Examination of the Effect of the GEMS Program on Problem Solving and Science Process Skills of 6 Years Old Children

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Abstract: The aim of this study is to determine the problem solving skills and science process skills of six year-old children who attended kindergarten and whether or not there is a difference in problem solving skills and science process skills of children receiving and not receiving the education with GEMS program. In the study using the experimental model with pre-test, post-test and control group, the sample group consisted of a total of 25 children including 11 children in experimental group and 14 children in control group who attended the preschool education. The "GEMS Program" was applied throughout a school year after applying pre-test to the children in the experimental group. In the scope of the study, "General Information Form" to obtain the data about the children and their families, "Parental Evaluation Form" including the evaluation of the parents about their children, "Problem Solving Scale in Science Education (PSSSE)" to determine the problem solving skills of the children and "Science Processes Observation Form (SPOF)" to measure the science process skills of the children were used. According to the results of the study, while a statistically significant difference was observed between the Problem Solving Scale in Science Education mean scores of the children in the experimental group who participated in the GEMS Education Program and of the children in control group, no statistically significant difference was observed between the mean scores obtained by the children in the experimental group from Science Processes Observation Form and the mean scores of the children in the control group.

Keywords: *GEMS, problem solving, problem solving scale, science process skills, preschool years.*

Introduction

The barriers the individual encounters in the process of reaching any goal are defined as problem. In addition, how these barriers can be overcome is another problem for the individual. Problems are not only new but they are also unknown conditions (Bingham, 1983; Morgan, 1982; Serin, Serin and Saygili, 2010; Unal and Aral, 2014a). Individuals have to find solutions for this new and unknown situation namely problems they encounter (Ozbay, 2002). The process of conscious operations made to overcome this problem, namely to overcome the barriers encountered during the process of reaching the goal is generally defined as problem solving process (Ozsoy, 2005). Problem solving defined as an ability that an individual must acquire is defined as overcoming the difficulties experienced in the process of reaching a goal. Another definition of problem solving is isolating the causes of a problem and removing or at least reducing its effects (Serin et al., 2010; Voss, Greene, Post, and Penner, 1983). Adults and children can utilize different sources to solve these problems they encounter (Gelbal, 1991). There are different factors affecting this process in terms of the child who reviews his/her knowledge for solution of a problem he/she encounters, uses his/her previous experiences, observes the surrounding models, and searches for a solution by reviewing the opportunities in the environment. The development of problem solving skills in children is directly associated with the child's age, readiness, attitude towards the problem, abilities, attitude, family, environment, experiences, information, and abilities (Bingham, 1983; Gelbal 1991; Zeytun, 2010). In addition, providing problem solving experiences to the children and supporting them with education problems are important in terms of problem solving skills (Aydogan, 2004). The development of thinking on the problems and the solution skills is directly related to the acquisition of science process skills (Tan and Temiz, 2003). Preschool children use senses in accessing information and recognizing environment. Children obtain the information, they get through their senses, by observing the events, establishing the cause-effect relationship between the concepts or cases they observed, using research instincts, performing measurements namely by using scientific processes (Unal and Akman, 2006). In this respect, there is a relationship between the science process skills and problem solving skills. With commencement of education process, children fulfill functions such as

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collect information, organizing the collected information, and make an inference over this organization. Children who can fulfill these basic and intermediate skills of the science process steps tend towards higher level of skills such as hypothesis building. The development of the child's science process skills also supports the development of abilities in the solution of the problems in his/her life. (Arnas, 2007; Charlesworth and Lind, 2003; Kazeni 2005). It is important to acquire science process skills and support the children in this subject starting from the early period during the acquisition of the problem solving skill, important in terms of the development of the child.

In the preschool period, which is one of the most important periods of the development process and has a multidimensional development; children perform effective learning depending on the power of their learning potential. It is important to plan the education, in which children are active and learning by doing and living, in such a way to support multidimensional development through different and rich materials in terms of effective learning. When this situation is taken into consideration, preschool education programs are expected to be effective for the children in areas such as self-awareness, social skills, awareness of their own cultures and other cultures, communication skills, perceptual motor skills, analytical thinking, problem solving skills, creativity, and aesthetic skills (Anliak and Dincer, 2005; Aral, Kandir and Can Yasar 2002; Senemoglu, 1994;). Another goal of the programs on early childhood education that prepare the children for life by supporting them in many areas during the development period is to make children qualified about how they can overcome the obstacles they will encounter in the course of life. The GEMS (Great Explorations in Math and Science) program, which is one of the alternative programs used in preschool education for the development of science process and problem solving skills in children, is called as the program of great explorations in science and mathematics (Pompea and Gek, 2002; Saglam, 2012). The GEMS program is defined as a quality and flexible program that brings exciting, effective science and mathematics activities into the class. Through the activities made with GEMS programs, opportunities supporting science and mathematics concepts, social development, thinking skills and physical development are offered to children. The GEMS program which activates the questioning which is the basis of scientific thinking by activating the curiosity feeling in children guides them to find answers to questions arising from their own researches. In this guidance process, it is aimed to train children as individuals who can question, think freely, and do analysis and synthesis. These aims directly affect science process and problem solving skills (Bergman, 2017; Cam, 2013; Pompea and Gek, 2002; Saritas, 2010; Yalcin and Tekbiyik, 2013). The GEMS program allowing children to reveal their unique ideas and to realize the activities in any environment when they are planned intends to create the perception for the children to be able to do science by themselves. With the GEMS activities carried out by using easily available and inexpensive materials, direct participation of the children in the process are provided and children's direct observation to the nature events and close examination of the nature events and living creatures are taken as basis. The GEMS program supporting the scientific processes in science and mathematics fields in children also directly affects the science process and problem solving skills of the children with this aspect (Bergman, 2017; Cam, 2013; Pompea and Gek, 2002; Saglam, 2012; Yalcin and Tekbiyik, 2013).

The GEMS program, which is used as an alternative approach in preschool education, concentrates especially on science and mathematics fields and confronts children with multidimensional problems. Additionally, the GEMS program creating the awareness about the natural environment, guides the children in the solution of the problems and the scientific processes that children face in all these processes. There are numerous studies in the literature about the preschool science education from the teacher's opinions to the effect of this education to the problem solving and science process skills of the children (Ayvaci, Dececioglu and Yigit, 2002; Garbet, 2003; Kildan and Pektas, 2009; Kuru and Akman, 2017; Sackes, 2014; Unal and Aral, 2014b)When examining from theoretical framework, it is seen that even though it is stated that GEMS program supports the development of children in early childhood education and gives them a scientific perspective. However, there is a limited number of studies in the literature indicating the effect of GEMS program on children's problem solving skills and science process skills.

A majority of the problem-solving skills prepared for children in the literature are especially related to the measurement of interpersonal problem solving skills. Besides, there is only one scale available that measures the problem solving skills of children related to scientific problems in the literature. This scale was developed for the purpose of observing how the science problem solving skills of children changed with the GEMS problem. The purpose of this study, therefore, is to examine the effect of GEMS program on the scientific problem-solving skills and on the science process skills of children.

Methodology

The mixed method study is defined as the incorporation of qualitative and quantitative methods, approaches, and concepts within a study (Creswell, 2003). In the studies, the use of both qualitative and quantitative methods is considerably widespread. In this study, the mixed method involving both qualitative and quantitative dimensions took place as a data collection technique was used, as well.

Research Goal

The aim of this study is to investigate the effect of GEMS education, which is used as an alternative approach in the early childhood education, on the problem solving and science process skills of 6 year-old children. The following three questions were sought in this direction;

1. Does GEMS education have any effect on problem solving skill of the 6 year children?
2. Does GEMS education have any effect on science process skills of the 6 year children?
3. Does GEMS education have any effect on problem solving and science process skills of children in terms of parents' opinions?

Sample and Data Collection

The aim of this study was to determine the effect of GEMS education program, applied to six year-old children attending preschool education institutions, on their problem solving and science process skills. The quantitative dimension the study was planned as a semi-experimental design and pre-test, post-test, and control group were used. While the dependent variable of this study design was "problem solving skills" and "science process skills" of 6 year-old preschool children, the independent variable investigating the effect on problem solving and science process skills of the children is the "GEMS Program". The qualitative dimension of the study involved the use of explanatory design. In explanatory design, the quantitative and qualitative data collections are not independent from each other, but connected to each other. In this design, the purpose of collecting the qualitative data is to obtain more elaborate data concerning the individuals to contribute to the quantitative data in the most suitable way (Creswell and Clark, 2011). In the scope of the study, the quantitative data were collected by using "Problem Solving Scale in Science Education" (PSSSE) to measure problem solving skills of children and "Scientific Processes Observation Form (SPOF)" to measure their science process skills. By the semi-structured interview form, the qualitative data were obtained to assess the opinions of the parents of the children in the experimental group concerning the effects of GEMS program on children. In this study, the mixed design in which qualitative and quantitative data were obtained was used. It was aimed to deeply analyze the effects of GEMS education on children by taking the opinions of parents.

While the GEMS program is applied to the children in the experimental group in the classes along with the education applications within the scope of the study, MEB preschool education program carried out within the scope of normal education activities in the classrooms was continued for the children in the control group. The Ministry of National Education's preschool education program implemented on the control group is an integrated education program. Even though it incorporates science and mathematics activities, it is not as intensive as the GEMS program in terms of science and mathematics activities. In addition, it does not has a material environment that is not rich and structured as much as the material variety used in GEMS. From this way, the education program applied on the control group is separated from the education program implemented on the experimental group. The GEMS program has themes and units different from the MEB preschool education program and consists of fully structured activities. Among the themes of the GEMS program, there are fingerprints, hats, shoes for September, wooden houses, wheels for October, bags, aprons, dinosaurs for November, clocks, chains, and gates for December, brush, money, penguins for January, frogs, eggs for February, pipes, stones and elephants for March, leaves, ladybug, and bees for April, lady beetles, ants, butterflies for May, and balls and lamps for June. In these themes, science topics such as creatures, environment, life cycle, physics, and world sciences are given with mathematics subjects such as patterns, order, figure, geometrical figure, spatial perception and problem solving. In the education program for the children in the experimental group, the GEMS program was not a an additional practice that took place for an hour, but teachers thematized this program with an understanding of integrated education program through activities such as games, drama, Turkish language activities, field trips, and experiments. The researchers did not have any intervention to the control group.

The study was conducted in the kindergartens of two private schools affiliated with the Ministry of National Education in the Malatya province in the school year of 2016-2017. Purposeful sampling method was preferred in determining schools. In the case that the units to be observed in the studies to be conducted are formed with people, events, objects or situations in certain qualities, this type of sampling is named as criterion sampling method from the purposive sampling methods (Buyukozturk, 2017). While determining the sample group in this study, 11 children in the kindergarten of a private school applying GEMS program were included in the experimental group and 14 children in the kindergarten of a private school in a similar socio-economic level were included in the control group.

GEMS workshop was established at the schools where the GEMS program was applied and the teachers who were going to apply the program received the necessary trainings about the implementation of the program. Within the scope of the training, the teachers were trained in the use of basic approaches and materials of the GEMS program. In the science and mathematics exploratory researches, they were trained on pattern, grouping, sorting and comparison studies suitable for the purpose of using the materials in GEMS workshop where appropriate experiments can be made for the development of the child. The children performed their activities at the GEMS workshop, with one lesson hour each day on weekdays.

Table 1.Distribution of demographic characteristics of the children participating in the study

Demographic Characteristics	Experimental Group		Control Group		Total	
	n	%	n	%	n	%
Gender						
Girl	4	36,4	6	42,9	10	40
Boy	7	63,6	8	57,1	15	60
Total	11	100	14	100	25	100
Age						
60-66 months	6	54,5	10	71,4	16	64
67-72 months	5	45,5	4	28,6	9	36
Total	11	100	14	100	25	100
Number of siblings						
Single child	5	45,5	7	50	12	48
2-3 siblings	6	54,5	7	50	13	52
Total	11	100	14	100	25	100
Duration of Preschool Education						
First Year	1	9,1	3	21,4	9	21,43
Second Year	5	45,5	11	78,6	33	78,57
Third Year	5	45,5	0	0	0	0
Total	11	100	14	100	25	100

Table 2. Distribution of demographic characteristics of families of the children participating in the study

Demographic Characteristics	Experimental Group		Control Group		Total	
	n	**%**	**n**	**%**	**n**	**%**
Mother's age						
29 years old and younger	2	18,2	2	14,3	4	16
30-39 years	8	72,7	9	64,3	17	68
40 years old and older	1	9,1	3	21,4	4	16
Total	11	100	14	100	25	100
Father's age						
29 years old and younger	1	9,1	1	7,1	2	8
30-39 years	8	72,7	9	64,3	17	68
40 years old and older	2	18,2	4	28,6	6	24
Total	11	100	14	100	25	100
Mother's Educational Level						
High School	3	27,3	3	21,4	6	24
University	7	63,6	11	78,6	18	72
Postgraduate	1	9,1	0	0	1	4
Total	11	100	14	100	25	100
Father's Educational Level						
High School	1	9,1	3	21,4	4	16
University	8	72,7	11	78,6	19	76
Postgraduate	2	18,2	0	0	2	8
Total	11	100	14	100	25	100

GEMS Program

The GEMS (Great Explorations in Math And Science) program which is defined as the program of great explorations in science and mathematics comes to the forefront as a quality and flexible program that brings exciting, effective science and mathematics activities to the classrooms. Within the scope of the program, opportunities supporting the science and mathematics concepts, social development, thinking skills and physical development are offered to the children. While it activates the questioning in children, it also guides them (Bergman, 2017; Cam, 2013; Pompea and Gek, 2002; Saritas, 2010; Saglam, 2012; Yalcin and Tekbiyik, 2013). Within the scope of GEMS program, the children in the experimental group performed different activities each day by using materials at the GEMS workshop, accompanied by teacher for an hour and the products they made were regularly exhibited at the school.

In the GEMS program, topics such as lady bugs, butterflies, ants, bees, fish, elephants, eggs, tree houses, balls, and lamps in their surroundings where children can have first-hand experiences and make observations have been addressed. These topics are discussed among the children, and open ended (diverging) questions are asked. These questions improve the problem solving skills of children by enabling them not only to think differently, but also make reasoning.

In the GEMS program, these concepts are not only limited in the science and mathematics activities executed in the one hour GEMS workshop, but they were also presented in an integrated program that involved music, art, drama and language activities. In the assessment stage of the program, both the emerging products and the acquired science process skills are assessed. For instance, in the topic of "elephants", the children were asked to draw a picture of what they know on elephants, and later they conversed about their knowledge on elephants. Afterwards, elephant masks were made in the art activities and a drama on astonishing trunks was made. This was followed by seeking answer to the question of what elephants eat, and making a chronological order in a story and children created their own stories. The tusk, neck, feet areas, the mother and baby elephants were compared with the children themselves with measurement of non-standard measurement units (lids, Legos, chains, paper-clips). In this way, children acquire the skills related to measuring, comparing, estimating, and concepts of amount and dimension.

Data Collection Tools

"General Information Form" to obtain the data related to the children and their families, "Parental Evaluation Form" including the assessments of the parents about their children, "Problem Solving Scale in Science Education (PSSSE)" to determine the problem solving skills of the children and "Science Processes Observation Form (SPOF)" to measure the children's science process skills were used in the study.

In General Information Form, there were questions about the demographic information to identify children and their families. Descriptive information about the parents were in the first part of the Parental Evaluation Form, and questions for determining the children's interest to scientific activities and the science and mathematics education, attitudes towards the solution of the problems they encounter and their interest to the environment and the nature were also in the second part of the form.

Problem Solving Scale in Science Education (PSSSE) was developed by Unal and Aral (2014a) to measure the problem solving skills of six year-old children in science education. In the scale, there are sixteen problem situations and pictures describing these problems. The scale has two subscales, the first subscale is "Science and Nature Problems (SNP - 9 items)", and the second subscale is "Material Usage Problems (MUP- 7 items)". The fit of the scale whose internal consistency coefficient is "0.75" between the people performing the independent evaluation was determined as "0.69" and its test retest correlation coefficient was measured as "0.96" (Unal and Aral, 2014a).

The Science Processes Observation Form consists of three subscales and 22 items and is a three-point likert type (always, sometimes, never). Subscales of the observation form are as follows: Science Processes Checklist (SPC-14 items), Problem Solving Checklist (PSC-3 items) and Scientific Attitude Observational Inventory (SAOI -5 items). According to the results of the confirmatory factor analysis of the form adapted into Turkish by Kuru and Akman (2017), the chi-square values calculated for model-data fitting were found to be significant ($\chi 2=1784.35$; $p<0.01$). It is stated that some fit statistics calculated with the same analysis have acceptable values for model data fit. In addition, high fit indices such as AGFI, GFI calculated for the attitude scale show that the model-data fit of the attitude scale is high. When taking all of these results into consideration, it is stated that the used Turkish version of the science processes observation form has a three-factor structure as in the original version. In addition, Cronbach's Alpha of "Science Processes Observation Form" and two split half correlations were calculated and found as 0.93 and 0.87, respectively. According to these results, the reliability of the form was determined to be high.

Analyzing of Data

The results obtained from the interviews conducted to determine the opinions of parents and teachers in the information form prepared for examining the effect of the GEMS program on the problem solving skills and science process skills of 6 year-old children were evaluated by using inductive analysis method. During the analysis, parents in the experimental group were coded as P1, P2,…P11. In order to show the objectivity and to present the study-related opinions of the participants realistically during the analysis of the obtained results, direct citations from the opinions of the parents were given. Results related to "Problem Solving Scale in Science Education (PSSSE)" and "Science Processes Observation Form (SPOF)" were analyzed and evaluated by using SPSS packaged software.

Findings / Results

In the first section of the study, the results obtained from the views of the parents in the experimental group were given. The second section of the study involved the results obtained from data collected in the direction of experimental design with pre-test and post-test control group.

Results Obtained from Qualitative Data

When examining the answers given to the question of "*how do you evaluate your child's interest in scientific activities?*" asked to evaluate the opinions of the parents about their children before the GEMS program, it was determined that the parents generally thought that their children were interested in scientific activities and their research and curiosity feelings were high. While P1 among the parents who drew attention to the scientific interests of the children expressed "*my child has curiosity and interest in everything that is new*", P5 expressed "*my child is interested in scientific activities,*

likes to do experiments and sometimes does experiments to which he/she put strange names". When examining the answers given to the question of "*How does your child react to natural events around him/her?",* it was understood that the children were generally curious about nature events, these events attracted their attention and they asked questions to understand the events. Among the parents explaining the interest of the child to the nature events, P3 responded as "*it draws his/her attention and he/she tries to learn by asking detailed question*" and E6 expressed "*my child asks the seasons, tries to understand what changes, loves to watch news, earthquakes attract his/her attention a lot*". In addition, some parents stated that the children's approach to the nature events was game-based and P1 among the parents expressed his/her opinion as "*my child gives game-oriented reactions, he/she feels happy to play snowballs when snow falls and sad when it rains since he/she cannot go out*". When examining answers the responses to the question "*How is your child's approach to mathematical problems?",* it was determined that parents generally thought that children were interested in mathematics. While P5 among the parents used the expression "*he/she is good with numbers, he/she questions the numbers with high digits a lot especially except for number he/she knows*", P6 said "*I believe my child likes mathematics very much, he/she enjoys solving problems".* In addition, P4 among the parents used the expression "*moderate interest*" and P1 expressed that "*my child has no special interest to the mathematics and is interested as much as every other child*" and said that their child had no special interest in mathematics. When examining the answers given to the question "*What does your child do to solve the problem when he/she encounter?",* it was determined from the parents that some children acted more simplistic about the problem solving and they generally wanted to get parents' support; on the other hand, some children did search of a solution to the problem very wishfully. P11 among the parents expressing the search of their children to the solution of the problem expressed "*He/she finds own solutions by keeping his/her own truths in the forefront, he/she generally finds selfish solutions, different perspective always attracts attention*", whereas, P10 expressed their children's search of problem solving as "*he/she tries to find the easiest and simplest solution for him/her, but he/she produces different solutions if he/she is alone*". However, some parents stated that their children gave different responses to the solution of the problem and P8 expressed this opinion as "*this can vary according to the shape of the problem, he/she can act very aggressively to a problem and sometimes he/she gets into panic*". Finally when the parents' responses to the question "*How do you evaluate the effects of preschool science activities on your child?*" were examined, it was determined that the parents thought that it had generally positive effects. Among the parents who had positive thoughts, P6 expressed that "*he/she loves it, fruiting of a tree that he/she planted made him/her very happy*" whereas P10 said "*his/her interest in the causes of the events makes us happy in terms of understanding that they cannot occur without any reason".* After the application of GEMS education program throughout the year, the parents expressed that the children's interests in science and mathematics increased in general, children started to ask more questions, started to do more activities with numbers and they were more successful in understanding and solving mathematical problems. P1 among the parents expressing these opinions said that "my daughter's interest in the mathematics and numbers increased with the GEMS education, she can use the number more easily, started to ask more questions, it has really affected the interest and success of the children in science and math fields positively".

Results related to the Problem Solving Scale in Science Education

The Shapiro-Wilk Test was used to examine the normality of the distributions of the data obtained from the Problem Solving Scale in Science Education. The Shapiro-Wilk Test is one of the statistical methods generally used in the studies when the sample size is less than fifty (Buyukozturk, 2017). According to Shapiro (1968), Shapiro-Wilk Test is suggested to be the strongest test (Cited by Acar, 1998). It was determined that the subscales and total pre-test mean scores of the Problem Solving Scale in Science Education did not show normal distribution in both groups (p<.05). Accordingly, pre-test scores of both groups were analyzed by using Mann Whitney-U test, one of non-parametric tests.

The post-test scores of Science and Nature Problems subscale of the Problem Solving Scale in Science Education were observed to be deviated from the normal in the experimental group (p<.05). Accordingly, post-test scores of both groups in the Science and Nature Problems subscale were analyzed by using Mann Whitney-U test, one of non-parametric tests. The mean scores of both groups in Material Usage Problems subscale and the total score of Problem Solving Scale in Science Education were compared by using Independent Samples t Test (Student t), a parametric test.

Table 3. The Mann Whitney-U test results on pre-test mean scores obtained by the children in both groups from the subscales of the Problem Solving Scale in Science Education

PSSSE	Group	n	$\overline{X}$	Median	Min.	Max.	Sd.	Mean Rank	MWU U	p
SNP	Experimental	11	1.81	1.88	1.00	2.11	.32	12.36		
	Control	14	1.88	1.94	1.44	2.22	.27	13.50	70.00	.698
MUP	Experimental	11	2.51	2.42	2.14	2.86	.16	10.45		
	Control	14	2.14	2.14	1.86	2.43	.21	15.00	49,00	.120
Total	Experimental	11	2.72	2.68	2.50	3.00	.14	10.95		
(SNP+MUP)	Control	14	2,02	2.50	2.25	2.75	.16	14.61	54.50	.214

When Table 3 was examined, it can be asserted that children in both groups showed similar characteristics in terms of problem solving skills at the beginning of the study. In addition, this also indicates the homogeneity of the distribution in the groups.

Table 4. Mann Whitney-U test results of the post-test mean scores of children in both groups for the Science and Nature Problems subscale of the Problem Solving Scale in Science Education

PSSSE	Group	n	$\overline{\text{X}}$	Median	Min.	Max.	Sd.	Mean Rank	MWU U	p
SNP	Experimental	11	1.81	1.88	1.00	2.11	.32	12.36		
	Control	14	1.88	1.94	1.44	2.22	.27	13.50	70.00	.698

When Table 4 was examined, it was determined that there was no significant difference in the Mann Whitney-U test results about the post-test mean scores of the children in the control and experimental groups for the subscales of the Problem Solving Scale in Science Education.

Table 5. Independent samples t-Test results related to the post-test mean scores of the children in both groups for the overall Problem Solving Scale in Science Education and its Material Usage Problems subscale

	Group	n	$\overline{\text{X}}$	Median	Min.	Max	Sd.	t	p	Effect Size**
MUP	Experimental	11	2.51	2.42	2.14	2.86	.16			
	Control	14	2.14	2.14	1.86	2.43	.21	-4.4	.000*	1.77
Total (SNP + MUP)	Experimental	11	2.72	2.68	2.50	3.00	.14			1.41
	Control	14	2.50	2.50	2.25	2.75	.16	3.5	.002*	

*p<.05 **cohen's d

When Table 5 was examined, the change observed in the problem solving scores of the children receiving education within the scope of GEMS Education before and after the application was found to be higher compared to the control group (p<.05). According to these results, it can be asserted that the fact that the children gained the experiences in the GEMS education program by doing-living was effective in the increase in the problem solving scores in science education of the children in the experimental group.

In the experimental studies, Independent Samples t-test (Student t test) which is a parametric measure to compare the both groups in case of normal distribution of the values of both groups was used; on the other hand, Mann-Whitney U test, one of non-parametric measurements, was used to compare both groups when the distribution did not show normality. The dependent samples t-Test was used when the distribution of values of the variables was normal; whereas, Wilcoxon Signed Rank Test was used when the distributions were not normal (Buyukozturk, 2017). In the measurements with significance level of 0.05, the value of p<.05 was considered as significant difference, and the value of p>.05 was considered as insignificant difference.

Table 6 shows Wilcoxon Signed Rank Test results according to the pre-test and post-test scores of the children in the experimental group for the subscales of the Problem Solving Scale in Science Education.

Table 6. Wilcoxon Signed Rank Test results on pre-test and post-test scores of children in the experimental group for the subscales of Problem Solving Scale in Science Education

PSSSE		Experimental Group						
		n	$\overline{\text{X}}$	Min.	Max.	Sd.	Wilcoxon z	p
SNP	Pre-test	11	1.81	1.00	2.11	.32		
	Post-test	11	2.18	1.56	2.56	.30	-2.51	.012*
MUP	Pre-test	11	2.27	1.86	2.43	.19		
	Post-test	11	2.51	2.14	2.56	.21	-2.15	.031*
Total (SNP + MUP)	Pre-test	11	2.01	1.38	2.25	.24		
	Post-test	11	2.32	2.06	2.63	.19	-2.83	.005*

*p < .05

When the Table 6 was examined, the difference between Science and Nature Problems subscale (z:-2.51, p<.05), Material Usage Problems subscale (z:-2.51, p<.05) and total (SNP + MUP) scores of the Problem Solving Scale in Science Education before and after GEMS education in children receiving GEMS education was significant (z:-2.83, p<.05). This difference was observed to be in favor of the post-test score. These results suggested that GEMS education had an important effect on improving children's problem solving skills in science education.

Table 7 shows the results of the Wilcoxon Signed Rank test on the pre-test and post-test scores of the children in the control group for subscales of the Problems Solving Scale in Science Education.

Table 7.Wilcoxon Signed Rank Test results about the pre-test and post-test scores of the subscales of the Problems Solving Scale in Science Education of the children in control group

PSSSE		n	$\overline{\text{x}}$	Min	Max.	Sd.	Wilcoxon z	p
					Control Group			
SNP	Pre-test	14	1.88	1.44	2.22	.27		
	Post-test	14	1.84	1.33	2.33	.27	-.637	.524
MUP	Pre-test	14	2.38	1.57	2.71	.38		
	Post-test	14	2.14	1.86	2.43	.20	-2.251	.024*
Total (SNP + MUP)	Pre-test	14	2.10	1.50	2.44	.28		
	Post-test	14	1.97	1.63	2.25	.18	-1.76	.077

*p<.05

When Table 7 was examined, the difference between the Science and Nature Problems subscale (z:-.637, p>.05) and total (SNP + MUP) (z:-1,76, p>.05) pre-test post-test scores of the Problem Solving Scale in Science Education was not determined to be significant in the control group (p>.05). The difference between Material Usage Problems subscale (z:-1.76, p<.05) scores was significant in favor of the pre-test.

As is seen in Table 7, the difference between the pre-test and post-test mean scores of scale total and the Material Usage Problems subscale of the scale of the children in the control group was significant in favor of the pre-test, in other words, post-test scores were determined to be lower than pre-test scores. This is thought to be associated with teachers' attitudes, inadequacy of preschool education institutions in terms of materials, and inadequacy of methods and techniques used (Ayvaci et al., 2002; Ercan and Yalcin, 2013; Garbett, 2003; Unal and Aral, 2014b; Zeytun, 2010).

Table 8 shows the Mann Whitney-U test results for the pre-test and post-test score differences of the children in both groups participating in the study for the Problem Solving Scale in Science Education subscales.

Table 8.Mann Whitney-U test results on pre-test and post-test score differences of children in both groups participating in the study for subscales of Problem Solving Scale in Science Education

PSSSE	Group	n	$\overline{\text{X}}$	Mean Rank	MWU	
					U	p
SNP	Experimental	11	.36	17.73		
	Control	14	-.03	9.29	25.00	.004*
MUP	Experimental	11	-.24	8.00		
	Control	14	.24	16.93	22,00	.002*
Total	Experimental	11	.87	15.18		
(SNP + MUP)	Control	14	.73	11.29	53.00	.189

*p<.05

When the Mann Whitney-U Test results in Table 8 were examined, the difference between the pre-test and post-test score differences of the children in both group participating in the study in Science and Nature Problems subscale of Problem Solving Scale in Science Education was significant, the difference between the pretest- posttest scores of Material Usage Problems subscale was significant (p<.05) and the difference between total (SNP + MUP) pretest-posttest scores of the scale was not significant (p>.05). This situation was associated with the fact that the difference between the scores of Material Usage Problems subscale was significant in favor of the pretest as shown in Table 7.

Analysis of the Data Obtained from Science Processes Observation Form

When the results of descriptive statistics and Shapiro-Wilk test of the pre-test mean scores obtained by the children in the Experimental and Control Groups from the Science Processes Observation Form were examined, the subscales of the Science Processes Observation Form and the total pretest mean scores showed normal distribution in the Experimental and Control Groups (p>.05). When the results of descriptive statistics and Shapiro-Wilk test of post-test mean scores obtained by the children in experimental and control groups obtained from the Science Processes Observation Form were examined, it was found that while total post-test mean scores of Science Processes Observation Form showed normal distribution (p> .05), the subscales of the Science Processes Observation Form did not show a normal distribution in the experimental and control groups (p<.05).

Table 9 shows Independent Samples t Test (Student t Test) results of the children in the experimental and control groups according to the pre-test mean scores of the subscales of Science Processes Observation Form.

Table 9. Independent Samples t Test results of children in both groups participating in the study concerning pre-test scores of the subscales of Science Processes Observation Form

SPOF	Group	n	$\overline{\mathrm{X}}$	Sd.	t	p	Effect Size cohen's d
SPC	Experimental	11	2.11	.42			
	Control	14	1.93	.30	1.17	.257	.470
PSC	Experimental	11	2.03	.48			
	Control	14	2.16	.40	.750	.462	.300
SAOI	Experimental	11	1.87	.39			
	Control	14	1.92	.52	.305	.763	.122
Total	Experimental	11	2.04	.40			
	Control	14	1.96	.34	.527	.604	.210

When Table 9 was examined, it was found that according to the independent samples t test results, pre-test mean scores obtained by the children from the Science Processes Observation Form did not show any statistically significant difference according to the experimental and control groups. In accordance with this result, it can be asserted that the characteristics of children of both groups were similar in terms of science processes at the beginning of education. This also reflected the homogeneity of the distribution of both groups.

Table 10 and Table 11 shows the results obtained by analyzing the difference between the post-test mean scores of the children in both groups included in the study for the subscales of the Science Processes Observation Form using Mann-Whitney U Test and Independent Samples t Test (Student t Test).

Table 10. Mann Whitney-U test results on the post-test mean scores of the children in both groups included in the study for the subscales of Science Processes Observation Form

SPOF	Group	n	$\overline{\mathrm{X}}$	Median	Min.	Max.	Sd.	Mean Rank.	MWU U	p
SPC	Experimental	11	2.90	2.85	2.71	3.21	.14	13.91		
	Control	14	2.83	2.85	2.50	3.00	.18	12.29	67.00	.575
PSC	Experimental	11	2.87	3.00	2.67	3.00	.16	13.32		
	Control	14	2.78	3.00	1.67	3.00	.38	12.75	73,50	.821
SAOI	Experimental	11	2.87	2.80	2.60	3.00	.13	11.59		
	Control	14	2.90	3.00	2.40	3.00	.18	14.11	61.50	.331

When Table 10 was examined, it was determined that the difference between the post-test mean scores obtained by the children in experimental and control groups from the subscales of the Science Processes Observation Form was not significant (p>.05).

Table 11. Independent Group t Test results on post-test mean scores of children in both groups participating in the study for Science Processes Observation Form

	Group	n	$\overline{\mathrm{X}}$	Median	Min.	Max.	Sd.	t	p
TOTAL	Experimental	22	2.89	2.86	2.77	3.09	.10		
	Control	20	2.84	2.86	2.59	3.00	.14	-1.06	.296

When Table 11 was examined, it was observed that the difference between the post-test mean scores of the children in experimental and control groups for the overall Science Processes Observation Form was not significant.

Table 12 shows the Wilcoxon Signed Rank test results according to pre-test post-test scores of children in the experimental group for the subscales of Science Processes Observation Form.

Table 12.Wilcoxon Signed Rank test results on pre-test and post-test scores of children in Experimental Group for the subscales of Science Processes Observation Form

SPOF		n	$\overline{\text{X}}$	Min.	Max.	Sd.	Wilcoxon z	p
					Experimental Group			
SPC	Pre-test	11	2.11	1.43	2.57	.42		
	Post-test	11	2.90	2.71	3.21	.14	-2.93	.003*
PSC	Pre-test	11	2.03	1.00	2.67	.48		
	Post-test	11	2.87	2.67	3.00	.16	-2.97	.003*
SAOI	Pre-test	11	1.87	1.20	2.60	.39		
	Post-test	11	2.87	2.60	3.00	.13	-.2.95	.003*
TOTAL	Pre-test	11	2.04	1.32	2.55	.40		
	Post-test	11	2.89	2.77	3.09	.11	-2.93	.003*

*p<.05

When Table 12 was examined, it was determined that the difference between SPC(z:-2.93, p<.05), PSC (z:-2.97, p<.05), SAOI (z:-2.95, p<.05) and total scores (z:-2.95, p<.05) obtained by the children participating in the GEMS education program from the Science Processes Observation Form before and after the experiment was significant. This difference was in favor of the post-test score. It can be asserted according to the obtained results that the applied GEMS education had an important effect for the children to develop problem solving skills in science education.

Table 13 shows the Wilcoxon Signed Rank test results according to the pre-test-post-test scores of children in the control group for the subscales of the Science Processes Observation Form.

Table 13.Wilcoxon Signed Rank test results on pre-test and post-test scores of children in the control group for the subscales of Science Processes Observation Form

SPOF		n	$\overline{\text{X}}$	Min.	Max.	Sd.	Wilcoxon z	p
					Control Group			
SPC	Pre-test	14	1.93	1.50	2.43	.30		
	Post-test	14	2.83	2.50	3.00	.18	-3.30	.001*
PSC	Pre-test	14	2.16	1.33	2.67	.40		
	Post-test	14	2.78	1.67	3.00	.38	-2.88	.004*
SAOI	Pre-test	14	1.92	1.20	2.80	.52		
	Post-test	14	2.90	2.40	3.00	.18	-3.30	.001*
TOTAL	Pre-test	14	1.96	1.45	2.55	.34		
	Post-test	14	2.84	2.77	3.09	.14	-3.29	.001*

*p<.05

When Table 13 was examined, it was determined that the difference between SPC(z:-3.30, p<.05), PSC (z:-2.88, p<.05), SAOI (z:-3.30, p<.05) and total scores (z:-3.29, p<.05) obtained by the children in the control group from the Science Processes Observation Form before and after the experiment was significant.

Table 14 shows Independent Samples t Test results of the children in the experimental and control groups for pre-test and post-test score differences of the subscales of the Science Processes Observation Form.

Table 14. Independent Samples t Test results on pre-test and post-test score differences of children in both groups from the subscales of Science Processes Observation Form

SPOF	Group	n	$\overline{\text{X}}$	Sd.	t	p
SPC	Experimental	11	.79	.50		
	Control	14	.89	.34	.596	.559
PSC	Experimental	11	.84	.45		
	Control	14	.61	.56	-1.12	.274
SAOI	Experimental	11	1.0	.38		
	Control	14	.97	.57	-.148	.884
TOTAL	Experimental	11	.84	.45		
	Control	14	.87	.38	.173	.865

When Table 14 was examined, it was determined according to the Independent Samples t Test that there was no significant difference between pre-test and post-test score differences of the children in the experimental and control groups for the Science Processes Observation Form.

Discussion and Conclusion

This study mainly investigated whether or not GEMS program contributed to children's problem solving skills and science process skills. According to the result of the study, it was determined that GEMS program is effective in supporting the problem solving skills and science process skills of the children.

The studies on both problem solving skills and the scientific process skills of the children in the preschool period as well as the studies including preparation of different training programs for the acquisition of these skills support the results obtained from these studies (Anliak and Dincer, 2005; Buyuktaskapu, Celikoz and Akman, 2012; Dogru, Arslan, Seker, 2011; Kuru and Akman, 2017; Ozdil, 2008; Ramani, 2005; Unal and Aral, 2014b).

When the obtained results were examined, it was determined that primarily parents expressed that by means of the GEMS education, the children's interest to the science and mathematics activities, nature and their environment increased, they started to ask more and different questions and the GEMS education had a positive impact on the children in general. It is seen that the studies in the literature have supported this situation and the applications based on the GEMS approach are positively responded by teachers, children, and parents (Saglam, 2012; Tekbiyik, Seyihoglu and Birinci Konur, 2017).

The study also indicated in the opinions of the parents that the relationship of the children with the environment increased and their requests for research and inquiries were warned. One of the goals of the GEMS program is to constantly increase children's curiosity and make the interrogation a part of daily life (Tekbiyik et al., 2017).

When the quantitative data obtained from the Problem Solving Scale in Science Education and the Science Processes Observation Form were evaluated together, it was determined that the GEMS training program in general had a positive effect on the children's scientific process and problem solving skills, and it caused a significant difference on the problem solving skills compared to the control group.

Science education is an important and effective application in the development of creativity and problem-solving skills in children (Hancer, Sensoy and Yildirim, 2003). In addition, the development of creativity also improves the problem solving skills in children (Yaman and Yalcin, 2005). In this sense, children's thinking, questioning, creativity and science process skills can be improved through GEMS education which is an understanding based on science education (Cam, 2013; Saritas, 2010; Tekbiyik et al., 2017). Saritas (2010) stated that the activities and materials used in the GEMS education affected positively all developmental areas of preschool children. Performing activities within the scope of GEMS education improve positive experiences and self-confidence about the science in preschool children (Barrett et al.,1999).

An important feature of GEMS activities is that GEMS requires the active participation of the child in activities. The child feels directly what the scientists exactly do during the activity, and how they use the science process skills (Barber et al., 1998; Tekbiyik et al., 2017). Studies have revealed that activities based on GEMS approach provide positive contributions to children's science process skills (Celik and Tekbiyik; 2016; Granger, Bevis, Saka and Southerland, 2009a; Saritas, 2010; Yalcin and Tekbiyik, 2013). Additionally, it was determined that by means of GEMS education, the children had higher knowledge increase and their interest based on certain subjects increased (Granger, Bevis, Saka and Southerland, 2009b).

The GEMS program is mainly based on science and mathematics activities, experimental studies and material use (Cam, 2013). GEMS activities are made by utilizing easily available and cheap materials. It was found that the children participating in the program which implements the active learning approach with simple tools that can be obtained easily in the literature writing had higher problem solving skills than traditional methods (Aydede and Matyar, 2009; Cagdas and Yildiz, 2003; Dharmadasa and Silvern, 2000; Dogru et al., 2011; Flick, 1993; Haury and Rillero, 1994; Lambert, 2001; Mirzaie, Hamidi and Anaraki 2009; Satterthwait, 2010; Stoll, Hamilton, Oxley, Eastman and Brent 2012; Unal and Aral, 2014b).

The development of problem solving skills in children is influenced by the types of activity performed and the activity materials used (Lambert, 2001). In the literature, there has been no study about problem solving skill of GEMS program. However, the positive effects of science activities and material studies on children's problem solving skills have also been reported in the studies in the literature (Anliak and Dincer, 2005; Cagdas and Yildiz, 2003; French, Conezio and Boynton, 2000; Guler and Bikmaz, 2002; Hong, 2008; Onen and Gurdal, 2006; Ramani, 2005; Unal and Aral, 2014b). Accordingly, it can be asserted that intensive science studies and material use in GEMS trainings affected the problem solving skills of the children positively.

Problem solving skills and science process skills in children can be influenced by many factors, but the experiences about the problems, the activities and the material usage are important factors that directly affect the development of these skills (Cam, 2013; Lambert, 2001). It can be asserted that the GEMS program has a direct influence on the problem solving skills and science process skills of children with rich material use and different experiences. The GEMS program, which provides opportunities for encountering scientific events for all children and guides them to

understand the events around them, is an incentive approach for overcoming the problems they face and thinking scientifically (Bergman, 2017; Cam, 2013; Pompea and Gek, 2002; Saritas, 2010; Saglam, 2012; Tekbiyik and Yalcin, 2013). When considering these aspects, it can be asserted that the GEMS program directly affects the problem solving and science process skills of the children in the experimental group and develops children in these areas by providing different experiences and rich materials.

In the study, it was determined that GEMS education caused a significant difference on the science process skills of the 6 year-old children but there was no significant difference between them compared to the control group. This was associated with the fact that the children in the control group were attending a private school and they had preschool experience before. Kuru and Akman (2017) stated in their study that science process skills could be affected by the children's preschool background, the physical structure of the school, and materials and activities used by the teacher.

When the study was considered as a whole, it was seen that the GEMS program gave effective results in terms of problem solving and science process skills of children. Problem solving and scientific process skills, which are very important in the preschool period and directly affect the later periods, are directly influenced by the education of children in this period.

Recommendations

Preschool education applications, importance of which is indisputable in terms of children, vary from country to country or from region to region within the borders of the same country. This change in application also differentiates the effects of pre-school education on children. Problem solving and science process skills, which are very important in the preschool period and directly affect the later periods, are directly affected by the education of children in this period.

According to this study, it is important to spread nationally and internationally the GEMS education which can directly affect the problem solving and science process skills of the children in order to enhance the quality of education that children receive during this period. In this respect, by taking into consideration that the main elements that highlight GEMS education are the use of rich materials and different scientific activities, it will be useful to put these elements to the front in the preschool education. In order to increase the awareness of teachers, which are one of the main elements of preschool education applications, about the materials and different activities in general, and different applications like GEMS education. In particular, activities for different subjects and gains grounding on GEMS approach can be developed and activities of the applications can be investigated. Within the scope of extension of GEMS program, teachers and families can be provided with courses, workshops, and seminars introducing the GEMS program.

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