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Effects of the STEM Education Program on Preschool Children's Science Process Skills

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Abstract

For more than a decade, STEM educational approaches have attracted the attention of educators. The aim of this study was to examine the effects of the Early STEM Education Program (ESTEMEP) on children's science process skills. The study utilized the semi-experimental research design and it was conducted with 26 six-year-old children in Istanbul during the 2017-2018 academic year. The "Preschool Science Process Skills Scale for 60-72 Month Old Children" was used in the study as a data collection tool. Before starting the education process, pretests were conducted with the experimental and control group. Secondly, the ESTEMEP was applied to the experimental group twice a week for 10 weeks, after which both groups were given a posttest. The covariance analysis test and Mann-Whitney U test were used for analyses, and the results show that, although the groups shared similar scores in the pretests, there was a significant difference in favor of the experimental group in the posttest scores. This finding shows that the ESTEMEP program is effective in the acquisition of science process skills (SPS).

Key words: *21st century skills; pre-school education; science process skills; STEM.*

Introduction

Science process skills

Today the number of studies and accumulation of knowledge are rapidly increasing thanks to both technological innovations and newly developed tools. The skills that scientists use in the process of revealing knowledge are called science process skills (SPS). In other words, science process skills are the behaviours of scientists that can be applied, taught and used in many fields (Padilla et al., 1984). These thinking skills, which are used for creating knowledge, thinking about problems and formulating results (Lind, 1998), are skills that not only scientists but everyone uses in their daily lives (Carin & Bass, 2001). Although science process skills are classified in different ways by researchers, many studies have divided science process skills into two categories: basic skills and combined skills. As the development of individual basic skills affects the acquisition of others (Kuhn et al., 2001), it represents the foundation for the acquisition of high-level skills (combined skills) (Meador, 2003). Considering the cognitive maturity of an individual, acquiring basic skills is appropriate for the younger age group (preschool and primary school), and the acquisition of combined skills is reserved for middle school and high school group (experimenting, creating models, interpreting data, etc.) (Soydan, 2017). In other words, competence in basic science process skills has an important role in the acquisition of advanced skills by laying the groundwork for attaining combined science process skills.

Definitions of basic science process skills are as follows:

Predicting: foreseeing the future based on available information (Harlen & Jelly, 1997). Therefore, the wider a person's knowledge of the subject is, the more likely they are to make correct predictions (Monhardt & Monhardt, 2006). Before making predictions in science education, children should be encouraged and supported to establish cause-effect relationships by asking questions such as "Why do you think so?" (Soydan, 2017). In other words, talking to children about the possibilities relating to events that have not yet happened, asking qualified questions on the basis of their existing knowledge and newly added information will support children in establishing connections between events as well as support them in constructing information in their minds.

Inferring: the ability to infer is defined by Myers et al. (2004) as reaching some conclusions or generalizations based on the learned information. The ability to make conclusions is influenced by the quantity and quality of the observations made by children during activities (Soydan, 2017). In this respect, it is important that children are guided by open-ended questions by the educator and have the opportunity to examine using different materials during observation. It should be noted that the prediction skill entails a statement about the future, while the inferring skill generates ideas about events that happened in the past.

Communicating: establishing scientific communication means sharing the findings of experiments, experiences and observations with various symbols, shapes and forms in a way that other people can understand (Buyuktaskapu, 2010). In other words, it is the skill of expressing the events examined and observed during the process in different ways and sharing them with other people. Young children can share these in different ways, such as talking, drawing pictures and creating graphics.

Observing: it is the examination of objects or events with one's senses or tools and devices (microscope, thermometer, etc.) that support these senses (Myers et al., 2004). When observing objects with young children, attention is paid to the differences between the objects rather than their similarities, and the general properties of these objects are emphasized rather than the detailed properties (Roden et al., 2005; Carin et al., 2005).

Sorting-Classifying: Carin (1993) states that the classification skill entails the ability to group events, information or objects according to their similarities or differences. When planning activities that support children's classification skills, their developmental characteristics should be considered. Preschool children who are in the pre-procedural period can group items according to one characteristic, but may have problems in grouping according to multiple characteristics (Soydan, 2017). For example, when children are given 6 stones, 3 black and 3 white, and 6 erasers, 3 white and 3 black, and asked to group them, some do it according to colour and some according to structure. When asked how else they can group them, few children will be able to answer the question correctly and name both features.

Measuring: it is the numerical expression of the properties of objects and events in a certain unit with the use of appropriate tools (Myers et al., 2004). While studying measurement skills with children, it is recommended to use non-standard measurement tools (Soydan, 2017). One of the reasons for this may be that children do not yet know how to use a standard measurement tool (Copley, 2000). Examples of non-standard measurements are measuring length by step, spanning or using objects such as pencils.

Children are innately willing and curious about research. This curiosity should be supported from the first years of life, and the child should be guided to maintain it systematically and correctly. According to Elkind (2001), children's acquisition of science process skills should be supported by providing appropriate formal experiences from the first moments in life. The role of the educator here is not to convey information to children but to provide them with science process skills and support children in acquiring knowledge and scientific principles on their own (Lapadat, 2000). STEM educational approach, which has been popular in recent years and has been shown to be effective in many studies, supports this role of educators.

Science, technology, engineering, math (STEM) educational approach

The STEM educational approach is an interdisciplinary approach (Akgunduz et al., 2015; Bybee, 2010; Sneideman, 2013). Piaget defined the concept of discipline as a field of teachable knowledge, which has its own content, method, education and procedure (Piaget, 1972, acc. to Jacobs, 1989). The interdisciplinary approach presents an in-depth focus on a subject of a certain discipline with the help of other related disciplines (Jacobs, 1989). In other words, the interdisciplinary approach starts from a problem, which it places in the focus of research, which is followed by gathering information from other related disciplines and proposing solutions based on making associations between the problem and the disciplines. Although science, technology, engineering and math were initially gathered under the name STEM by the NSF (National Science Foundation) in 2001, their history dates back to the early 19th century in different names or different combinations (Ostler, 2012). According to Merril, STEM education can be accomplished if the fields of study are handled as a single dynamic without being divided into disciplines (Merril, 2009, acc. to Erdogan & Stuessy, 2015). These disciplines cannot be considered independent from each other since they coexist in nature (Moomaw, 2013), which means that STEM is an integrative educational approach (Bybee, 2010; Kelley & Knowles, 2016). Corlu et al. (2014) claimed that the STEM approach is the result of integration of at least two disciplines and indicated that teachers and students' interests, knowledge and skills are among the factors that shape this process.

Importance of the STEM educational approach

The STEM approach provides an opportunity for the individual to use the information obtained from different fields in an effective and original way and to handle them as a whole, go beyond memorized information and produce solutions to the problems encountered in daily life with the information obtained from different disciplines. A certain age-appropriate level of knowledge and a readiness is expected from the individual in order to utilize the STEM approach. It aims to raise individuals with ability to think differently and innovatively, enables students to think in an interdisciplinary manner like engineers, produce appropriate solutions to existing problems and to determine the most suitable among the proposed solutions (Bybee, 2010). It has been emphasized in different studies that STEM education is significant in the acquisition of qualifications that the industry and technological development require from both individuals and society. It is grounded on engineering approach to problems and coming up with solutions with the use of science and mathematics combined with technology (Kennedy & Odell, 2014). The fact that US students' mathematics achievement was lower than the success of students from other countries influenced the emergence of STEM as a concept (Gonzalez & Kuenzi, 2012). It was thought that STEM education would increase the success and interest of students in this discipline. Development of a positive attitude towards STEM disciplines and strengthening STEM skills could contribute to the economic development of the country by meeting the need for qualified personnel in these disciplines. Sanders (2009) and Kelley and Knowles (2016) have shown that another benefit of STEM is its contribution to economies and amassing labour force, thus supporting the development of countries.

STEM education is part of formal and informal education from the pre-school education level (Moomaw, 2013) to the post-doctorate level (Gonzalez & Kuenzi, 2012). It is a very important goal to reveal and develop the potential of children in the preschool period, and in this way increase the level of children's readiness in other education levels (Polat & Bardak, 2019). Gunsen and Uyanık Balat (2017) mention three important factors, namely curriculum, teacher training and family, in helping children in preschool gain STEM skills. An appropriate education program for children, which is one of these three important factors, should support children's simple academic skills and make them feel that these academic skills have various purposes and benefits (Katz, 2010).

Sparkes (2017) states 7 stages for suitable implementations for the pre-school level. These stages are asking questions, imagining, planning, creating, testing, developing and communicating. This order can be completed in one go, or if necessary, it can revert to the previous stages at any stage. To summarize, in STEM implementation, children ask questions, examine the problem from a critical point of view, produce solutions to problems with original thoughts, they are productive and they cooperate and communicate in groups. It was claimed by Aldemir and Kermani (2016) that STEM activities which are well-built, full of stimuli and developmentally appropriate support preschool children's high level of STEM understanding and collaboration. In their study, Wan et al. (2020) categorized STEM related early childhood studies in four types: programming robots, traditional engineering design, digital games and comprehensive approach. In another study, 13 students between the age of 4 and 5 participated in a 2-week intervention program, which involved using 15 iPad educational applications for learning numeracy (Miller, 2018). Children's pre- and post-performance scores on numeracy skills were assessed and little difference was found between the overall post-intervention scores of children who used iPads and those who did not (Miller, 2018).

According to Tugluk and Ocal (2017), inclusion of STEM education will also encourage children to be curious, research and learn by doing. DeJarnette (2018), observed that children who participated in hands-on STEAM-modelled lessons were smiling and talking excitedly during their visit at the STEM center. Aldemir and Kermani (2017) also stated that STEM activities could develop young children's proficiency in mathematics, science and engineering concepts. Furthermore, according to Malone et al. (2018), engineering design activities could help children to gain deeper understanding of the work of scientists and engineers.

In early years, if children start to build STEM concepts and skills, these acquired skills and concepts will help them to further explore more complex and abstract concepts after entering elementary school (Geary et al., 2013; Locuniak & Jordan, 2008). Furthermore, research shows that children's early experiences in science, technology, engineering and mathematics will increase their probability of dealing with and succeeding in these areas in the future (Hassan et al., 2019; Park et al., 2017). In other words, the fact that children receive STEM education at an early age may positively affect their future orientation to STEM-related jobs, and this may be beneficial in meeting the STEM workforce needs of society. In his research, Atik (2019) examined the impact of STEM applications on preschool children's SPS. The research results show that STEM applications are statistically significant in improving children's SPS. Akcay (2019) examined the impact of STEM applications on preschool children's problem-solving skills and the results showed a significant difference in favour of the experimental group. In another study, researchers analyzed the impact of science activities attended by families on 5-6 year old children's science process skills and attitudes towards science (Yılmaz, 2017). According to the results, children who participated in the program had significantly better posttest scores.

The importance of early exposure to STEM was highlighted by some studies (Bagiati et al., 2010; Bybee & Fuchs, 2006). In the literature, most of the studies on STEM education were conducted at the higher education or university level, which shows the need for conducting research on applying STEM in the early years (Martin-Paez & Aguilera, 2019). In this context, the research question of this study was set:

"What is the effect of an education program based on the STEM approach on preschool children's science process skills?"

Methodology

The aim of the study

The current study aimed to investigate the effect of the STEM Program on the science process skills of 60-66 month-old children attending pre-school. Thus, it focused on answering the following questions:

What is the effect of the Early STEM Program (ESTEMEP) on children's science process skills?

Is there any difference between the posttest results on the Preschool Science Process Skills Scale between the experimental and control group?

Are the skills children acquired during the program's implementation (experimental group) retained?

Preparation of the ESTEMEP program

Relevant literature was thoroughly researched while preparing the program. ESTEMEP activities were mostly created by the first author of this study, in line with the literature and examples therein. The activities published by Moomaw (2013) and Sparkes (2017) were taken as examples while creating the program, for example, different types of surfaces were provided for the children to examine: rough, smooth and slippery. Then the children were shown a wooden board with three different surfaces: less rough, very rough and slippery. They were asked to predict on which surface the toy racecar would go faster. Then the slope of the board was increased and the children were asked about whether the car would go faster or slower. The activity continued with the children changing the slope and playing with the cars. In order to transform what the children experienced into a product, they were asked to form groups and create a racetrack with different difficulty levels. After that, the produced racetracks were evaluated and compared.

General background and participants

This research, which aimed to examine the effects of the STEM Program (ESTEMEP) designed for 60-66 month old preschool children on their science process skills, was conducted using the semi-experimental research method. This method does not utilize random, but convenient sampling, that is, the groups were already formed (Buyukozturk et al., 2008). However, the experimental group was chosen randomly.

Parents did not know to which groups their children belonged. Classroom teachers and the researcher conducting the pre-post tests were aware of the children's distribution in the groups. Children from both groups had similar daily routines in the course of the program's implementation.

The mentioned daily routine entailed a program prepared in line with the recommendations and indicators of the preschool education curriculum published by the Ministry of National Education in 2013. This program does not provide the content of the activities, but plans age-appropriate skills that children should acquire. Schools in each region were given a task of designing activities that support these acquisitions and respect the assigned indicators. The daily routine entailed children coming to school at 8:30 a.m., planning the day, free time, breakfast, the day's activity, lunch, rest, afternoon activities, a snack, evaluation and going home.

The attendance rate for both groups was similar. The aim of using the experimental research model was to assess the impact of the independent variable on the dependent variable. After the application of pretests with all participants, the independent variable (ESTEMEP) was applied (for 10 weeks) to one part of the participants (experimental group). Then, the posttests were conducted and the impact of the application evaluated (Fraenkel & Wallen, 2009). According to Fraenkel and Wallen (2009), programs lasting more than eight weeks are beneficial for students.

The research sample consisted of 26 children between 60 and 66 months of age attending a kindergarten in Istanbul during the 2017-2018 academic year. 15 children were in the experimental group and 11 in the control group. Before the start of the study, necessary permissions from institutions and parents were obtained, and the parents were informed about the process. The children were also informed about the study and knew that the participation in the activities was voluntary. Cluster sampling method was used, i.e. the study was conducted without changing the nature or structure of the classes. The experimental and control group were determined randomly. Demographic information about the participants is given in Figure 1.

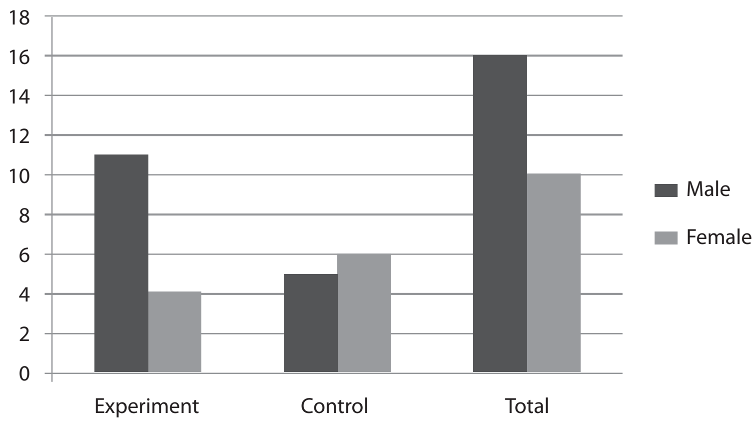


Figure 1. Gender distribution of the children in the experiment and control group

Figure 1 shows that 15 (58 %) out of 26 children were in the experimental group while the other 11 (42 %) were in the control group. When the gender distribution of the experimental group is examined, it is seen that 4 (27 %) children were female and the remaining 11 (73 %) male. Gender distribution of the control group shows, on the other hand, that 6 (54 %) out of 11 children were female and 5 (46 %) male.

The sampling power of the study was analyzed. The power is defined as the probability of finding a difference when, in fact, a difference exists (Fraenkel & Wallen, 2009). It was determined that the sampling power of the study was 0.80 and the effect size 0.22, according to the number of groups and values of means and standard deviations. While the power level of the sample is sufficient, it can be stated that the effect sizes are sufficient but weak (Power> 0.70, effect size> 0.15, Kocher, 1999) The sample's power and effect sizes were calculated using G * Power software, Version 3.1.7.

Instruments and procedures

This research utilized the quantitative method, and the data were collected via *Personal Information Form* and *Preschool Science Process Skills Scale for 60-72-Month-Old Children* developed by Ozkan (2015).

Personal Information Form consists of questions about the child's name, gender, age, parents' education level and the family's income.

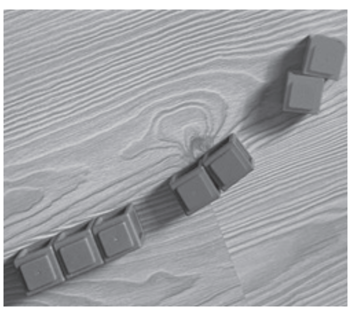
Preschool Science Process Skills Scale for 60-72 Month Old Children. Factor load values of the scale range from 0.89 to 0.96. Cronbach's alpha coefficient 0.81 found the split-half reliability result to be 0.79. The scale consists of 31 items and has four sub-dimensions: prediction-inference-scientific communication, classification, assessment and observation. The answers were scored with 1 point for correct and 0 points for incorrect answer. The maximum overall score was 31 and the minimum 0. Some examples of sub-dimensions of the scale are given below.

Prediction-Inference-Scientific Communication:

Third task of this dimension: "I have two ice cubes of the same size in my hand. I'll throw one in hot water and one in cold water. Tell me which melts faster."

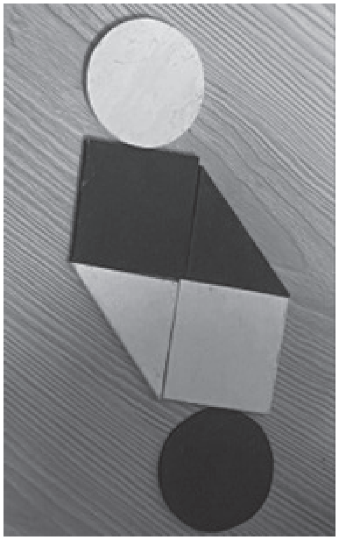
Classification:

First task of this dimension: "There are blocks of different colors here. Group these blocks according to their similarities."



Photograph 1. First task in the classification sub-dimension

Second task of this dimension: "There are some geometric shapes here. Group these shapes according to their similarities."



Photograph 2. Second task in the classification sub-dimension

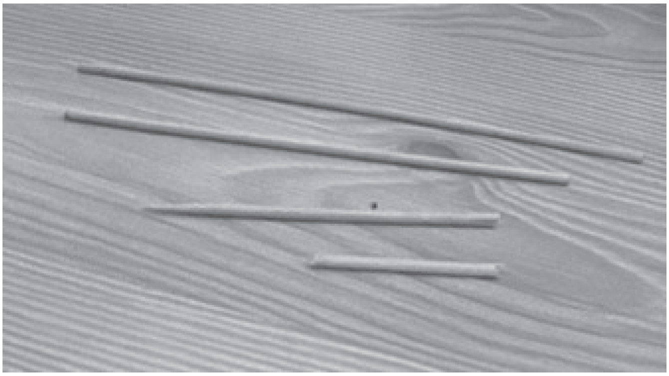
Assessment:

Sixth task of this dimension: "There are three objects here. Pick them up one by one and tell me which one is the lightest." Although volumes of the boxes are the same, their weights are different. If the child shows the lightest one, they gain 1 point, and if not, they gain 0 points.

Photograph 3. Sixth task of the assessment sub-dimension

Observation:

Fourth task in this sub-dimension: "There are sticks here. Rank these sticks from the shortest to the longest."



Photograph 4. Fourth task of the observation sub dimension

For each task children gain 1 point if they complete it correctly. If their answer is false, they get 0 points. The test was administered individually to each child by the researcher in an empty classroom. The personal information form was filled out by the teachers using information from the children's files. Before starting the education process, all participants filled out the pretest, after which experimental and control groups were determined and STEM activities conducted with the experimental group twice a week, in the course of 10 weeks. Meanwhile, the control group followed regular daily routine. Upon the program's completion, final-tests were conducted and finally, after one month, the retention test was applied to the experimental group.

Data analysis

The collected data were analyzed with SPSS. The frequency distributions were calculated according to participants' gender.

Non-parametric tests were conducted since the numbers of participants in the experimental and control group was under 15 (Fraenkel & Wallen, 2009). Since the small size of the sample (under 30) requires it (Buyukozturk et al., 2008), the distribution's normality was also examined. The results of the applied Shapiro-Wilk's test showed that the data were not normally distributed neither for individual sub-dimensions nor for the overall scale ($p<.05$).

The study used the Wilcoxon Test in order to compare the pretest-posttest results of the participants in the experimental and control group, Mann Whitney U Test to compare the posttest scores of the experimental and control group (except for prediction-inference-scientific communication sub-dimension), ANCOVA test to compare the prediction-inference-scientific communication sub-dimension of the experimental and control group, and Wilcoxon-Signed Rows Test to compare the experimental group's posttest and retention test scores.

Because there was a significant difference in pretest results in favour of the control group in terms of prediction-inference-scientific communication sub-dimension of the scale, ANCOVA analysis was applied for the comparison of experimental and control in prediction-inference-scientific communication sub-dimension. While applying the ANCOVA analysis, histogram results were considered and the distribution's normality assumed because there is no version of ANCOVA for non-parametric analysis.

Results

This section looks at whether the applied ESTEMEP has had a significant impact on the experimental group children's science process skills acquisition and if the kindergarten's routine daily flow has considerably affected the control group children's science process skills acquisition. Moreover, the study also examined whether a difference existed in the control and experimental group between the initial state and the one ten weeks after, i.e. after the program's completion. Another point that was researched was the retention of the applied ESTEMP's benefits. According to the results, the effects of the implementation continued in the retention test. The results of the Mann Whitney U Test for comparing the pre-test scores of the groups are given in Table 1.

Table 1
The results of Independent Mann Whitney U Test regarding the comparison of experimental and control group children's results for the overall scale and its sub-dimensions

	Groups	N	Mean rank	Sum of ranks	U	p
Prediction-Inference-Scientific Communication	Experimental	15	10.47	157.00	37.00	.016
	Control	11	17.64	194.00		
Classification	Experimental	15	12.03	180.50	60.50	.232
	Control	11	15.50	170.50		
Assessment	Experimental	15	14.17	209.50	72.50	.597
	Control	11	12.59	141.50		
Observation	Experimental	15	13.97	209.50	75.50	.699
	Control	11	12.86	141.50		
Science Process Skills	Experimental	15	11.57	173.50	53.50	.128
	Control	11	16.14	177.50		

According to Table 1, a statistically significant difference was found in favour of the control group in terms of prediction-inference-scientific communication ($U=37.00$, $p<.05$). It is observed that the mean rank of the experimental group's prediction-inference-scientific communication skill is M.R.=10.47 and the control group's M.R=17.64. The data presented in Table 1 show no statistically significant difference in the scores of classification, assessment, observation and the overall scale ($p>.05$). It can be inferred, according to the obtained data, that the groups are mutually similar, except in the first sub-dimension.

According to Table 2, statistically significant difference was found between the experimental group children's pre- and posttest results for the overall scale and its sub-dimensions in favour of the posttest ($p<.05$). According to this result, it can be said that the applied ESTEMEP has had a positive impact on the experimental group children's science process skills.

Table 2

The results of Wilcoxon-Signed Rows Test regarding the comparison of the experimental group children's results on the pretest-posttest for the overall scale and its sub-dimensions

		N	Mean rank	Sum of ranks	z	p
Prediction-Inference-Scientific Communication	Negative Row	0	.00	.00	3.43	.001
	Positive Row	15	8.00	120.00		
	Equal	0				
Classification	Negative Row	0	.00	.00	3.33	.001
	Positive Row	14	7.50	105.00		
	Equal	1				
Assessment	Negative Row	1	8.00	8.00	2.24	.025
	Positive Row	10	5.80	58.0		
	Equal	4				
Observation	Negative Row	1	4.00	4.00	2.65	.008
	Positive Row	10	6.20	62.00		
	Equal	4				
Science Process Skills	Negative Row	0	.00	.00	3.41	.001
	Positive Row	15	8.00	120.00		
	Equal	0				

Table 3

The results of Wilcoxon-Signed Rows Test regarding the comparison of the control group children's pre-and posttest results for the overall scale and its sub-dimensions

		N	Mean rank	Sum of ranks	z	p
Prediction-Inference-Scientific Communication	Negative Row	2	2.00	4.00		
	Positive Row	8	6.38	51.00	2.41	.016
	Equal	1				
Classification	Negative Row	4	6.38	25.50		
	Positive Row	6	4.92	29.50	.20	.83
	Equal	1				
Assessment	Negative Row	2	5.00	10.00		
	Positive Row	5	3.60	18.00	.70	.48
	Equal	4				
Observation	Negative Row	4	6.25	25.00		
	Positive Row	5	4.00	20.00	.31	.75
	Equal	2				
Science Process Skills	Negative Row	2	3.00	6.00		
	Positive Row	8	6.31	49.00	2.20	.027
	Equal	1				

According to Table 3, statistically significant difference was found between control group children's results on the pretest and posttest for prediction-inference-scientific communication sub-dimension and the overall scale ($p<.05$) in favour of the posttest.

According to this result, it can be said that the applied routine curriculum has had a positive impact on the control group children's prediction-inference-scientific communication scientific process skill (p>.05).

Table 4
The results of ANCOVA regarding the comparison of experimental and control group children's posttest results for Prediction-Inference-Scientific Communication sub-dimension

Variance Source	Sum of Squares	df	Mean of Squares	F	Significance Level (p)
Prediction-Inference-Scientific Communication	32.257	1	32.257	10.928	.003
Group	40.457	1	40.457	13.707	.001
Error	67.889	23	2.952		
Total	2067.00	26			
Corrected Total	119.885	25			

Table 4 shows a significant difference between the children who participated in the ESTEMEP and those who did not (F=13.707, p<.05). While there is a difference in favour of the control group in the pretests, posttests indicate a difference in favour of the experimental group. This shows that children who participated in the ESTEMEP program scored higher in this sub-dimension of the scale, compared to children who attended preschool but did not participate in the supporting program.

Table 5
The results of Mann Whitney U Test regarding the comparison of experimental and control group children's posttest scores for the overall scale and its sub-dimensions

	Groups	N	Mean rank	Sum of ranks	U	p
Classification	Experimental	15	17.70	265.50	19.50	.001
	Control	11	7.77	85.50		
Assessment	Experimental	15	16.20	243.00	42.00	.027
	Control	11	9.82	108.00		
Observation	Experimental	15	16.47	104.00	38.00	.016
	Control	11	9.45	247.00		
Science Process Skills	Experimental	15	17.40	261.00	24.00	.002
	Control	11	8.18	90.00		

According to Table 5, there was a statistically significant difference between the children who participated in the ESTEMEP and those who did not in terms of results for classification, assessment, observation and the overall scale (U=19.50, p<.05; U=42.00, p<.05; U=38.00, p<.05; U=24.00, p<.05). The table shows the mean rank of the experimental group's classification skill of M.R=17.70 and M.R=7.77 for the control group. The mean rank of the experimental group's assessment skill was M.R=16.20

and of the control group M.R=9.82. The obtained mean rank of the experimental group's observation skill was M.R=16.47, and of the control group's M.R=9.45. The mean rank of the experimental group's results on the overall scale was M.R=17.40, whereas the control group's was M.R=8.18. This shows that science process skills of the children who participated in the ESTEMEP were higher in 3 sub-dimensions and the overall scale, when compared to the children in the control group, who attended the routine curriculum.

Table 6
The results of Wilcoxon-Signed Rows Test regarding the comparison of the experimental group children's posttest-retention scores for the overall scale and its sub-dimensions

		n	Mean rank	Sum of ranks	z	p
Prediction-Inference-Scientific Communication	Posttest	15	6.75	27.00	.55	.58
	Retention Test	15	5.57	39.00		
Classification	Posttest	15	3.00	9.00	1.51	.131
	Retention Test	15	1.00	1.00		
Assessment	Posttest	15	2.00	4.00	.57	.564
	Retention Test	15	2.00	2.00		
Observation	Posttest	15	4.38	17.50	.63	.527
	Retention Test	15	3.50	10.50		
Science Process Skills	Posttest	15	5.00	20.00	.78	.434
	Retention Test	15	5.83	35.00		

According to Table 6, there is no statistically significant difference in the posttest and retention test scores of the children participating in the program in terms of all the sub-dimensions and the overall scale scores ($p>.05$). This result shows the long-term effect of applying the ESTEMEP on science process skills retention of the experimental group.

Discussion and conclusion

The results of this research show a statistically significant difference between the experimental group children's pretest and posttest results for the overall scale and its sub-dimensions, i.e. prediction-inference-scientific communication, classification, assessment and observation skill. It can be inferred from this result that the applied ESTEMEP has considerably influenced preschool children's overall science process skills. It is important to examine each sub-dimension and the overall result on the scale separately because each sub-dimension measures a different variable. For example, while a child may have a weak result in , for example, measuring skills, he/she may have a high overall result. It is therefore important to consider the overall result as well as results in individual sub-dimensions if one aims to obtain an in-depth cognisance of the researched construct.

Atik (2019) and Bal (2018) acquired similar findings in their research in which they examined the impact of STEM applications on preschool children's SPS. In their study, which examined the impact of STEM applications on preschool children's problem-solving skills, Akcay (2019) found a significant difference in favour of the experimental group. Buyuktaskapu (2010) found that the constructivist science education program developed as part of the study had a positive impact on the preschool children's science process skills. In another study, in which the impact of the science curriculum on preschool children's SPS was analyzed (Ozkan, 2015), it was stated that the applied program was influential. In their study, Aladé et al. (2016) showed that child-targeted educational media can support preschoolers' learning of a novel measurement skill. Yılmaz (2017) analyzed the impact of science activities attended by families on the 5-6 year-old children's science process skills and attitudes towards science and found a statistically significant difference in the posttest scores of the children who had participated in the program. These findings are in line with Toprakkaya's (2016) study on questioning-based science activities applied in outdoor space, Yagcı's (2016) study on nature and environment applications and Gunsen et al.'s (2018) study on the impact of a constructivist science education program on children's SPS.

There is no significant difference between the control group children's pretest and posttest scores in classification, assessment and observation sub-dimension. However, there is considerable difference in the control group's pretest-posttest scores of the prediction-inference-scientific communication sub-dimension and the overall scale in favour of the posttest. It can be concluded based on this result that the routine curriculum had a considerable positive impact on the mentioned sub-dimension and the overall result of the children from the control group. This result is similar to the results obtained by Buyuktaskapu (2010) and Yılmaz (2017), whereas it is different from those by Akcay (2019), Bal (2018), Ozkan (2015), Toprakkaya (2016) and Yagcı (2016).

While a statistically significant difference was in favour of the control group's pretests results on the prediction-inference-scientific communication sub-dimension of the scientific process scale, the posttest shows a statistically significant difference in favour of the experimental group. The groups were the same in the other sub-dimensions and the overall scale scores, while there was a significant difference determined in favour of the experimental group in the posttests. This shows that children who participated in the ESTEMEP scored higher in the prediction-inference-scientific communication sub-dimension of the scale than the children who did not participate. In addition, a considerable difference was found in the classification, assessment, observation and overall scale scores in favour of the children from the experimental group. These findings are similar to the findings of Akcay (2019), Ozkan (2015), Buyuktaskapu (2010), Toprakkaya (2016) and Yılmaz (2017) in the relevant literature. In another study, Saraç (2018) examined the effects of STEM practices on students' learning in a meta-analysis study. In this study, 23 articles published between 2010 and 2017 on primary, secondary and tertiary education were analysed. The effect sizes for students were calculated in academic achievement, science process skills and attitudes towards STEM disciplines. The study reported a significant effect of 0.820 for science process skills.

There was no statistically significant difference found between the experimental group children's posttest and retention test scores in terms of all sub-dimensions and the overall scale. This shows the long-term effect of applying the ESTEMEP. This finding is in line with the results of many studies in the literature (Akcay, 2019). In their study, Becker and Kyungsuk's (2011) identified that cohesive STEM lessons within the curriculum resulted in a positive impact on elementary students' achievement.

This study shows the importance of ESTEMEP in early years. According to the current study, compared with regular preschool education program in Turkey, STEM educational approach has a positive effect on children's science process skills, i.e. predicting, inferring, communicating, observing, classifying and measuring. A study conducted by Watts et al. (2014) shows that preschool children's math ability predicted their achievement in math at the age of 15. Therefore, we expect that earlier experiences of the experimental group could have an effect on their achievement in STEM related areas and their job preference later on (Sheehan et al., 2018). According to the study results, in-service training can be offered to preschool teachers about ESTEMEP education, and they can be supported to develop awareness and a positive attitude about the issue. There are a few studies about the STEM educational approach at the preschool level. Qualitative or mixed studies ought to be conducted to gain a more in-depth understanding of this concept. Further studies can be done to examine the impact of STEM applications on preschool children's different abilities (such as critical and creative thinking and problem solving). Studies should be conducted with different participants or a larger sample, so that generalizations can be made.

There are some limitations of this study. The study is a quantitative study based on the data obtained from a scale. It is important to carry out qualitative or mixed-methods studies to more deeply understand the topic. Because of the children's age, the size of the sample was small. Further research studies ought to be conducted on bigger samples. As a possible drawback of this study, the gender ratio between the experimental and control group could also be mentioned.

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Utjecaj STEM obrazovnoga programa na vještine znanstvenoga mišljenja predškolske djece

Sažetak

Pristupi STEM obrazovanja već više od desetljeća privlače pažnju edukatora. Cilj je ovoga istraživanja ispitati utjecaj programa ranoga STEM obrazovanja (PRSTEMO) na vještine znanstvenoga razmišljanja djece. Istraživanje je imalo polueksperimentalni dizajn i obuhvatilo je 26 djece u dobi od šest godina. Provedeno je u Istambulu tijekom 2017./2018. školske godine. Kao mjerni instrument u istraživanju je korištena Skala vještina znanstvenoga razmišljanja predškolske djece u dobi od 60 do 72 mjeseca. Prije početka obrazovnoga procesa s kontrolnom i eksperimentalnom grupom proveden je predtest. Uslijedila je primjena PRSTEMO-a u eksperimentalnoj skupini dva puta tjedno u periodu od 10 tjedana. Nakon toga su obje skupine rješavala posttest. Za analizu podataka korišteni su Mann Whitney U test i analiza kovarijance. Rezultati pokazuju da su grupe imale slične rezultate u predtestu i značajnu razliku u korist eksperimentalne skupine u posttestu što znači da je rani STEM obrazovni program učinkovit u stjecanju vještina znanstvenoga mišljenja (VZM) predškolske djece.

Ključne riječi: *predškolsko obrazovanje; STEM; vještine 21. stoljeća; vještine znanstvenoga mišljenja.*

Uvod

Vještine znanstvenoga mišljenja

U današnje vrijeme broj istraživanja i količina znanja ubrzano rastu zahvaljujući tehnološkim inovacijama i novim alatima. Vještine koje koriste znanstvenici u procesu otkrivanja novih spoznaja zovu se vještine znanstvenoga mišljenja (VZM). Drugim riječima, vještine znanstvenoga mišljenja su ponašanja znanstvenika koja se mogu primijeniti, poučavati i koristiti u mnogim područjima (Padilla i sur., 1984). Te vještine, tj. vještine koje se koriste za stvaranje znanja, razmišljanje o problemima i formuliranje rezultata (Lind, 1998) vještine su kojima se svi koriste u svakodnevnom životu, a ne samo znanstvenici (Carin i Bass, 2001). Iako istraživači različito klasificiraju vještine znanstvenoga mišljenja, većina istraživanja dijeli ih u dvije kategorije: osnovne vještine i kombinirane vještine. Kako razvoj jedne od tih vještina utječe na razvoj drugih (Kuhn i sur., 2001), usvajanje tih vještina kod djece predstavlja osnovu za stjecanje vještina visoke razine (kombiniranih vještina) (Meador, 2003). S obzirom na kognitivnu zrelost pojedinca stjecanje osnovnih vještina može biti namijenjeno za mlađu dobnu skupinu (predškolska dob i osnovna škola), a stjecanje kombiniranih vještina rezervirano za više razrede osnovne i srednju školu (eksperimentiranje, stvaranje modela, tumačenje podataka itd.) (Soydan, 2017). Drugim riječima, kompetencija u osnovnim vještinama znanstvenoga mišljenja ima važnu ulogu u stjecanju naprednih vještina, tj. predstavlja temelj za kombinirane vještine znanstvenoga mišljenja.

Definicije osnovnih vještina znanstvenoga mišljenja su sljedeće:

Predviđanje: Predviđanje budućnosti na osnovi postojećih informacija (Harlen i Jelly, 1997). Što osoba više zna o nekoj temi, vjerojatnije je da će ona donositi točna predviđanja (Monhardt i Monhardt, 2006). Prije predviđanja u obrazovanju u području znanosti djecu bi trebalo poticati i podržavati u uspostavljanju uzročno-posljedičnih odnosa postavljajući im pitanja poput: „Zašto tako misliš?" (Soydan, 2017). Drugim riječima, razgovor s djecom o mogućnostima vezanim uz događaje koji se još nisu zbili te postavljanje primjerenih pitanja na koja djeca odgovaraju na osnovi postojećega znanja i novih informacija, pomoći će djeci u povezivanju događaja, kao i konstruiranju znanja u njihovim umovima

Zaključivanje: Myers i suradnici (2004) definiraju sposobnost razmišljanja kao donošenje zaključaka ili generalizacija na osnovi dobivenih informacija. Sposobnost zaključivanja je pod utjecajem kvantitete i kvalitete dječjega promatranja tijekom aktivnosti (Soydan, 2017). U tom smislu važno je djeci postavljati pitanja otvorenoga tipa i dozvoliti im da tijekom opservacija istražuju koristeći razne materijale. Treba napomenuti da vještina predviđanja podrazumijeva izjavu o budućnosti, a vještina zaključivanja ideju o događajima koji su se dogodili u prošlosti.

Komuniciranje: Uspostavljanje znanstvene komunikacije je dijeljenje rezultata eksperimenata, iskustava i promatranja u obliku različitih simbola i formi na način koji drugi ljudi mogu razumjeti (Buyuktaskapu, 2010). Drugim riječima, to je vještina izražavanja proučavanih i promatranih događaja na različite načine, tj. njihovoga dijeljenja s drugim ljudima. Djeca mlađe dobi mnogu ihpodijeliti na različite načine, npr. razgovorom, crtanjem ili slikanjem.

Promatranje: Ispitivanje predmeta ili događaja osjetilima i instrumentima (mikroskop, termometar itd.) koja potpomažu osjetila (Myers i sur., 2004). Pri promatranju predmeta djeca mlađe dobi često više pridaju pažnju razlikama među predmetima nego njihovim sličnostima, a naglašavaju opća svojstva tih predmeta, ne detalje (Roden i sur., 2005; Carin i sur., 2005).

Razvrstavanje-Klasificiranje: Prema Carinu (1993) vještina klasificiranja odnosi se na grupiranje događaja, informacija ili objekata prema njihovim sličnostima ili razlikama. Prilikom planiranja aktivnosti za razvoj dječjih vještina klasifikacije u obzir treba uzeti njihove razvojne karakteristike. Predškolska djeca u predoperacijskom stadiju mogu grupirati predmete prema jednoj osobini, ali mnoga imaju problema u grupiranju prema višestrukim karakteristikama (Soydan, 2017). Na primjer, kada se djeci da ukupno 6 kamenčića, od kojih su tri crna i tri bijela, i ukupno šest gumica, tri bijele i tri crne, i kada ih se traži da ih grupiraju, neki to čine prema boji, a neki prema strukturi predmeta. Kada ih se pitalo kako ih se još može grupirati, malo je djece sposobno odgovoriti točno, tj. reći prema obje značajke.

Mjerenje: Numerički izraz svojstava predmeta i događaja u nekoj cjelini s primjerenim alatima (Myers i sur., 2004). Prilikom učenja vještina mjerenja s djecom, preporučeno je koristiti se nestandardnim mjernim instrumentima (Soydan, 2017). Jedan od razloga za to može biti da djeca još ne znaju kako se koristiti standardnim alatima za mjerenje (Copley, 2000). Primjeri nestandardnih mjera su mjerenje dužine korakom, pedljima ili upotrebom predmeta poput olovaka.

Djeci je urođena volja i znatiželja za istraživanjem. Ta znatiželja treba se njegovati od prvih godina života, a dijete bi u tom procesu trebalo voditi na sustavan i ispravan način. Prema Elkindu (2001), stjecanje vještina znanstvenoga razmišljanja djece trebalo bi podupirati kroz primjerna formalna iskustva od rođenja. Uloga edukatora u tom procesu nije prenositi djeci informacije, već ih opremiti vještinama znanstvenoga mišljenja i primjenjivati pristup poučavanja zasnovan na tim vještinama, kako bi djeca sama usvojila znanje i znanstvene principe (Lapadat, 2000). STEM obrazovani pristup, koji se u zadnje vrijeme popularan i dokazano učinkovit, podupire ovu ulogu edukatora.

Znanstveni-tehnološki-inženjerski-matematički (STEM) obrazovni pristup

STEM obrazovni pristup je interdisciplinarni pristup (Akgunduz i sur., 2015; Bybee, 2010; Sneideman, 2013). Koncept discipline definirao je Piaget kao polje znanja koje se može poučiti, koje ima svoj sadržaj, metodu, obrazovanje i postupak (Piaget, 1972, prema Jacobs, 1989). Interdisciplinarni pristup fokusira se na predmet istraživanja u specifičnoj disciplini i, osim toga, dubinski proučava predmet koristeći druge povezane discipline (Jacobs, 1989). Drugim riječima, u interdisciplinarnom pristupu u središte dolaze problem i disciplina iz koje taj problem proizlazi. Zatim se prikupljaju informacije iz različitih disciplina vezanih uz problem i predlaže se rješenje uspostavljanjem veza između problema i dobivenih informacija. Iako znanost, tehnologija, inženjerstvo i matematika predstavljaju prve discipline koje je okupio naziv STEM NSF-a (Nacionalnog udruženja za znanost) iz 2001. godine, njihova povijest počinje u ranom 19. stoljeću u različitim imenima ili kombinacijama (Ostler, 2012). Prema Merrilu, STEM obrazovanje može se ostvariti ako se poljima proučavanja pristupa kao cjelini, a da ih se ne dijeli u discipline (Merril, 2009, prema Erdogan i Stuessy, 2015). Te se discipline ne mogu smatrati neovisnima jedna o drugoj jer u prirodi postoje zajedno (Moomaw, 2013), što znači da je STEM integrativni obrazovni pristup (Bybee, 2010; Kelley i Knowles, 2016). Corlu i suradnici tvrde da je STEM pristup rezultat integracije najmanje dvije discipline te da su interesi, znanje i vještine učitelja i učenika među faktorima koji oblikuju taj proces.

Važnost STEM obrazovnoga pristupa

STEM pristup osigurat će priliku za pojedinačnu upotrebu informacija dobivenih iz različitih polja na učinkovit i originalan način, za njihovu obradu u cjelini koja nadilazi puko pamćenje informacija te stvaranje rješenja za svakodnevne probleme pomoću dobivenih informacija. Od pojedinaca se očekuje određena razina znanja i spremnosti prema dobnoj skupini. Ovaj pristup nastoji odgojiti pojedince sa sposobnostima drugačijega i inovativnoga razmišljanja o vlastitu znanju, omogućiti učenicima da razmišljaju interdisciplinarno poput inženjera, stvaraju kvalitetna rješenja za postojeće probleme i odabiru najprimjerenije rješenje među predloženima (Bybee, 2010). Istraživanja naglašavaju da je STEM obrazovanje značajno u stjecanju kvalifikacija koje pred pojedince i društva stavljaju industrija i tehnološki razvoj. STEM obrazovanje zasnovano je na inženjerskom pristupu problemima i stvaranju rješenja upotrebom znanosti i matematike u kombinaciji s tehnologijom (Kennedy i Odell, 2014). Činjenica da su učenici u SAD-u imali slabiji uspjeh u matematici od onih u drugim zemljama, utjecao je na pojavu STEM-a kao koncepta (Gonzalez i Kuenzi, 2012). Smatralo se da će STEM obrazovanje povećati uspjeh i interes učenika za ovu disciplinu i razviti pozitivne stavove prema STEM disciplinama i razvoju STEM vještina, te tako doprinijeti ekonomskom razvoju zemlje zadovoljavajući potrebu za kvalificiranim osobljem u tim disciplinama. Sanders (2009) i Kelley i Knowles (2016) pokazali su još jednu korist STEMA: doprinos ekonomiji zemalja i stvaranju radne snage koja pomaže razvoj.

STEM obrazovanje dio je formalnoga i neformalnoga obrazovanja od predškolske razine (Moomaw, 2013) do poslijediplomskoga obrazovanja (Gonzalez i Kuenzi, 2012). Vrlo je važno otkriti i razviti potencijal djece u predškolskom razdoblju i na taj način povećati razinu spremnosti djece za druge obrazovne razine (Polat i Bardak, 2019). Gunsen i Uyanık Balat (2017) navode kurikul, obrazovanje učitelja i obitelj kao tri važna faktora u procesu stjecanja STEM vještina predškolske djece. Primjeren obrazovni program za djecu trebao bi podupirati jednostavne akademske vještine djece i dati im osjećaj da te vještine imaju raznolike svrhe i koristi (Katz, 2010). Sparkes (2017) navodi sedam stadija za odgovarajuće primjene na razini predškolskoga obrazovanja: postavljanje pitanja, zamišljanje, planiranje, stvaranje, testiranje, razvijanje i komunikacija. Ovaj redoslijed može se završiti odjednom ili se proces, ako je to potrebno, može vratiti unatrag u bilo koji stadiji. Iz navedenoga slijedi da u primjeni STEM aktivnosti djeca postavljaju pitanja, ispituju problem s kritičkim stavom, stvaraju rješenja za probleme s originalnim razmišljanjem, produktivna su te surađuju i komuniciraju u grupnom radu. Aldemir i Kermani (2016) tvrde da su dobro osmišljene STEM aktivnosti pune poticaja i primjerene razvoju osnova za visoku razinu STEM razumijevanja predškolske djece i njihovu suradnju. U svojem istraživanju Wan i suradnici (2020) kategorizirali su studije o STEM području u obrazovanju ranoga djetinjstva u četiri tipa: programiranje robota, tradicionalni inženjerski dizajn, digitalne igre i sveobuhvatni pristup. U drugom istraživanju trinaest učenika u dobi od četiri i pet godina sudjelovalo je u intervencijskom program koji je trajao dva tjedna i uključivao korištenje 15 obrazovanih aplikacija za učenje računanja na iPad-u (Miller, 2018). Ocijenjene su dječje vještine računanja u predtestu i posttestu te je ustanovljena mala razlika između cjelokupnih rezultata na posttestu djece koja su se koristila iPad-om i one koja nisu (Miller, 2018).

Prema Tugluku i Ocalu (2017), uvođenje STEM obrazovanja također će potaknuti djecu da budu znatiželjna, istražuju i uče kroz aktivnost. DeJarnette (2018) je primijetio da su se djeca koja su sudjelovala u neposrednoj nastavi STEM modeliranja smijala i uzbuđeno govorila tijekom njihova posjeta STEM centru. Osim toga, Aldemir i Kermani (2017) navode da STEM aktivnosti mogu razviti znanje djece mlađe dobi o matematičkim, znanstvenim i inženjerskim konceptima. Osim toga, prema Maloneu i suradnicima (2018), aktivnosti inženjerstva mogu pomoći djeci da steknu dublje razumijevanje posla znanstvenika i inženjera.

Ako djeca u ranoj dobi počnu stjecati STEM koncepte i vještine, oni će im pomoći u daljem istraživanju složenih i apstraktnih ideja nakon osnovne škole (Geary i sur., 2013; Locuniak i Jordan, 2008). Osim toga, istraživanja pokazuju da rana iskustva djece u znanosti, tehnologiji, inženjerstvu i matematici povećavaju vjerojatnost da će se baviti i uspjeti u tim područjima u budućnosti (Hassan i sur., 2019; Park i sur., 2017). Drugim riječima, STEM obrazovanje djece u ranoj dobi može pozitivno utjecati na njihovu buduću orijentaciju na poslove u STEM području, što predstavlja korist za društvo s potrebom za radnom snagom u STEM području. Atik je u svojem istraživanju (2019) ispitivao utjecaj STEM aplikacija na VZM predškolske djece. Rezultati toga istraživanja pokazali su da STEM aplikacije statistički značajno poboljšavaju vještine znanstvenoga mišljenja djece. Akcay (2019) je istraživao utjecaj STEM aplikacija na vještine rješavanja problema predškolske djece i pronašao značajnu razliku u korist eksperimentalne skupine. U još jednoj studiji istraživači su analizirali utjecaj znanstvenih aktivnosti obitelji na vještine znanstvenoga mišljenja petogodišnjaka i šestogodišnjaka te njihove stavove prema znanosti (Yılmaz, 2017). Rezultati su pokazali značajnu razliku u rezultatima posttesta u korist djece koja su sudjelovala u programu.

Važnost ranoga izlaganja STEM-u naglašena je u istraživanjima (Bagiati i sur., 2010; Bybee i Fuchs, 2006). U povezanoj literaturi većina istraživanja o STEM obrazovanju provedena su na razini visokoga obrazovanja, što otkriva potrebu za provođenjem takvih istraživanja u ranim godinama (Martin-Paez i Aguilera, 2019). S obzirom na to, slijedi istraživačko pitanje ove studije: „Koji je utjecaj obrazovnog programa zasnovanoga na STEM pristupu na vještine znanstvenoga mišljenja predškolske djece?"

Metode

Cilj istraživanja

Ovim istraživanjem nastojalo se ispitati utjecaj STEM programa na vještine znanstvenoga mišljenja predškolske djece u dobi od 60 do 72 mjeseca. Stoga su formulirana sljedeća istraživačka pitanja:

Koji je utjecaj ranoga STEM programa (ESTEMEP) na vještine znanstvenoga mišljenja djece?

Ima li razlike između eksperimentalnih i kontrolnih skupina u rezultatima posttesta na Skali vještina znanstvenoga mišljenja predškolske djece?

Jesu li se postignuti ishodi djece koja su sudjelovala u programu (eksperimentalna skupina) zadržali?

Priprema ESTEMEP programa

Prilikom pripreme PRSTEMO-a detaljno je pregledana relevantna literatura. Aktivnosti programa većinom je kreirao prvi autor ovoga rada, u skladu s literaturom i primjerima u literaturi. Aktivnosti koje su osmislili Moomaw (2013) i Sparkes (2017) služile su kao primjeri prilikom kreiranja programa. Na primjer, s djecom su se ispitivale različite površine - gruba, glatka, klizava. Zatim se djeci pokazala drvena daska s tri različite površine: manje gruba, vrlo gruba i skliska. Od njih se tražilo da predvide na kojoj će površini trkaći autić ići najbrže. Zatim se povećao nagib ploče pa su djeca trebala odgovoriti na pitanje hoće li autić ići brže ili sporije. Aktivnost se nastavila tako da su djeca mijenjala nagib i igrala se s autićima. Kako bi dječje doživljaje pretvorili u produkt, djeca su se grupirala i radila trkaće staze različite težine. Nakon toga su stvorene trkaće staze koje su ocijenjene i uspoređene.

Opća pozadina i sudionici

Ovo istraživanje, kojim se nastojalo ispitati utjecaj STEM programa (PRSTEMO) na vještine znanstvenoga mišljenja predškolske djece starosti 60 do 72 mjeseca, provedeno je kao polu-eksperimentalno istraživanje u kojemu je izbor grupa bio namjeran, tj. nisu promijenjene strukture već postojećih vrtićkih skupina (Buyukozturk i sur., 2008). Nasumično je odabrana eksperimentalna skupina. Za razliku od razrednih učitelja i istraživača, roditelji nisu znali kojoj skupini djeca pripadaju. Tijekom provedbe programa, djeca iz obje skupine imala su slične dnevne rutine.

Spomenuta dnevna rutina predstavlja program pripremljen u skladu s naputcima i odredbama kurikula za predškolsko obrazovanja Ministarstva državnoga obrazovanja iz 2013. godine. Program ne nudi sadržaj aktivnosti, ali određuje vještine koje bi djeca trebala usvojiti prema dobnim skupinama. Škole u svakoj regiji dobile su zadatak kreirati aktivnosti za stjecanje ciljanih ishoda i indikatore prema njihovim regionalnim karakteristikama. Tijek dana bio je sljedeći: dolazak u školu u 8.30, planiranje aktivnosti za taj dan, slobodne aktivnosti djece, doručak, sudjelovanje u aktivnosti dana, ručak, odmor, poslijepodnevne aktivnosti, užina, evaluacija. Nakon opisanoga tijeka djeca odlaze kućama.

Stopa pohađanja nastave za obje grupe bila je slična. Cilj upotrebe eksperimentalnoga istraživačkog modela bio je procijeniti utjecaj nezavisne varijable (PRSTEMO) na zavisnu varijablu (VZM). Nakon što su svi sudionici riješili predtest, proveden je kreirani program u trajanju od deset tjedana, s određenim brojem sudionika (eksperimentalna skupina). Nakon toga proveden je posttest i ocijenjen utjecaj provedbe programa (Fraenkel i Wallen, 2009). Prema Fraenkelu i Wallenu (2009), programi koji traju duže od osam tjedana korisni su za neke učenike.

Uzorak ovoga istraživanja obuhvatio je 26 djece starosti od 60 do 72 mjeseca koja su pohađala vrtić u Istambulu tijekom 2017./2018. školske godine, a od toga ih je 15 bilo u eksperimentalnoj skupini i 11 u kontrolnoj skupini. Prije početka istraživanja dobivene su potrebne dozvole od institucija i roditelja djece, koji su isto informirani o procesu istraživanja. Djeca su također dobila informacije o istraživanju te su da znala da ne moraju sudjelovati u aktivnostima ako to ne žele. Upotrijebljena je metoda uzorkovanja klastera, a istraživanje provedeno bez promjene prirode i strukture predškolskih skupina. Eksperimentalna i kontrolna skupina određene su nasumično. Slika 1 predstavlja demografske karakteristike sudionika.

Slika 1.

Prvi grafički prikaz pokazuje da je 15 (58 %) od 26 djece bilo u eksperimentalnoj skupini, a ostalih 11 (42 %) u kontrolnoj skupini. S obzirom na spol, uočljivo je da je u eksperimentalnoj skupini bilo 4 djevojčice (27 %) i sedam dječaka (73 %), a u kontrolnoj skupini bilo je 6 djevojčica (54 %) i 5 (46 %) dječaka.

Analizirana je valjanost uzorka istraživanja, koja predstavlja vjerojatnost pronalaženja razlike u slučaju kada ona postoji (Fraenkel i Wallen, 2009). U ovome istraživanju vrijednost dobroga pristajanja uzorka bila je 0,80 i veličine učinka 0,22 prema broju skupina i razinama aritmetičke sredine i standardne devijacije. Dok su vrijednosti pristajanja uzorka dovoljne, za razine veličine učinka može se reći da su dovoljne, ali slabe (Power> 0,70, veličina učinka> 0,15, Kocher, 1999). Vrijednosti pristajanja i veličine učinka izračunati su upotrebom G * Power softver, verzija 3.1.7.

Instrumenti i postupci

U ovome istraživanju korištena je kvantitativna metoda, a podatci su sakupljeni putem Obrasca s osobnim informacijama i Skale vještina znanstvenoga mišljenja predškolske djece starosti od 60 do 72 mjeseca koju je kreirao Ozkan (2015).

Obrazac s osobnim informacijama sadrži podatke o imenu djeteta, spolu i dobi, razini obrazovanja majke i oca i prihodu obitelji.

Skala vještina znanstvenoga mišljenja predškolske djece starosti od 60 do 72 mjeseca - vrijednosti zasićenja faktora skale bile su u rasponu od 0,89 do 0,96. Cronbachov alpha koeficijent 0,81 found the split-half reliability result to be 0,79. Skala se sastoji od 31 čestice i četiri poddimenzije. Te poddimenzije su predviđanje, zaključivanje i znanstvena komunikacija, klasifikacija, procjena i opservacija. Točni odgovori vrednovali su se jednim bodom, a rezultat za netočan odgovor bio je nula. Maksimalan ukupan rezultat na skali bio je 31, a minimalan 0. Neki primjeri poddimenzija skale predstavljeni su u nastavku.

Poddimenzija predviđanja-zaključivanja-znanstvene komunikacije:

Treći zadatak ove dimenzije: „U ruci imam dvije kocke leda jednake veličine. Jednu ću staviti u vruću, a drugu u hladnu vodu. Reci mi koja će se prije otopiti."

Poddimenzija klasifikacije:
Prvi zadatak u ovoj dimenziji: „Ovdje vidiš kocke različitih boja. Grupiraj ih prema sličnosti."

Fotografija 1.

Drugi zadatak u ovoj dimenziji: „Ovdje vidiš neke geometrijske oblike. Grupiraj ih prema sličnostima."

Fotografija 2.

Poddimenzija procjene:
Šesti zadatak ove dimenzije: „Ovdje su tri predmeta. Podigni ih jednog po jednog i reci koji je najlakši." Iako su volumeni kutija jednaki, njihove su težine različite. Ako dijete pokaže najlakši, dobiva jedan bod.

Fotografija 3.

Poddimenzija promatranja:
Četvrti zadatak u ovoj dimenziji: „Ovdje vidiš štapiće. Posloži ih od najkraćega do najdužega."

Fotografija 4.

Za svaki ispravno riješen zadatak djeca su dobivala jedan bod. Netočno riješeni zadatci nisu nosili bodove. Svako dijete je individualno rješavalo uz prisutnost istraživača u praznoj učionici. Učitelji su ispunjavali obrazac s osobnim informacijama koristeći informacije u dosjeima djece. Prije početka programa sa svim sudionicima proveden je predtest i određene su eksperimentalna i kontrolna skupina. U eksperimentalnoj skupini provedene su STEM aktivnosti dva puta tjedno tijekom deset tjedana. U međuvremenu, kontrolna skupina slijedila je već ustaljenu svakodnevnu rutinu. Nakon toga provedeni su završni testovi. U konačnici je proveden i test retencije s eksperimentalnom skupinom, mjesec dana nakon provedbe projekta.

Analiza podataka

Prikupljeni podatci analizirani su u SPSS programu. Distribucije učestalosti izračunate su prema varijabli spola sudionika.

Provedeni su neparametrijski testovi budući da je broj sudionika u eksperimentalnoj i kontrolnoj skupini bio manji od 15 (Fraenkel i Wallen, 2009). Provedena je i provjera normalnosti distribucije podataka zbog maloga uzorka (manje od 30 ispitanika) (Buyukozturk i sur., 2008). Prilikom analize rezultata Shapiro-Wilk testa otkriveno je da podatci nisu pokazali normalnu distribuciju kroz skalu i njezine poddimenzije ($p<,05$).

U istraživanju je primijenjen Wilcoxon test za usporedbu rezultata na predtestu i posttestu sudionika u eksperimentalnoj i kontrolnoj skupini. Nadalje, primijenjen je Mann Whitney U test kako bi se usporedili rezultati na posttestu eksperimentalne i kontrolne skupine (osim za poddimenziju predviđanja-zaključivanja-znanstvene komunikacije). Također je provedena analiza kovarijance (ANCOVA) radi usporedbe poddimenzije predviđanja-zaključivanja-znanstvene komunikacije eksperimentalne i kontrolne skupine i Wilcoxonov test sume rangova za usporedbu rezultata sudionika u eksperimentalnoj skupini na posttestu i testu retencije.

Zbog značajne razlike u rezultatima predtesta u korist kontrolne skupine u poddimenziji predviđanja-zaključivanja-znanstvene komunikacije, upotrijebljena je analiza kovarijance (ANCOVA) za usporedbu rezultata eksperimentalne i kontrolne skupine na posttestu. Prilikom provedbe analize kovarijance razmatrani su rezultati histograma uz pretpostavku normalne distribucije podataka jer ne postoji verzija ANCOVA-e za neparametrijsku analizu.

Rezultati

U ovome dijelu rada razmatra je li primijenjeni program (PRSTEMO) značajno utjecao na vještine znanstvenoga razmišljanja djece u eksperimentalnoj skupini u usporedbi s onima djece u kontrolnoj skupini koja su slijedila uobičajeni odgojno-obrazovni program. Osim toga, ovdje su predstavljeni rezultati o zadržavanju stečenih vještina, tj. uspoređuje se početno stanje djece i ono nakon deset tjedana. Rezultati pokazuju da su učinci primjene programa zadržani u testu retencije. U Tablici 1 prikazani su rezultati predtesta eksperimentalne i kontrolne skupine.

Tablica 1.

Podatci iz Tablice 1 pokazuju značajnu razliku u korist kontrolne skupine u dimenziji predviđanja-zaključivanja-znanstvene komunikacije ($U = 37,00$, $p < ,05$). Vidi se da je srednji rang eksperimentalne skupine za dimenziju predviđanja, zaključivanja i znanstvene komunikacije $MR = 10,47$, a u kontrolnoj skupini on iznosi $MR = 17,64$. Nije ustanovljena značajna razlika u rezultatima dimenzija klasifikacije, procjene i promatranja i ukupnom rezultatu skale ($p > ,05$). Može se zaključiti da su skupine slične, osim u prvoj poddimenziji.

Tablica 2

Iz Tablice 2 vidljiva je statistički značajna razlika između rezultata u predtestu i posttestu djece eksperimentalne skupine u svim dimenzijama skale i ukupnom rezultatu. Prema tome, može se zaključiti da je primijenjeni program imao pozitivan utjecaj na vještine znanstvenoga razmišljanja djece u eksperimentalnoj skupini.

Tablica 3

Podatci u Tablici 3 pokazuju statistički značajnu razliku između rezultata predtesta i posttesta u korist posttesta djece iz kontrolne skupine u dimenziji predviđanja, zaključivanja i znanstvene komunikacije i rezultata na cjelokupnoj skali ($p < ,05$). Prema tome, može se zaključiti da je primijenjeni redovni kurikul imao pozitivan učinak na vještine znanstvenoga mišljenja djece iz kontrolne skupine u dimenziji klasifikacije, procjene i promatranja ($p > ,05$).

Tablica 4

Podatci prikazani u Tablici 4 prikazuju značajnu razliku između djece koja su sudjelovala u programu i one koja nisu (F = 13,707, p < ,05). Iako postoji razlika u korist kontrolne skupine u predtestu, rezultati posttesta pokazuju razliku u korist eksperimentalne skupine. Ovaj rezultat govori u prilog tome da su djeca koja su sudjelovala u primjeni programa imala više rezultate u ovoj dimenziji skale, nego ona koja su pohađala redovni program i nisu sudjelovala u PRSTEMO-u.

Tablica 5

Rezultati u Tablici 5 pokazuju statistički značajnu razliku između djece koja su sudjelovala u programu i one koja nisu u dimenzijama klasifikacije, procjene i promatranja i rezultatima cjelokupne skale (U = 19,50, p < ,05; U = 42,00, p < ,05; U = 38,00, p < ,05; U = 24,00, p < ,05). Srednji rang za vještinu klasifikacije u eksperimentalnoj skupini iznosio je MR = 17,70, a srednji rang kontrolne skupine MR = 7,77. Srednji rang vještine procjene u eksperimentalnoj skupini iznosio je MR = 16,20, a u kontrolnoj skupini MR = 9,82. Srednji rang vještine promatranja u eksperimentalnoj skupini bio je MR = 16,47, a u kontrolnoj MR = 9,45. Naposljetku, srednji rang za cjelokupnu skalu u eksperimentalnoj skupini iznosio je MR = 17,40, a u kontrolnoj skupini MR = 8,18. Ovi rezultati pokazuju razvijenije vještine znanstvenoga mišljenja djece koja su sudjelovala u primjeni PRESTEMO-a u 3 dimenzije i cjelokupnoj skali, u usporedbi s djecom iz kontrolne skupine, koja su pohađala redovni program.

Tablica 6

Iz Tablice 6 vidljivo je da nije ustanovljena statistički značajna razlika između rezultata posttesta i testa retencije djece koja su sudjelovala u programu za sve poddimenzije i rezultat cjelokupne skale (p > ,05). Ovaj rezultat pokazuje dugoročni učinak primjene PRSTEMO-a na vještine znanstvenoga mišljenja djece iz eksperimentalne skupine.

Rasprava i zaključak

Rezultati ovoga istraživanja pokazuju statistički značajnu razliku između predtesta i posttesta djece iz eksperimentalne skupine za sve poddimenzije skale – predviđanje/zaključivanje/znanstvena komunikacija, klasifikacija, procjena i promatranje te za cjelokupnu skalu. Prema tome, može se zaključiti da je primjena programa značajno utjecala na vještine znanstvenoga mišljenja djece predškolske dobi u eksperimentalnoj skupini u cijelosti i prema svim poddimenzijama skale. Važno je ukupan rezultat na skali i pojedinačne dimenzije jer svaka mjeri drugu varijablu. Na primjer, dijete može imati nedovoljno razvijene vještine mjerenja, a visok ukupan rezultat vještina znanstvenoga mišljenja.

Atik (2019) i Bal (2018) došli su do sličnih rezultata u svojem istraživanju u kojem su ispitivali utjecaj STEM aplikacija na vještine znanstvenoga mišljenja predškolske djece. Nadalje, u svojem istraživanju utjecaja STEM aplikacija na vještine rješavanja problema predškolske djece Akcay (2019) je otkrio značajnu razliku u korist eksperimentalne skupine. U još jednom istraživanju Buyuktaskapu (2010) je pokazao da program konstruktivističkoga znanstvenog obrazovanja ima pozitivan utjecaj na vještine znanstvenoga mišljenja predškolske djece. Još je jedno istraživanje ispitivalo utjecaj kurikula znanosti, zasnovanoga na učenju putem zaključivanja, na vještine znanstvenoga mišljenja predškolske djece (Ozkan, 2015), u kojemu je otkriveno da je primijenjeni program imao pozitivan utjecaj. U svojem istraživanju Alade i suradnici (2016) pokazali su da obrazovani mediji namijenjeni djeci pomažu u procesu učenja novih vještina mjerenja. Yilmaz (2017) je u svojem istraživanju utjecaja znanstvenih aktivnosti obitelji na vještine znanstvenoga mišljenja i stav prema znanosti petogodišnjaka i šestogodišnjaka otkrio statistički značajnu razliku između rezultata predtesta i posttesta sudionika u provedbi programa. Ti su rezultati sukladni onima koje je dobio Toprakkaya (2016) u svojem istraživanju znanstvenih aktivnosti zasnovanih na propitivanju i primijenjenih na otvorenom, Yagcıjevom (2016) istraživanju aplikacija o prirodi i okolini te rezultatima istraživanja Gunsena i suradnika (2018) utjecaja konstruktivističkogaa znanstveno-obrazovnog programa na vještine znanstvenoga mišljenja djece.

U ovom istraživanju nije ustanovljena značajna razlika između rezultata predtesta i posttesta u poddimenzijama klasifikacije, procjene i promatranja. Ipak, pronađena je značajna razlika u rezultatima predtesta i posttesta u dimenziji predviđanja-zaključivanja-znanstvene komunikacije i cjelokupnoj skali kontrolne skupine u korist posttesta. Ovaj rezultat navodi na zaključak da redovni kurikul ima značajan pozitivan utjecaj na jedan dio vještina znanstvenoga mišljenja djece u kontrolnoj skupini, tj. predviđanje, zaključivanje i znanstvenu komunikaciju. Ovaj je rezultat u skladu s rezultatima koje su dobili Buyuktaskapu (2010) i Yılmaz (2017), a razlikuje se od onih do kojih su došli Akcay (2019), Bal (2018), Ozkan (2015), Toprakkaya (2016) i Yagcı (2016).

U predtestu je ustanovljena značajna razlika u korist kontrolne skupine za poddimenziju skale znanstvenoga mišljenja predviđanja-zaključivanja-znanstvene komunikacije, a posttest pokazuje značajnu razliku u korist eksperimentalne skupine. Skupine su međusobno jednake u drugim poddimenzijama i rezultatima cijele skale. Nasuprot tome, otkrivena je značajna razlika u korist eksperimentalne skupine u posttestovima, što pokazuje da su djeca koja su sudjelovala u PRSTEMO-u imala više rezultate u poddimenziji predviđanja-zaključivanja-znanstvene komunikacije, nego djeca koja nisu sudjelovala u provedbi programa. Osim toga, ustanovljena je značajna razlika u vještinama klasifikacije, procjene i promatranja i rezultatima cjelokupne skale u koristi djece iz eksperimentalne skupine. Ovi su rezultati u skladu s rezultatima Akcay (2019), Ozkana (2015), Buyuktaskapua (2010), Toprakkayaja (2016) i Yılmaza (2017) u relevantnoj literaturi. U još jednom istraživanju Saraç (2018) je ispitivao utjecaj STEM praksi na učenje učenika koristeći metaanalizu. U tom istraživanju analizirana su 23 rada o osnovnom, srednjoškolskom i visokom obrazovanju objavljena između 2010. i 2017. godine. Veličine učinka izračunate su za akademski uspjeh učenika, vještine znanstvenoga mišljenja i stavove prema STEM disciplinama. Veličina učinka vještina za vještine znanstvenoga mišljenja iznosila je 0,820.

Nije pronađena značajna razlika u posttestu i testu retencije djece u eksperimentalnoj skupini na svim poddimenzijama i cjelokupnoj skali. Ova činjenica pokazuje dugoročni učinak primjene PRSTEMO-a i sukladna je rezultatima istraživanja u literaturi (Akcay, 2019). U svojem istraživanju Becker i Kyungsuk (2011) su ustanovili da kohezivna nastava u STEM području rezultira pozitivnim utjecajem na uspjeh učenika u osnovnoj školi.

Ovo istraživanje pokazuje važnost PRSTEMO-a u ranim godinama. Prema ovom istraživanju, u usporedi s klasičnim kurikulom, STEM pristup obrazovanju ima pozitivan učinak na vještine znanstvenoga mišljenja djece, tj. predviđanje/zaključivanje/komuniciranje, promatranje, klasificiranje i mjerenje. Istraživanja Wattsa i suradnika (2014) pokazuje da su matematičke sposobnosti predškolske djece prediktor njihova uspjeha u matematici u dobi od 15 godina. Očekivano je da će ranija iskustva eksperimentalne skupine imati učinak na njihov uspjeh u STEM područjima i kasnije na njihov odabir zanimanja (Sheehan i sur., 2018). S obzirom na rezultate ovoga istraživanja, učiteljima se može osigurati profesionalno usavršavanje u području PRSTEMO-a te im treba pružiti potporu u razvijanju svijesti i pozitivnoga stava o toj temi. Postoje malobrojna istraživanja o STEM obrazovanom pristupu na predškolskoj razini. Stoga je potrebno provoditi kvalitativne ili miješane studije kako bi se steklo dublje razumijevanje ovoga koncepta. Dalja istraživanja mogu se provoditi kako bi se ispitao učinak STEM aplikacija na predškolsku djecu u različitim varijablama (poput kritičkoga mišljenja, kreativnoga mišljenja i rješavanja problema). Istraživanja se mogu provoditi s različitim sudionicima i na većem uzorku. Na taj se način rezultati istraživanja mogu usporediti i generalizirati.

Ovo istraživanje ima neka ograničenja. Ono je kvantitativno i zasnovano na podatcima dobivenim primjenom skale. Važno je provesti kvalitativno ili miješano istraživanje kako bi se steklo dublje razumijevanje ovoga pitanja. Ovaj je uzorak bio malen zbog dobi djece. Prijedlog za buduća istraživanja je da se provedu na većem uzorku. Neravnomjeran omjer spolova između kontrolne i eksperimentalne skupine također se može shvatiti kao nedostatak ovoga istraživanja.