	Z	p
Recognizing the problem	Pretest	19	3.26	3	1	5	1.05	3.5	−2.365	**0.018***
	Permanence test	19	3.95	4	3	5	0.71	6.56		
Identifying the problem	Pretest	19	3.79	4	0	5	1.18	5	−2.433	**0.015***
	Permanence test	19	4.58	5	4	5	0.51	8.18		
Asking questions about the problem	Pretest	19	1.63	2	0	4	1.07	3	−3.626	**0.001***
	Permanence test	19	3.68	4	1	5	0.89	9.88		
Predicting the cause of the problem	Pretest	19	3.26	3	0	5	1.19	4	−3.104	**0.002***
	Permanence test	19	4.37	4	3	5	0.60	7.77		
Deciding the efficiency of information for solving the problem	Pretest	19	3.16	3	1	5	1.01	5.5	−2.882	**0.004***
	Permanence test	19	4.21	4	2	5	0.79	8.38		
Identifying elements of the problem	Pretest	19	3.32	3	2	5	1.06	2.5	−2.716	**0.007***
	Permanence test	19	4.26	4	3	5	0.73	7.3		
Using objects differently than its known	Pretest	19	2.63	3	2	4	0.60	6.5	−2.309	**0.021***
	Permanence test	19	3.05	3	2	4	0.62	6.5		
Predicting the outcome of a set of actions	Pretest	19	3.53	4	2	5	1.07	6.75	−2.053	**0.040***
	Permanence test	19	4.16	4	3	5	0.76	6.45		
Finding the most appropriate solution	Pretest	19	3.79	4	2	5	0.98	5.5	−0.504	0.614
	Permanence test	19	3.95	4	3	5	0.71	7.5		
Choosing the most unusual solution from many possible solutions	Pretest	19	1.74	1	0	5	1.15	7.5	−3.043	**0.002***
	Permanence test	19	3.16	3	1	5	0.96	8.04		
Total Problem Solving Skills Scale	Pretest	19	30.11	30	19	40	5.08	0	−3.830	**0.001***
	Permanence test	19	39.37	39	34	45	3.13	10		

*p < 0.05

In the case of defining the problem, which is one of the problem-solving skills' subscales of the experimental group, and asking questions about the problem, the cause of the problem, deciding the efficiency of information for solving the problem, identifying the elements of the problem, using objects differently than its known, predicting the result of a set of actions, using the most unusual solution from many possible solutions, and solving a problem, the permanence test scores were significantly higher than the pretest mean scores. Finding the most appropriate solution permanence test mean score is observed to be higher than the pretest mean score, although there is no statistically significant difference from the pretest mean score.

DISCUSSION AND CONCLUSION

The effect of the STEM-Based Education Program on the problem-solving skills of five-year-old children attending kindergarten has been analyzed. The study group of the research involves 37 five-year-old children attending a private kindergarten. The "Problem Solving Skills Scale (4–7 years old)'s form" developed by Aydoğan et al. (2012) was used for the pretest–posttest and retention test in the study. In addition, demographic information, such as the child's gender, birth order, educational status of the parents, monthly income, were collected with the "General Information Form" developed by the researcher. The STEM activities were applied by the researcher two days a week for eight weeks; no intervention was made to the control group and the current education program was continued.

According to the analyses made for the subpurpose of the study, firstly, it was determined that there was no statistically significant difference between the experimental and control groups in the PSSS total and subscale pretest-test scores ($p < 0.05$). The total of the PSSS of children in the experimental group who have received STEM-Based Education Program and the subscales of defining the problem, asking questions about the problem, defining the factors of the problem, predicting the outcome of a set of actions, finding the most appropriate solution, choosing the most unusual solution among many possible solutions' scores were significantly higher than the posttest scores of the control group ($p < 0.05$).

The posttest scores of children in the experimental group, the total of the PSSS, and noticing the problem, defining the problem, asking questions about the problem, predicting the cause of the problem, deciding on the adequacy of the information for the solution of the problem, defining the elements of the problem, using objects differently than its known, predicting the outcome of some actions, and choosing the most unusual solution among many possible solutions' scores were significantly higher than the pretest scores ($p < 0.05$).

It can be said that these activities, which are based on the engineering design cycle used in the STEM-Based Education Program applied to the experimental group, contribute to the problem-solving skills of children as well as provides them with engineering skills because this cycle consists of nine steps, i.e., defining the need or the problem; identifying the needs; developing possible solutions; choosing the best possible solution; drafting, testing, and evaluating the solution; presenting the solution; redesigning; and deciding. In addition, teaching methods and techniques of expression, educational games, observations, demonstrations, modeling, research–examination, group discussion, answering questions, brainstorming, research, experiment, games, role-playing, dramatization, etc., used in the activities, along with Turkish, games, music, art, drama, literacy preparation, science, and mathematics education activities in which these techniques are used were applied by incorporating with each other. In this context, it is normal to say that the training program applied is effective in understanding and defining the problem, collecting the necessary information for the solution of the problem, determining the solution of the problem, choosing the most appropriate solution for the problem, implementing the solution determined for the problem, and solving and evaluating the problem.

In support of the research findings, Lamb et al. (2015) analyzed the changes in children in terms of content, cognitive, and affective aspects during the inclusion of STEM education in the current education program, and also examined the development of children in the dimensions of science, mathematics, and technology; it was emphasized that STEM activities had an effect on the development of children in these dimensions. In this context, it has been indicated that STEM education at an early age has great importance for children's development. A total of 37 children, 17 in the experimental group and 20 in the control group, participated in the study in which the effect of STEM activities was examined; this study was conducted by Bal (2018) on the scientific process and problem-solving skills of 48–72-months-old children. As a result of the research, it has been indicated that STEM activities improved children's scientific process and problem-solving skills. In a similar study, Akgündüz and Akpınar (2018) applied science and mathematics activities to preschool children using engineering skills and interdisciplinary associations. As a result of the research conducted through qualitative patterns, it was observed that children gained science and mathematics skills. It has been determined that 21st-century skills, such as creativity, critical thinking, collaboration, and communication, have been developed. In addition, Cooper and Heaverlo (2013) examined the conditions that affect girls' interest in STEM-related fields in terms of problem-solving. In this regard, a relationship was observed between problem-solving skills and STEM disciplines. It has been indicated that an interest in problem-solving creates an interest in STEM disciplines, and in the same way, an interest in STEM disciplines creates an interest in problem-solving. In view of all these studies, it can be said that STEM activities play a major role in the development of children's problem-solving skills. Özsoy (2017) emphasized the importance of STEM education in order to raise individuals with 21st-century skills, such as problem-solving, critical thinking, creativity, and cooperation, in his study aimed to explain the applicability of creative drama in STEM education. Within the scope of the study, it was seen that problem-solving and mathematical thinking skills, which are the basis of STEM education, and creative drama achievements overlap with each other. As a result of the study, it has been emphasized that an effective teaching environment would be created by using creative drama in STEM education.

Based on the results of the above studies, it is shown that the education provided through STEM activities is effective in the development of children's problem-solving skills. This condition supports the finding of the research that the problem-solving skills of children will be increased with the provided education. Does the STEM-Based Education Program prepared for children attending kindergarten show persistence in children's problem-solving skills depending on the effect of education? This question was analyzed as the second subpurpose of the study. It was observed that the effect of the education was preserved with the permanence test applied to the experimental group three weeks after the last test. In addition, when analyzing the pretest–permanence test scores, the total of the PSSS and the subscales of defining the problem, asking questions about the problem, defining the elements of the problem, predicting the outcome of a set of actions, finding the most appropriate solution, and choosing the most unusual solution among many possible solutions' scores were observed to be significantly higher than the pretest scores ($p < 0.05$).

In support of the research findings, in the experimental studies conducted by Öcal (2018), in order to reveal the effect of the Early STEM Education Program on the scientific process skills of children, it was concluded that the Early STEM Education Program positively affected the scientific process skills of preschool children and the effect was permanent. In the study carried out by Alabay and Özdoğan (2018), in order to examine the effect of inquisition-based science activities applied to preschool children on scientific process skills, no significant difference was observed between the posttest scores of observation, classification, estimation, measurement, data recording, inference, and total scientific process skills and permanence scores.

In the posttest scores of the children in the control group who did not receive the STEM-Based Education Program, the PSSS was observed solely to be significantly higher than the total pretest scores ($p < 0.05$). It may have been affected by the variables that the researcher did not control and could not intervene in. According to this result, the cognitive development included in the MEB 2013 Pre-School Education Program applied in kindergarten "K2 Makes a prediction about the object, situation, event." "K19. The acquisition such as "finding solutions to problems" and their indicators could improve the problem-solving skills of the control group children (MEB, 2013).

As a result of the research, it is seen that the STEM-Based Education Program significantly affects the problem-solving skills of children. For this reason, education programs that support children's STEM and problem-solving skills at every stage of education should be reinforced with various activities. With the education programs that support children's problem-solving skills, understanding and defining the problem, collecting the necessary information for the solution of the problem, determining the way to solve the problem, choosing the most appropriate solution for the problem, applying the solution determined for the problem, and solving and evaluating the problem can also be developed.

New acquisitions and indicators can be added to support STEM and problem-solving skills while preschool education programs are reorganized. Various activities related to STEM and problem-solving skills can be included in the preschool education program for the development of 21st-century skills. In order to improve children's STEM and problem-solving skills, teachers can organize educational environments in a way that supports children's problem-solving skills by giving more place to the achievements and indicators in the education program in monthly and daily plans. More detailed information on the subject can be obtained by researching with a mixed method in which qualitative and quantitative methods are used together. Similar to the current study, more studies can be continued with different age groups in the same time period and the differences in interest and problem-solving skills towards STEM education can be examined in terms of age variables. STEM education programs for teachers can also be prepared and implemented. Thus, it can be ensured that teachers continue STEM activities in their classrooms.

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