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STEM ETKİNLİKLERİNİN ÖĞRENCİLERİN BİLİMSEL YARATICILIKLARINA VE AKADEMİK BAŞARILARINA ETKİSİ *

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Özet

Bu çalışmanın amacı, Lego temelli STEM (Fen-Teknoloji-Mühendislik-Matematik) etkinliklerinin ortaokul 6. sınıf öğrencilerinin bilimsel yaratıcılıklarına ve akademik başarılarına etkisini belirlemektir. Çalışmada deneysel araştırma yöntemlerinden biri olan yarı deneysel araştırma yöntemi kullanılmıştır. Çalışma 2017-2018 eğitim-öğretim yılı bahar döneminde bir devlet ortaokulunda gerçekleştirilmiştir. Çalışmanın yürütüldüğü okulda öğrencilere Bilimsel Yaratıcılık Ölçeği (BYÖ) ve Akademik Başarı Testleri uygulanmıştır. Çalışmaya toplam 85 öğrenci katılmıştır. Çalışma grubunda 29 öğrenci kontrol grubu, 28 öğrenci deney grubu-1 ve 28 öğrenci deney grubu-2 olarak araştırmacı tarafından ayrılmıştır. Uygulama 7 hafta sürmüştür. Deney gruplarında fen bilimleri dersleri Lego temelli STEM etkinlikleri ile işlenmiştir. Çalışmada Bilimsel Yaratıcılık Ölçeği (BYÖ) ve Kuvvet, Hareket Akademik Başarı Testi (KHABT), Maddenin Özellikleri Akademik Başarı Testi (MÖABT), Hayvanlar Akademik Başarı Testi (HABT) ve Ses Akademik Başarı Testi (SABT) kullanılmıştır. Gruplara ilişkin ön test-son test farkının normal dağılım gösterip göstermediği Kolmogorov-Smirnov testi ile kontrol edilmiştir. Normallik varsayımının sağlanamadığı ölçek ve testlerde Wilcoxon İşaretli Sıralar Testi, normallik varsayımının sağlanabildiği ölçek ve testlerde ise İlişkili Örneklemler T testi yapılmıştır. Grupların son testlerinin karşılaştırılmasında ise Tek Faktörlü Varyans Analizi (ANOVA) yapılmıştır. Çalışmanın sonucunda, BYÖ ile ilgili özgünlük boyutlarında deney grubu-1 lehine anlamlı bir fark bulunmuştur. Akademik başarı testlerinin analizinde ise sadece MÖABT'ye ilişkin son test puanlarında anlamlı bir fark bulunmamıştır. KHABT, HABT ve SABT son test sonuçlarında deney grubu 1 lehine anlamlı bir fark bulunmuştur. Ayrıca grupların HABT ile ilgili son test puanlarının karşılaştırıldığı analizde de deney grupları lehine anlamlı bir fark bulunmuştur. Çalışma sonucunda Lego temelli STEM etkinliklerinin gerçekleştirildiği deney gruplarındaki öğrencilerin bilimsel yaratıcılıklarının geliştiği ve akademik başarılarının arttığı tespit edilmiştir.

Anahtar kelimeler: STEM, lego, bilimsel yaratıcılık, akademik başarı

* *Bu çalışma yazarın yüksek lisans tezinin bir bölümünden üretilmiştir.*

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THE EFFECT OF STEM ACTIVITIES ON THE SCIENTIFIC CREATIVITY AND ACADEMIC SUCCESS OF STUDENTS

Abstract

The purpose of this study is to identify the effect of Lego based STEM (Science-Technology-Engineering-Mathematics) activities on the scientific creativity and academic success of middle-school 6th grade students. In the study, the semi experimental research method which is one of the experimental research methods was used. The study was carried out at a state middle-school in the spring semester of the 2017-2018 academic year. At the school in which the study was carried out, the students were applied the Scientific Creativity Scale (SCS) and the Academic Success Tests. A total of 85 students participated in the study. In the study group, 29 students were separated as the control group, 28 students as experimental group-1 and 28 students as experimental group-2 by the researcher. The application lasted for 7 weeks. In the experiment groups, the physical sciences lessons were taught together with the Lego based STEM activities. In the study, scientific creativity scale and Force and Motion Academic Success Test (FMAST), Properties of Matter Academic Success Test (CMAST), Animals Academic Success Test (AAST) and Sound Academic Success Test (SAST) were used. Whether the pretest-posttest difference related to the groups displayed normal distribution was checked with the Kolmogorov-Smirnov test. In scales and tests in which it was not possible to achieve normalcy assumption, the Wilcoxon Signed Ranks Test and in those in which it was possible toachieve normalcy assumption, the Paired Samples T test was done. In the comparison of the groups' posttests, the Single Factor Variance Analysis (ANOVA) was carried out. As a result of the study, a significance difference was found in favor of experiment group-1 in the originality dimensions related to SCS. In the analysis of the academic success tests, a significant difference was not found only in the posttest scores related to CMAST. In the posttest results of FMAST, AAST and SAST, a significant difference was found in favor of experiment group 1. In addition, in the analysis in which the posttest scores of the groups related AASTwere compared, a significant difference was found in favor of the experiment groups. As a result of the study, it was determined that the scientific creativity of the students in the experiment groups in which Lego based STEM activities were carried out developed and their academic success increased.

Key words: STEM, lego, scientific creativity, academic success

INTRODUCTION

Until the 2000's, although numerous technological advancements have taken place, the developments and changes which took place after the year 2000 have opened a new page in the world of science. This speedy advancement in science and technology has started making its reflections apparent in the world of education as well. Many countries have steered towards implementing new educational approaches they can integrate in the developments in science and technology. Among these educational approaches, the one which has recently come to the agenda and many educators gravitated towards is STEM (Science-Technology-Engineering-Mathematics) education, which is a blend of mathematics, physical sciences, engineering and technology. As to understand why STEM education needs to be used and what its target is, it would be sufficient to have a look at the developments experienced in technological areas in the global scale. In 1957, the first spark of technological competition has been lit with a satellite launched by Russia. When Russia's satellite launch initiative was successful, the USA as another global power of the period has become uneasy and started giving importance to space researches to counteract Russia. The first reaction to the Sputnik satellite vehicle has been fruitful in terms of the founding of NASA (Portree, 1998; White, 2014). After the founding of NASA, in particular the race between the USA and Russia has gained speed. This race which took place between the two countries in the global scale has also turned into a race in terms of space. After Sputnik was sent to space, there have been numerous views on the country's political circles about how the USA should take place in this race. While researches continued in the USA, Russia has been successful in sending another live being into space with Sputnik-2 after the first one. This being that was called 'Dog Laika' has lost its life within a few hours. Although the USA has initially been left behind in this race has been able to show its greatest reaction so far 12 years later. Exactly 12 years after Sputnik was launched, the USA realized the first manned landing to the Moon on 20 July, 1969 and gave the first response to Sputnik. Neil Armstrong and Buzz Aldrin's names were written in history as the two astronauts who made this event possible. This event has attracted attention for the USA in the STEAM area as a breaking point (Portree, 1998; White, 2014). In this respect, identifying the breaking points of STEM starting from its emergence until the present time in order to be able to understand its development step by step will allow us to better understand what STEM is. STEM has been shaped around the political agenda until the end of 1990's. The political agenda has taken its place as the first phase of STEM. Therefore, STEM starting point has been a political agenda. Along with this political agenda as the target of increasing labor force and quality in different disciplines, it was aimed at increasing the quality of STEM

in terms of disciplines. During this process, although teachers were not very successful in teaching the disciplines separately at the primary education level, they have in general taught these as separate disciplines (S.T.E.M). This process has been defined as the second stage of STEM. The third phase of the history of STEM has been defined as interpretation. While teachers steered towards the sciences of mathematics and science in general in line with the traditional understanding of education, they ignored the disciplines of technology and engineering. The reasons which come to the fore for this were not having sufficient documents related to the curriculum and guides to give to the teachers which would help them use these two disciplines. The fourth stage in the historical process of STEM is considered to be the emergence of STEM education. Educators who recognized the pedagogical effect of STEM have been able to use it by integrating it to education. In this historical process, "STEM education" has become a part of the literature. However, although immense material and moral efforts have been spent towards STEM education, not much success has been achieved in this education. The last stage of the historical adventure of STEM has become the integrated STEM education. With this education in which more STEM areas were integrated, an understanding of education was adopted where these four disciplines were applied together (Blackley and Howell, 2015; Moore and Smith, 2014; Sanders, 2009). STEM's historical timeline is presented in the figure below (Figure 1).

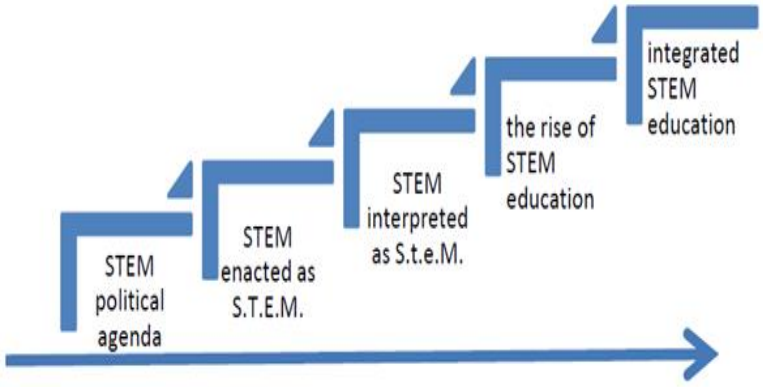

Figure 1. STEM timeline - integrated STEM education

Innovations and inventions are aspects which directly affect economy. This is the underlying Properties in the sub-problem of why STEM education has an important place in the education system of countries. In particular the innovations and inventions in the areas of engineering and technology influence a country's economic level. Naturally, in order to be able to acquire this economical gain, it is necessary to integrate engineering and technology to education as well. Countries give a great deal of importance to students who

receive education in this education system for their own good. Therefore, they aim at observing the differences between the countries which would participate in the exams to be held throughout the world. Our country is among the countries to take these worldwide exams as well. Turkey in its last participation in these exams has taken the 54th place among 72 countries in the PISA exam held in 2015; the 50th place among 72 countries in science literacy and the 50th place among 72 countries in mathematics literacy. When the participation timings of these exams are analyzed, it draws the attention that our country has not been able to achieve a significant success since 2006 (Roberts, 2012; Taş et al., 2016; Yıldırım et al., 2013). Educators underline that due to the failures in these exams, the method with which these disciplines are taught in the manner they are integrated will increase the success levels of students in these exams and that they will be able to learn these subjects in a more efficient way. In this manner, an environment in which students can come face to face with daily life problems which are the essence of these questions, in other words an environment where they can establish a relationship with real life (Katehi et al., 2009; National Academy of Science, 2010). In this respect, students' attempting to solve the problems they face in real life through STEM related solutions can greatly contribute to the development of their scientific process skills, life skills and engineering and design skills.

Although STEM education does not have an exact definition in the literature, the people or groups studying this subject have developed different definitions (Langdon et al., 2011). STEM education expresses learning and teaching in the scientific areas of science, technology, mathematics and engineering. This process involves the educational activities carried out by an individual in all grade levels starting from the pre-school period (Gonzalez and Kuenzi, 2012). STEM education helps students to understand the operational principles of objects used in daily life and thoughts about how the used technology can further be advanced. STEM education involves knowledge, skills and beliefs which are created with the emergence of more than one STEM subject area (Çorlu et al., 2014). Educators believe that students form better connections with the real world since they develop their problem solving skills, analytical thinking skills and critical thinking skills (Brophy et al., 2008; Morrison et al., 2006). Therefore, engineering applications in STEM education are focused on the main themes of problem solving and creating innovations (Bybee, 2010). Skills such as problem solving, analytical thinking and critical thinking are regarded as 21st century skills. Different institutions have defined 21st century skills differently. Among these institutions, Ministry of National Education (MoEN) definition expresses it as creative and innovative thinking and being open to these, critical thinking, problem solving and decision making, using

learning strategies, learning to learn and self-evaluation in upper cognitive skills, using Turkish accurately and using a foreign language in the beginner level, working by cooperating, information literacy, information communication technology literacy, awareness of domestic and global citizenship, consciousness and skills about life and career and having social responsibility awareness (MoEN, 2011).

It can be observed that, upper level skills and creativity are given importance to in the physical sciences education programs developed until the present time. In particular creativity and creative thinking skills have gained even more importance in each revised program. In physical sciences, activities which develop students' creativity to make it possible for them to produce and develop more creative solutions for real life problems should be organized (Shanahan and Nieswandt, 2009). Scientific creativity is defined as a skill which has a unique production and scientific process in science, technology or in any other area (Rawat, 2010). In another definition, it is expressed as a process in which an original product is created which influences individuals or societies. In addition, the properties of scientific creativity are listed as follows (Hu and Adey, 2002);

- Scientific creativity involves creative scientific experiences, producing creative scientific solutions and creative scientific activities.
- Scientific creativity is a type of skill.
- Scientific creativity needs to be based on scientific knowledge and skills.
- Creativity and analytical intelligence are regarded as the two different factors of a single function which has its origins in mental skills.
- Scientific creativity should be in the form of a combination of stagnant and developmental structure.

Lego applications significantly increase in the skills of students such as creativity, visualization, sharing and reaching conclusions (Lin et al., 2009). These applications have been developed based on the constructivist teaching theory. With the purpose of carrying the constructivist theory on step further, the word 'constructivism' has been added the suffix 'on' and the word 'constructionism' was started to be used. It has been expressed that the indication of learning is not spending a long time a material or subject but that it should be targeted to produce concrete and visible products at the end of that time period (Papert, 1993). Legos are noteworthy materials which can be used in physical science lessons since they increase the willingness and motivation of students to participate in the lessons (Julià and Antolí, 2019). Learning with Legos has numerous reflections on education. As a result of Lego applications,

students can transform the thought they form in their minds into concrete objects through the active learning method (Chambers et all., 2008). It has been observed that students are able to find solutions for complex problems and that their problem solving skills were developed (Danahy et all., 2014). As a result of Lego applications, a significant increase takes place in students' motivations towards physical sciences and technology (Williams et al., 2012). It is seen that Lego applications have a noteworthy effect on students' scientific process skills and their self-perception (Koç et al., 2015). It has been observed that Lego applications make it possible for students better understand the relationship between piece-whole and learn about the functions of these shapes (Yu et al., 2011). As a result of Lego applications, students' willingness to work in a cooperative manner increases and this results in developments in students' upper level thinking and communication skills (Nourbakhsh et al., 2005).

Problem of Research

The purpose of this study is to make it possible for the 6th grade students to solve real life problems presented to them within the framework of a scenario using Lego based STEM activities. In addition, the purpose is to identify the effect of these activities on the scientific creativity and academic success of the students. The active participation of the students, finding solutions to real life problems and being able to use upper level skills are the expected properties from science literate individuals. Therefore, a great responsibility falls on the shoulders of educators to teach and plan to their lessons in a manner which triggers these skills and talents of the students. Since Lego based STEM activities develop students' creative thinking skills, allow them to produce a product using logic and reasoning and involve activities in which they transform their imagination to concrete objects, it is important that they are integrated to education. Since these activities are different from the traditional teaching methods, they can increase the interest of students through using scientific areas such as science-technology and engineering-mathematics. Legos which are materials of engineering designs presents students to try concrete methods about a problem they face. They also give students the chance to immediately change their solution for a problem when it does not work out (Brophy et al., 2008; LEGO Education, 2014). In this study, it is considered as well that these activities will contribute greatly to the educators and students since it is aimed at increasing the interest and motivation of the students towards their lessons. In this study, since it is targeted for Lego based STEM activities to influence students' success and their attitude towards their lessons, it is considered important that some subjects are taught through these activities. When the literature is analyzed, it can be seen that the number of studies which

deal with Lego based STEM activities is limited. Therefore, it is considered that this study will greatly contribute to the literature.

In this study, the effect of Lego based STEM activities on the academic success, and scientific creativity of 6th grade students towards the physical sciences lesson. Within this scope, the answer to the question, "Do STEM activities affect the academic success and scientific creativity of the students?" is sought. Within the framework of this main problem, the answers to the following sub-problems are also sought: The sub-problems are:

- Has a change occurred in the scientific creativity of the students prior to and after the Lego based STEM activities?
- Has a change occurred in the academic success of the students prior to and after the Lego based STEM activities?

METHODOLOGY

In this study, the pretest-posttest control grouped semi experimental method was used. According to the results obtained from the pre and posttests carried out in experimental studies, the effect of the technique used on the experiment group can be analyzed (Ary et al., 2019). The experimental method stands out as the most suitable method for the purpose of this study for this reason. In the study, two groups make-up the experiment group and 1 group makes-up the control group. While in the experiment groups of the study the 6ht grade science lesson subjects were taught though the Lego based STEM activities, the current education program was used in the control group. The 6th grade science lesson subjects were taught for 7 weeks in the experiment and control groups. The schematized version of the experimental design used in the study is shown in Table 1 below.

Table 1. Experimental design of research

Group	Pre-test	Application	Post-test
Experiment1	SCS, MTLSS, FMAST, SAST AAST, CMAST	STEM Activities	SCS, MTLSS, FMAST, SAST, AAST, CMAST
Experiment2	X		SCS, MTLSS, FMAST, SAST, AAST, CMAST
Control	SCS, MTLSS, FMAST, SAST AAST, CMAST		SCS, MTLSS, FMAST, SAST AAST, CMAST

Sample

The applications were carried out with the 6th grade students. In the school in which these applications were carried out, there are 3 classes in this grade level. The experiment and control groups were chosen from these classes. In the identification of the control and experiment groups of the study, the grade averages of the first semester were used (Table 2).

Table 2. Average success rates of 6th grade fall semester

Group	N	X	S
6/A (Control Group)	29	78.88	15.41
6/B (Experiment-I Group)	28	79.66	17.05
6/C(Experiment-II Group)	28	78.63	13.45

Instruments and Procedurs

The data were collected through the Scientific Creativity Scale and the Academic Success Tests. With the purpose of identifying the students' scientific creativity, the Scientific Creativity Scale which was developed by Hu and Adey (2002) and the identification of the adaptation and evaluation stages carried out by Deniş Çeliker and Balım (2012) was used. The scale's reliability coefficient was determined as .86. The scale's reliability coefficient in this study was calculated as well and it has been determined as .81. The scoring of the scale consists of 3 main points. These points are given by adding the fluency score, flexibility score and originality score. In each question, a calculation is done by adding different points. The fluency score is calculated as the number of valid answers the students give to the questions, regardless of the quality of the answers. The flexibility score is the result of calculating an area or an approach used in the answers of the students. For instance, if a student is giving only the solid matter as examples for conductors, then the students is given 1 point. The originality score is calculated through turning the frequencies of all the obtained answers into a table. In the scientific creativity scale used in the study, there is no limit to the points a student can receive in terms of fluency and flexibility score. However, there is a certain point limitation in the calculation of the originality score. A student can receive 20 points the most in the originality score. With the purpose of measuring the academic success of the students, academic success tests under different topic headings were given. The original versions of the tests were developed by Wendell and Rogers (2013). The tests' adaptation to Turkish process, validity and reliability was carried out by the researcher. After the adaptation to Turkish, the tests were controlled by two academicians competent in both languages and the necessary corrections were made. Some of the questions which were in the original versions of the success tests were removed from the tests in line with the views of field experts and

new questions were added as a after the control of these experts. The new questions which were added to the test were taken from the success test developed by The Engineering is Elementary (EiE, 2017). The reliability studies of the academic success tests which were developed within the framework of Turkish adaptation and the views of the experts were carried out. The reliability study was carried out through the 465 8th grade students receiving education at the same school the study was being conducted. A reliability coefficient was calculated for each academic success test of the study. The reliability coefficients calculated in relation to the academic success tests are given in Table 3.

Table 3. Reliability coefficients for academic achievement tests

Academic Achievement Test	KR-20	Number of questions	Number of students
Force and Motion	.73	11	465
Properties of Matter	.74	10	465
Animals	.77	11	465
Sound	.75	10	465

The application was carried out in the spring semester of the 2017-2018 academic year. In the study, Scientific Creativity Scale and the Academic Success Tests were given to the experiment and control groups. The data collection tools were applied as pretest to the control group. While the pretest applications were carried out, the lesson teacher continued to teach the subjects. The lessons were taught using the Physical Sciences textbook which is a part of the education program of MoEN. The textbook involves lectures about the subjects related to the activities, examples from daily life related to the subjects and activities. At the end of the units, there is an evaluation phase after the general summary of the subjects. At the end of the application, the posttests of the scales given to the experiment groups were given to the control group as well. While the pretests of the experiment groups were carried out, the lesson teacher (same teacher as the control group) continued to teach the subjects. However, Lego based STEM activities were carried out in these groups as different from the control group. In the experiment groups, a process consisting of Curriculum + Lego based STEM activities was carried out. Prior to the activities, the students were separated into groups in line with the classroom size. The experiment groups consisting of 28 students were separated into 6 different groups. The groups consisted of 5, 5, 5, 5, 4 and 4 students. Since the number of male and female students was different in the experiment groups, it was not possible to put an equal number of students in each group. However, it was given importance to having mixed groups. The study lasted for 7 weeks. The activities in the study were carried out under the scope of the Physical Sciences lesson which is a part of the program for 4 hours a week. The control

and Experiment Group-1 were applied pretests and posttests and the Experiment Group-2 was applied a posttest. On the first week, the pretests of the scales were applied. On the last week, the posttests of the scales were applied to the students. In the Academic Success tests, the pretest of the academic success one week prior to the activity was applied. After the activity was carried out, the Academic Success test related to that activity was immediately applied.

As the 1st Activity, the students were asked to design a car within a scenario in relation to the Force and Motion unit. The students were given a sample car which they could design with Lego pieces. However, the students were told that they did not have to create exactly the same car design and that they could work on a design which would complete the task related to the activity. As the 2nd Activity, the students were asked to design an animal model within a scenario in relation to the Living Beings and Life subject. A different animal model was given to each of the groups. Since there were different animal models in this activity, the students were asked to create exactly the same model. After the Lego pieces related to the model were given, the students created the animal models. As the 3rd Activity, the students were asked to design a house model within a scenario in relation to the Matter and Heat unit. All of the groups were given the same house model. However, they were given Lego pieces of different colors and they were asked about the relationship between colors and heat insulation. The house model which was considered to have the best heat insulation was chosen among the models of the groups. In addition, the students were told that they could create design which they thought would have the best insulation regardless of the model they were given. As the 4th Activity, the students were asked to design a musical instrument model related to the Sound and its Properties subject. The same musical instrument model was given as a design to each group. After the students completed creating the musical instrument designs, they were given rubber bands and asked to place these on their designs in a manner which would create more sound. The musical instrument model which created the highest sound among the groups was chosen and the task related to that activity was completed. The first activity called 'design a car,' in terms being an example for process of the activity aimed at making students realize the properties of force, balanced and unbalanced forces and their effects on objects. During the time period in which this activity was carried out, since the students had learned about the subject in the past, they were expected to create their designs without any intervention in line with the activity task. When the gains of the activity related to the STEM disciplines is analyzed, the students were expected to arrange the dimensions and height of the model cars with the

purpose of find a solution to the given problem in relation to the discipline of mathematics. In addition, the students were expected to join the suitable Lego pieces in relation to this dimension. In terms of the discipline of technology, the task was determined as using the Lego pieces. In terms of the discipline of engineering, the task was determined as creating a model car design using the Lego pieces within the scope of this scenario.

RESULTS

In this section, the analysis results and evaluations about the scientific creativity scale and academic success tests used in the study are given place to. In order to see the pretest-posttest difference of the Control Group and Experiment Group-1, the paired samples t test was carried out. In the testing of normalcy, the Kolmogorov-Smirnov test was used. In scales and tests in which normalcy assumption was not achieved, the Wilcoxon Signed Ranks Test was performed. In the comparison of the posttests of the Control Group, Experiment Group-1 and Experiment Group 2, ANOVA analysis was carried out.

Scientific Creativity Findings

Due to not being able to achieve normalcy assumption in the differences between the dimensions of the scale applied to the control group, the Wilcoxon Signed Rank Test which is one of the non-parametric tests was performed (Table 4).

Table 4. The wilcoxon signed rank test results of the scientific creativity test for control group

Score Type	Posttest-Pretest	N	Mean Rank	Sum of Ranks	*Z*	*p*
Originality	Negative rank	0	0	0		
	Positive rank	13	7.00	91	-3.606	<.001
	Ties	16				
Fluency	Negative rank	6	9.00	54		
	Positive rank	14	11.14	156	-2.056	.400
	Ties	9				
Flexibility	Negative rank	12	11.38	136.50		
	Positive rank	15	16.10	141.50	-1.277	.202
	Ties	2				

When Table 4 is analyzed, it can be seen according to the results of the Wilcoxon Signed Ranks Test performed to determine whether there is a difference between the pretest and posttest values of the control group that, there is a significant difference in the originality score (z=-3,606, p< .05) of the students who participated in the study. It is seen that this significant difference

is in favor of the posttest in the originality score. Since normalcy assumption was achieved in the dimensions of the scale applied to the Experiment Group-1, the paired samples t test was carried out (Table 5).

Table 5. Paired samples t-test results scientific creativity test for experimental group-I

Score Type		N	*X*	S	sd	*t*	*p*
Originality	Pre-test	28	4.96	2.52	27	-3.230	.003
	Post-test	28	6.46	1.91			
Fluency	Pre-test	28	6.43	2.28	27	-0.583	.565
	Post-test	28	6.68	2.56			
Flexibility	Pre-test	28	16.79	4.06	27	-1.050	.303
	Post-test	28	17.93	6.50			

In the study involving a 28 student study group in which the effect of Lego based STEM activities on the scientific creativity of the students was analyzed, as a result of the paired samples t test carried out to see the difference between prior to and after the application, a significant difference was observed in the calculations done prior to and after the application in the originality score ($t(27) = -3.230$, $p=.003$). A significant difference in the calculations done for the fluency score and the flexibility score ($p>0.05$) was not observed. The One Way ANOVA analysis was performed for the unrelated samples in order to compare the posttest scores of the scientific creativity of the control group, experiment group-1 and experiment group-2. The One Way ANOVA findings are given in Table 6.

Table 6. One-way ANOVA results of scientific creativity for post-test scores of the groups'

		Sum of squares	*F*	*p*	Meaningful Difference
Originality	Between group	6.603	0.819	.445	-
	Within group	330.644			
Fluency	Between group	53.906	4.763	.011	Cont.Group- Exp. Group I
	Within group	464.047			
Flexibility	Between group	16.608	0.281	.755	-
	Within group	2420.286			

As a result of the test, a significant difference was not found in the analysis related to the originality score [$F(2, 82)= 0.819$, $p>.05$]. Although there is no significant different in the originality scores, experiment group-1's average was found to be higher than the average of the control group. A significant difference was found in the score averages of the fluency scores of the groups

[F(2, 82)= 4.763, p=.011]. As a result of the Tukey multiple comparison test done to see between which groups the difference resulted from, it was seen that the significant difference was between the control group and experiment group-2. A significant difference was not found between the averages of flexibility scores [F(2, 82)= 0.281, p>.05].

Academic Success Findings

Since normalcy assumption was not achieved in the differences between the pretest and posttest scores in the academic success tests related to the control group, the Wilcoxon Signed Rank Test which is one of the non-parametric tests was performed (Table 7).

Table 7. Results of wilcoxon signed rank test of academic achievement tests for control group

	Post test- pre test	N	Mean rank	Sum of rank	*Z*	*p*
FMAST	Negative rank	10	9.60	96	-0.041	.968
	Positive rank	9	10.44	94		
	Ties	10				
AAST	Negative rank	8	12.31	98.50	-0.245	.806
	Positive rank	12	9.29	111.50		
	Ties	9				
CMAST	Negative rank	8	7.88	63	-0.171	.864
	Positive rank	7	8.14	57		
	Ties	14				
SAST	Negative rank	12	10.67	128	-0.881	.378
	Positive rank	8	10.25	82		
	Ties	9				

According to the results of the Wilcoxon Signed Rank Test related to the force and Motion academic success test of the control group, a significant difference was not observed between the pretest and posttest scores (z=-0.041, p>.05). According to the results of the Wilcoxon Signed Rank Test related to the animals academic success test,a significant difference was not observed between the pretest and posttest scores (z=-0.245, p>.05). According to the results of the Wilcoxon Signed Rank Test related to the force and Properties of Matter academic success test of the control group, a significant difference was not observed between the pretest and posttest scores (z=-0.171, p>.05). Lastly, according to the results of the Wilcoxon Signed Rank Test related to the sound academic success test of the control group, a significant difference was not observed between the pretest and posttest scores (z= -0.881, p>.05). Since normalcy assumption was achieved in the differences between the pretest and posttest scores of the dimensions of the scale applied to experiment group-1, the paired samples t test was carried out (Table 8).

Table 8. Results of paired sample t-test of academic achievement tests for experimental group -1

		X	*t*	*p*
FMAST	Pre-test	13.84	-2.242	.033
	Post-test	15.05		
AAST	Pre-test	14.25	-2.820	.008
	Post-test	16.06		
CMAST	Pre-test	15.50	-0.238	.814
	Post-test	15.64		
SAST	Pre-test	12.48	-2.738	.011
	Post-test	14.66		

When Table 8 was analyzed, a significant difference [t(27)=-2.242, p=.033] was found between the pretest evaluation (Xpretest=13.84) and posttest evaluation (Xsontest= 15.05) as a result of the paired samples t test done with the purpose of seeing the pretest and posttest change in the study involving 28 students, in terms of the students' force and motion academic success test. It was seen that the significant difference was in favor of the posttest. As a result of the paired samples t test done with the purpose of seeing the pretest and posttest change related to the students' animals academic success test, a significant difference was observed between the pretest and posttest evaluations [t(27)=-2.820, p=.008]. As a result of the paired samples t test done with the purpose of seeing the pretest and posttest change related to the students' properties of matter academic success test, a significant difference [t(27)=-0.238, p>.05] was not found between the pretest (Xpretest=15.50) and posttest (Xposttest= 15.64) evaluations. Although a significant difference was not found, the score averages are in favor of the posttest. As a result of the paired samples t test done with the purpose of seeing the pretest and posttest change related to the students' sound academic success test, a significant difference was found between the pretest and posttest evaluations [t(27)=-2.738, p=.011].

The One Way ANOVA findings are given in Table 9. In order to determine whether there is a difference between the posttest scores related to the Force and Motion academic success test of the control group, experiment group-1 and experiment group-2, the score averages of the study groups were compared through the one-way variance analysis for the unrelated samples. As a result of the test, a significant difference was not found in the analysis of the posttest scores [F(2-82)=1.303, p>.05]. Although a significant difference was not found, when the students' posttest scores are analyzed, it can be seen that the averages of experiment group-1 and experiment group-2 are higher than the posttest score average of the control group. In order to determine whether there is a difference between the posttest scores related to animals academic success test

of the control group, experiment group-1 and experiment group-2, the score averages of the study groups were compared through the one way variance analysis for the unrelated samples. As a result of the test, a significant difference was found in the analysis of the posttest scores [F(2-82)=14.298, p<.001].

Table 9. One-way ANOVA results of academic test for post-test scores of the groups'

		Sum of squares	***F***	***p***	**Meaningful Difference**
FMAST	Between group Within group	27,137 927,102	1,303	.277	-
AAST	Between group Within group	282,548 997,957	14,298	<.001	Cont. Group-Exp. Group I Cont. Group-Exp. Group II
CMAST	Between group Within group	11,472 1183,722	0,397	.673	-
SAST	Between group Within group	59,734 1224,660	2,000	.142	-

As a result of the Tukey multiple comparison test done with the purpose of finding out from which groups this difference resulted from, it was seen that the significant difference was between the control group and experiment group-1 and the control group and experiment group-2 [F(2, 82)=14.268, p<.001]. As a result of the Tukey multiple comparison test done with the purpose of finding out from which groups this difference resulted from, it was seen that the significant difference was between the control group and experiment group-1. In order to determine whether there is a difference between the posttest scores related to Properties of Matter academic success test, the score averages of the study groups were compared through the one way variance analysis for the unrelated samples. As a result of the test, a significant difference was not found in the analysis of the posttest scores [F(2, 82)=0.397, p>.05]. Although a significant difference was not found, it was seen that the score averages of experiment group-1 and experiment group-2 are higher than the control group's posttest score average. In order to determine whether there is a difference between the posttest scores related to sound academic success test, the score averages of the study groups were compared through the one way variance analysis for the unrelated samples. As a result of the test, a significant difference was not found the analysis of the posttest scores [F(2, 82)=2.000, p>.05]. Although a significant difference was not found, it was seen that the score averages of experiment group-1 and experiment group-2 are higher than the control group's posttest score average.

DISCUSSION

In this study, the effect of these activities on the scientific creativity and academic success of the students has been analyzed. Instead of making the students directly memorize a scientific information, it is aimed at making it possible for them to find creative solutions to the problems they come face to face with in daily life. In line with this aim, students' upper level skills such as problem solving skills, creative thinking skills and critical thinking skills are underlined in MoE's general aims and objectives (MoE,2017). It is considered that the STEM activities applied to the students are directed towards developing these skills. In the study, when the scientific creativity scores of experiment group-1, in which Lego based STEM activities were carried out, prior to and after the application were analyzed, it was seen that the students' posttest score averages are higher than the pretest scores. A significant difference was observed in favor of the posttest in the scale's originality score. Taking these findings as the starting point, it was concluded that Lego based STEM activities positively affect the students' scientific creativity. When the literature is reviewed, it can be seen that there are studies in which similar findings were obtained. In Chen and Lin's study (2019) on students, it was determined that STEM activities develop students' scientific creativity. There are studies as well in which it was shown that students produced creative and innovative solutions through engineering applications and that these applications have a positive effect on creativity (Cantrell et al., 2006; Demir & Köse, 2022; Siew & Ambo, 2018; Ugras, 2018). In another study on teacher candidates, it was determined that a product created using STEM disciplines affects creativity (Güngör & Köse, 2023; Mayasari et al., 2016). When the dimensions related to the scientific creativity scale were analyzed, it was determined that the score average of the experiment group in which pretest and posttest were applied is higher compared to the other groups in the originality dimension. In this case, it can be stated that Lego based STEM activities develop the original ideas of the experiment group-1 students in terms of the questions in the scale. When experiment group-2 students were compared with the other experiment group's students, it was determined that they had a higher average in the flexibility dimension. In this case, it can be stated that the students in this group used more approaches towards the solution of a problem and developed methods after the application compared to the other group. It was seen that the fluency scores of the control group students were higher compared to the experiment group in both pretest and posttest scores. Therefore, it was concluded that the control group students gave more correct answers to the questions. Taking this as the starting point, it was concluded that Lego based STEM activities do not have a great effect on the students' fluency scores.

The academic success tests were separated in line with the subject areas. Different academic success tests were applied. It was determined that the students' posttest scores were higher in the pre and posttest change in experiment group-1 in terms of the force and Motion academic success test and a significant difference was seen between the pre and posttest scores. It can be stated that Lego based STEM activities increase the success of the students in this group in terms of the force and Motion academic success test. When the control group's pre and posttest changes were analyzed, it was seen that their pretest scores were higher. When the groups were compared to the control group, it was seen that they have increased the force and Motion academic success. In this case, it can be stated that the students increased their academic success through Lego based STEM activities. These results display similarities with some other studies in the literature. In Irkıçatal's study (2016), it was determined that after school STEM activities positively affected the students' academic success. In Wendell and Rogers' study (2013), when the students' pre and posttest changes are taken into consideration it was determined that as a result of the Lego based STEM activities increased their academic success. When we took a look at the results of the animals academic success test, a significant difference was found in the pre and post test scores of experiment group-1. It was observed that this significant difference was in favor of the posttest. In this case, it can be stated that the Lego based STEM activities applied to the students increased their success related to this academic success test. When we made a comparison with the control group to see the effect of the activities, it was seen that a change did not take place in the control group. When the posttest scores of the groups were analyzed, a significant difference was seen in their posttest score changes. It was seen that this significant difference was in favor of the posttest score. There are studies which have shown that STEM activities increase the academic success of the students (Shahali et al., 2015; Wendell and Rogers, 2013). When the results of the Properties of Matter academic success test were analyzed, a significant difference was not found in the experiment group in which pre and post tests were applied. However, it was seen that the posttest score of experiment group-1 is higher than the pretest score. When the score average of experiment group-1 was analyzed, it was seen that it was higher than the score of the control group. Although there is no significant difference, it was seen that the score average of the experiment groups are higher in comparison to the control group. In this case, it can be stated that this is the result of the efficiency of the Lego based STEM activities. In Wendell and Rogers' study (2013), similar findings were obtained. Although there are not too many studies in the literature about this subject area, there are studies which showed that the students increased their academic success scores through different methods

(Hollman et al., 2019). When the results of the sound academic success test were analyzed, a significant difference was found in the score average of the experiment group in which pre and posttests were applied. As a result of this significant difference in favor of the posttest score, it was determined that Lego based STEM activities increased the academic success of the students in this subject area. When compared with the control group, a positive and significant difference was observed in the score averages of the experiment groups. In this case, this shows the effectiveness of Lego based STEM activities which are one of the STEM applications on the academic success of the students. In Wendell and Rogers' study (2013) in which they used Lego materials on this subject area contains similarities with our study.

Conclusions and Implications

This research was carried out with Lego based STEM (Science-Technology-Engineering-Mathematics) activities on the scientific creativity and academic success of middle-school 6th grade students.

In the light of the findings obtained as a result of the study, these suggestions can be made:

- This study involves a 7 week period. When it is taken into consideration that STEM activities have a positive effect on the students, spreading the duration of the STEM applications to a longer time interval might give beneficial results for both education-teaching and students.
- Since this study is about subjects related to science which is one of the STEM areas, it was carried out in science lessons. However, it is considered that the placement of STEM applications in other lessons as well can be more effective in increasing the motivation and developing the career awareness of the students.
- Within the scope of the study, although the physical conditions and sizes of the classrooms negatively affected the study, the improvements of the physical conditions of the classrooms and arranging their sizes accordingly with the purpose of carrying out the activities more productive manner will improve the fruitfulness of the activities.
- This study dealt with the activities applied to 6th grade students. However, it is important to carry out these activities in different grade levels as well. Although the students displayed a positive development about the sub-problems of the study, it is considered that lower grade students' participating in activities in STEM areas will make it possible for them to have awareness at younger ages.

- It is considered that applications in which the activities are spread to a longer time slice will increase the success of the students more.
- In this study, various activities and studies were carried out on subject areas: “Force and Motion,” “Living Beings and Life,” “Matter and Heat” and “Sound and its Properties.” Activities on different subject areas can be developed and carried out.
- Within the scope of the study, Legos as one of the STEM activity materials were used. In other studies, different materials related with STEM can be used and different activities can be carried out.
- The academic success tests applied prior to and after the activities can be applied by the researchers by developing new tests with different questions.

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Genişletilmiş Özet

Giriş

Bu çalışmanın amacı, 6. sınıf öğrencilerinin Lego temelli STEM etkinliklerini kullanarak bir senaryo çerçevesinde kendilerine sunulan gerçek yaşam problemlerini çözüm üretmelerini sağlamaktır. Ayrıca bu etkinliklerin öğrencilerin bilimsel yaratıcılıklarına ve akademik başarılarına etkisini tespit etmektir. Öğrencilerin aktif katılımı, gerçek yaşam problemlerine çözüm bulabilmeleri ve üst düzey becerileri kullanabilmeleri fen okuryazarı bireylerden beklenen özelliklerdir. Dolayısıyla derslerin öğrencilerin bu beceri ve yeteneklerini tetikleyecek şekilde işlenmesi ve planlanması için eğitimcilere büyük sorumluluk düşmektedir. Lego temelli STEM etkinlikleri, öğrencilerin yaratıcı düşünme becerilerini geliştiren, mantık ve muhakeme becerilerini kullanarak bir ürün ortaya koymalarını sağlayan ve hayal güçlerini somut nesnelere dönüştürdükleri etkinlikleri içerdiğinden, eğitime entegre edilmesi önemlidir. Bu etkinlikler geleneksel öğretim yöntemlerinden farklı olduğu için fen-teknoloji ve mühendislik-matematik gibi bilimsel alanları kullanarak öğrencilerin ilgisini arttırmaktadır. Mühendislik tasarımlarının malzemesi olan legolar, öğrencilere karşılaştıkları bir sorunla ilgili somut yöntemler deneme fırsatı sunar. Ayrıca öğrencilere bir problem için buldukları çözüm işe yaramadığında hemen değiştirme şansı verir (Brophy vd., 2008; LEGO Education, 2014). Bu çalışmada, Lego temelli STEM etkinliklerinin öğrencilerin başarılarını ve becerilerini etkilemesi hedeflendiğinden, bazı konuların bu etkinlikler aracılığıyla öğretilmesinin önemli olduğu düşünülmektedir. Literatür incelendiğinde Lego temelli STEM etkinliklerini ele alan çalışmaların sınırlı sayıda olduğu görülmektedir. Dolayısıyla bu çalışmanın literatüre büyük katkı sağlayacağı düşünülmektedir.

Araştırmaya ilişkin alt problemler şunlardır:

- Lego temelli STEM etkinlikleri öncesinde ve sonrasında öğrencilerin bilimsel yaratıcılıklarında bir değişim meydana gelmiş midir?
- Lego temelli STEM etkinlikleri öncesinde ve sonrasında öğrencilerin akademik başarılarında bir değişiklik meydana gelmiş midir?

Yöntem

Bu çalışmada ön test-son test kontrol gruplu yarı deneysel yöntem kullanılmıştır. Deneysel çalışmalarda gerçekleştirilen ön ve son testlerden elde edilen sonuçlara göre, kullanılan tekniğin deney grubu üzerindeki etkisi analiz edilebilmektedir (Ary vd., 2019). Çalışmada iki grup deney grubunu, bir grup ise kontrol grubunu oluşturmaktadır. Çalışmanın deney gruplarında 6. sınıf fen bilimleri dersi konuları Lego temelli STEM etkinlikleri ile işlenirken, kontrol

grubunda mevcut öğretim programı kullanılmıştır. 6. sınıf fen bilimleri dersi konuları deney ve kontrol gruplarında 7 hafta boyunca işlenmiştir. Uygulamalar 6. sınıf öğrencileri ile gerçekleştirilmiştir. Bu uygulamaların gerçekleştirildiği okulda bu sınıf düzeyinde 3 şube bulunmaktadır. Deney ve kontrol grupları bu sınıflardan seçilmiştir. Çalışmanın kontrol ve deney gruplarının belirlenmesinde birinci dönem not ortalamaları kullanılmıştır

Bulgular

Kontrol grubu, deney grubu-1 ve deney grubu-2'nin bilimsel yaratıcılık puanları arasında fark olup olmadığını test etmek amacıyla çalışma gruplarının puan ortalamaları ilişkisiz örneklemler için tek yönlü varyans analizi ile karşılaştırılmıştır. Grupların akıcılık puan ortalamaları arasında anlamlı bir fark bulunmuştur [$F(2, 82)= 4.763$, $p=.011$]. Farkın hangi gruplar arasında olduğunu görmek için yapılan Tukey çoklu karşılaştırma testi sonucunda anlamlı farkın kontrol grubu ile deney grubu-2 arasında olduğu görülmüştür. Akademik başarı testlerinde sadece Hayvanlar Akademik Başarı testinde anlamlı fark bulunurken, diğer testlerde ortalama puanda deney gruplarının son test puanlarının daha yüksek olduğu tespit edilmiştir.

Tartışma, Sonuç ve Öneriler

Sontest puanı lehine oluşan bu anlamlı fark sonucunda Lego temelli STEM etkinliklerinin öğrencilerin bu konu alanındaki akademik başarılarını artırdığı tespit edilmiştir. Kontrol grubu ile kıyaslandığında deney gruplarının puan ortalamalarında pozitif ve anlamlı bir fark gözlenmiştir. Bu durumda STEM uygulamalarından biri olan Lego temelli STEM etkinliklerinin öğrencilerin akademik başarısı üzerindeki etkililiğini göstermektedir. Wendell ve Rogers'ın (2013) bu konu alanında Lego materyallerini kullandıkları çalışmaları araştırmyala benzerlikler içermektedir. Çalışma sonucunda elde edilen bulgular ışığında şu önerilerde bulunulabilir; bu çalışma 7 haftalık bir süreyi kapsamaktadır. STEM etkinliklerinin öğrenciler üzerinde olumlu etkisi olduğu göz önünde bulundurulduğunda, STEM uygulamalarının süresinin daha uzun bir zaman aralığına yayılması hem eğitim-öğretim hem de öğrenciler açısından faydalı sonuçlar verebilir. Bu çalışmada konu alanları üzerinde çeşitli etkinlikler ve çalışmalar gerçekleştirilmiştir: "Kuvvet ve Hareket", "Canlılar ve Yaşam", "Madde ve Isı" ve "Ses ve Özellikleri". Farklı konu alanlarına yönelik etkinlikler geliştirilebilir ve gerçekleştirilebilir.