



## THE EFFECT OF GEMS APPROACH ON SCIENCE PROCESS SKILLS OF MIDDLE SCHOOL STUDENTS

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### **Abstract:**

The aim of this study is to examine the effect of the GEMS (Great Exploration in Math and Science) approach on the scientific process skills of the students in the "Force and Energy" unit of the seventh grade science course of secondary school. The study was designed according to the semi-experimental pattern with pre-test post-test control group from quantitative data analysis methods. The study group of the study consists of 32 seventh grade students. The application studies lasted a total of 4 weeks. In the experimental group (N=16), the GEMS-based learning program was processed, and in the control group (N=16), the courses were taught according to the 2018 science curriculum. As a data collection tool, the scientific process skill test (SPST) consisting of 26 multiple-choice items was used before and after the application. The SPSS package program was used in the analysis of the findings. In the SPST data analysis obtained from the scales of the groups, independent samples "Mann Whitney U test" and "Wilcoxon signed rows test" were used. As a result of the research, it was seen that SPST scores showed a statistically significant difference in the experimental group where the courses based on the GEMS-based learning program were carried out compared to the control group where the courses were processed according to the 2018 science curriculum. In the experimental group where the courses based on the GEMS approach were conducted, it was concluded that the scientific process skill test scores were high. According to the results obtained from the study, in-service training should be provided to teachers in order to use the GEMS (Great Exploration in Math and Science) based learning program more effectively, and it may be recommended to prepare guidebooks for GEMS approach for science teachers.

**Keywords:** GEMS, scientific process skill, science education, force and energy

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## 1. Introduction

The rapid development of science and technology worldwide affects human life in every field. People who adapt to the rapid development of science and technology make a significant difference compared to other people. One of the important fields affected by the rapid development and change of science and technology is education (Çümen, 2018). The education system aims for individuals to think analytically, question, observe, express themselves, learn to learn, and put their thoughts into action (Ministry of Education, 2018).

In science education, it is aimed to adopt the scientific process skills expected from students and to produce solutions to the problems they encounter, to develop awareness, curiosity, attitude, and interest (Ministry of Education, 2013). Looking at the literature on science education in today's world and in our country, it is seen that it is more important for students to learn how science is done, how the scientific process is made sense of and used, rather than learning the concepts, laws, generalizations, and theories of science (Bati, 2013).

When the 2013 Elementary Science Curricula and 2018 Elementary Mathematics Curricula, which were renewed and updated by the Ministry of National Education Board of Education (Ministry of Education, 2013; 2018), are reviewed, it is seen that importance is given to student-centered approaches that investigate, question, discover knowledge with active participation, use knowledge, adopt scientific process skills, adapt to science and technology, and associate the concept learned with daily life (Ministry of Education, 2013; 2018). GEMS is one of the approaches that enable students to discover the meaning of life by learning to learn, discovering knowledge, solving problems, and discovering the meaning of life by both doing and living as scientists in an environment where they are active.

The GEMS approach is a flexible approach that makes science and mathematics fun and enables students to make observations and discoveries, and at the same time to retain information through classification and grouping (Barett et al., 1999). It also aims to develop basic skills and concepts in science and mathematics, critical thinking, experiencing by doing and living, communicating with peers, and developing a positive attitude towards science and mathematics (Barber & Bargman, 2000).

GEMS is a program that reveals and develops skills such as critical thinking, questioning, independent learning, analysis, synthesis, and questioning habits in the process of activities in which students are active, starting from the preschool period and continuing until the eleventh grade (Saritaş, 2010).

GEMS, which consists of fun Science and Mathematics activities, is also connected to other subjects. GEMS activities, where the learner is at the center, offer the opportunity to experience real life. GEMS can contribute to the development of the existing curriculum program or can be applied alone (Barett et al., 1999).

When we look at the GEMS approach, it is revealed that there are methods, techniques, evaluation forms, and common goals similar to the MoNE 2013 Science Curriculum and MoNE 2005 Mathematics (1-5) Curriculum. In the Science Curriculum,

emphasis was placed on the learning strategy based on research, questioning, and problem-solving skills in which the student constructs knowledge, with the student being active in the preparation and processing of the lessons and the teacher as a guide, based on the environments in which the student will show the path to be followed. The 2005 Curriculum for Mathematics (1-5) aims to develop skills such as problem-solving, using mathematical concepts, positive attitudes towards mathematics, associating with different disciplines (art, aesthetics), and using mathematical models.

The science and mathematics activities in GEMS start with action. Students discuss the basic concepts in the GEMS activities and after reaching a certain level of thinking, they start to question. These activities will motivate students to learn concepts and ideas better, leading to experience and critical thinking. The materials used in GEMS activities are easy to find and inexpensive. There is no need for special training in science or mathematics for course teachers (Barber et al., 1998, pp. 5-7).

According to Barber (1998), GEMS activities demonstrate the inquiry-based "guided discovery" approach in the best way, allowing students to grasp the concepts found in science and mathematics and to develop inquiry skills in their daily lives in line with the needs.

GEMS was first established through the Lawrence Hall of Science Science Center at the University of California (Barber & Bargman, 2000). When the literature is examined, Saritaş (2010) investigated the effect of GEMS learning program on concept acquisition and school readiness levels of preschool students. Sağlam (2012) examined the effectiveness of the Science and Mathematics Great Inventions Program. Çam (2013) introduced the GEMS-based learning program in his study. Ceylan, Tüysüz, and Tatar (2016) took the opinions of pre-service teachers studying in science teaching about GEMS activities. Ceylan (2016) examined the effect of GEMS-based learning program on the academic achievement, scientific reasoning self-efficacy, and attitudes towards astronomy of fourth grade students studying in the department of science teaching on the subjects of "Earth, Moon and Stars".

Tekbıyık, Şeyihoğlu, and Konur (2017) examined the effect of classroom and science teachers' ability to design GEMS activities within the scope of in-service training. Çümen (2018) investigated the effect of GEMS-based learning program on the academic achievement, conceptual changes, and science process skills of 6th grade students on the subject of density. Karamustafaoğlu and Aktaş (2020) examined GEMS approach activities and teachers' views on the implementation of this approach. Nas (2021) investigated the effect of GEMS-supported education program on children's mathematics skills in preschool education. It is seen that there are also foreign scientific studies (Granger, Bevis, Saka, & Southerland, 2009; Olsen & Slater, 2009; Pompea & Gek, 2002). When the studies were analyzed as a whole, there were no studies on the effect of the GEMS approach on the science process skills of middle school students. For this reason, it is thought that the study aiming to investigate the effect of GEMS activities on science process skills and mental structures will contribute to the literature.

The aim of this study is to examine the effect of the experimental group, in which the lessons were taught according to the GEMS approach, and the control group, in which

the 2018 science curriculum was taught, on the science process skills of seventh grade students in the "Force and Energy" unit of the science course. In the light of this problem, answers to the following questions were sought:

- Is there a statistically significant difference between the experimental and control groups in terms of pre-test scores?
- Is there a statistically significant difference between the experimental and control groups in terms of the post-test SPST scores?
- Is there a statistically significant difference between the pre-test and post-test SPST scores of the experimental group in which lessons based on the GEMS approach were conducted?
- Is there a statistically significant difference between the pre-test and post-test SPST scores of the control group in which 2018 science curriculum-based lessons were implemented?

## 2. Material and Methods

### 2.1 Research Design

The study was conducted using a pretest-posttest control group, quasi-experimental design. A quasi-experimental design is a research design used to understand the cause-effect relationships between variables (Büyüköztürk, 2007). Observing the effect of a variable in an event on the result is the biggest difference that distinguishes experimental designs from other research designs (Fraenkel & Wallen, 2006; as cited in Büyüköztürk, Kılıç Çakmak, & Büyüköztürk, 2007). Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2008, p. 180).

### 2.2 Study Group

The study group consisted of 32 7th grade students studying in a secondary school in a province in the Central Black Sea region in Turkey in the fall semester of the 2022-2023 academic year. Information about the students in the study group is given in Table 1.

**Table 1:** Distribution of Students in the Experimental and Control Groups

Gender	Experimental Group	Control Group	Total
Female	10	10	20
Male	6	6	12
Total	16	16	32

### 2.3 Data Collection Tools

In the study, the Scientific Process Skills Test was used to collect data. Detailed information about the data collection tools used in the study is given below.

#### 2.3.1 Scientific Process Skills Test

The test consisting of 26 items with 4 options developed by Öztürk (2008) was used as the science process skills test. The internal consistency Cronbach alpha reliability

coefficient of the scientific process skills test was 0.88. The scientific process skills in this study include the sub-skills of observing, classifying, determining variables, predicting, measuring, and interpreting data, number and space relations, hypothesizing, deciding, modeling, changing and controlling variables, recording data, experimenting, and drawing conclusions.

In the scoring of the test, 1 point was given to the question with the correct answer. The question that was left blank and answered incorrectly was evaluated as 0 points.

## 2.4. Data Analysis

In the study, the analysis of the findings obtained from the science process skills test was done with the SPSS package program. In order to find answers to the problem and sub-problems in accordance with the aim of the study, normality analysis was performed with the Shapiro-Wilk test and the results are presented in Table 2.

**Table 2:** Normality Test Findings of Pre-Test SPST Data

Variable		N	Skewness	Kurtosis	Shapiro-Wilk
Pre-test	Experimental Group	16	-1.39	0.80	.12
	Control Group	16	0.49	-1.41	.02

\*p<0.05

When Table 2 is examined, it was determined that the data found in the Shapiro-Wilk normality test ( $p<0.05$ ) did not show normal distribution. Mann-Whitney U test, one of the nonparametric tests, was used to analyze the data. Wilcoxon signed-rank test was used for the same group of students before and after the application. The reason for using Mann Whitney U test and Wilcoxon signed-ranks test, which are nonparametric tests, is that the measurement scores of the related measurement sets are continuous and the measurements are at least equally spaced measurement level (Büyüköztürk, 2011).

## 2.5. Application Process

The study was conducted in the fall semester of the 2022-2023 academic year with seventh grade students studying in a district of a province in the Central Black Sea Region. The experimental group ( $n=16$ ) and the control group ( $n=16$ ) consisted of randomly selected classes. The application was carried out in 4 weeks. The Scientific Process Skills Test was administered as a pre-test. The experimental group was taught with the GEMS-based learning program, and the control group was taught with the PBS-based learning program. The application started on November 21, 2022 and ended on December 23, 2022. The application was carried out by the researcher in the experimental and control groups. In the experimental and control groups, the SPST was applied as a post-test, and data analysis was carried out.

### 3. Findings

Is there a statistically significant difference between the experimental and control groups in terms of the pretest SPST scores? The Mann-Whitney U test conducted to find an answer to this sub-problem is shown in Table 3.

**Table 3:** Mann-Whitney U Test Results of Experimental and Control Groups' Pre-Test BSCT

Group	n	Rank mean	Row sum	U	p
Experimental Group	16	15.13	242.00	106.00	.40
Control Group	16	17.88	286.00		

In Table 3, no statistically significant difference was found between the experimental and control groups in terms of the SPST pre-test scores ( $p > 0.05$ ). In this case, it can be stated that the groups' SPST pre-test score levels were equivalent.

The findings related to the second sub-problem of the study, "Is there a statistically significant difference between the experimental and control groups in terms of the post-test scores of SPST?" are presented in Table 4.

**Table 4:** Mann-Whitney U Test Results of the Post-Test SPST of the Experimental and Control Groups

Group	n	Rank mean	Row sum	U	P
Experimental Group	16	22.16	354.50	37.50	.00
Control Group	16	10.84	173.50		

In Table 4, there is a significant difference between the groups in terms of the Mann-Whitney U test results of the post-test SPST ( $p < 0.05$ ). It can be concluded that the experimental group in which the GEMS-based learning program was applied was more effective on the science process skills post-test scores than the control group in which the SPST was applied.

The findings related to the third sub-problem of the study, "Is there a statistically significant difference between the pre-test and post-test SPST scores of the experimental group in which GEMS-supported lessons were applied?" are presented in Table 5.

**Table 5:** Comparison of Experimental Group Students' Pre-Test and Post-Test SPST Scores

	N	Rank mean	Z	P	
E1-E2	0 <sup>a</sup>				
Total	16 <sup>b</sup>	.00	-3.52	0.00	a. $E_2 < E_1$
	0 <sup>c</sup>	8.50			b. $E_2 > E_1$
	16				c. $E_2 = E_1$

When Table 5 is analyzed, it is seen that the post-test SPST score of all 16 students in the experimental group was higher than the pre-test SPST score. According to these data, there is a statistically significant difference ( $P = 0.00$ ) in the SPST test scores of the experimental group students to whom the GEMS-based learning program was applied.

This difference is a positive difference and it can be said that the GEMS-based learning program has an important effect on increasing the development of students' scientific process skills in the teaching of the Force and Energy unit of the 7th grade Science course. The findings related to the fourth sub-problem of the study, "Is there a statistically significant difference between the pre-test and post-test SPST scores of the control group in which 2018 science curriculum-based lessons were taught?" are presented in Table 6.

**Table 6:** Comparison of Control Group Students' Pre-Test and Post-Test SPST Scores

	N	Rank mean	Z	P	
C1-C2	6 <sup>a</sup>				
Total	7 <sup>b</sup>	7.83			a. C <sub>2</sub> <C <sub>1</sub>
	3 <sup>c</sup>	6.29	-0.10	0.91	b. C <sub>2</sub> >C <sub>1</sub>
	16				c. C <sub>2</sub> =C <sub>1</sub>

When Table 6 is analyzed, it is seen that the posttest SPST score of all 16 students in the control group was lower than the pre-test SPST score. According to these data, there is no statistically significant difference between the SPST scores of the control group students to whom the 2018 science learning program was applied (P=0.91). The results of the 2018 science curriculum-based lessons show that the control group did not have an effect on increasing the development of students' scientific process skills in the teaching of the Force and Energy unit of the 7th grade science course.

#### 4. Discussion and Conclusion

In the world and in our country, a great deal of research has recently been conducted in order to increase the efficiency of educational programs. In particular, research on bringing Science and Mathematics together has accepted scientific processes as a common point and projects have been developed in this context. One of these projects is GEMS (Saritaş, 2010). The GEMS program aims to enable students to learn the main concepts in science and mathematics, to develop positive attitudes towards science and mathematics courses by emphasizing the importance of these concepts, and to gain individuals who can think independently and critically. The program has been tested by teachers in many countries around the world, primarily in the USA (Barett et al., 1999; as cited in Yalçın & Tekbıyık, 2013). In this study, the effect of the GEMS approach on the scientific process and skills of middle school students was examined. Before starting the study, a pre-test was applied to the experimental and control groups, and a post-test was applied to the seventh grade science course force and energy unit science process skills test at the end of the application, and the following results were obtained.

In the experimental and control groups, there was no statistically significant difference between the groups according to the SPST pre-test score results before the application. It can be interpreted that the pre-test scores of the experimental and control groups were equivalent to each other before the application.

In the experimental and control groups to which the post-test SPST was applied, it was determined that the experimental group, in which the lessons based on the GEMS approach were carried out, showed a statistically significant difference in favor of the experimental group in the development of post-test science process skills compared to the control group in which the 2018 science curriculum was taught. In the post-test, it is seen that the experimental group, in which the lessons based on the GEMS approach were carried out, was more effective in the development of scientific process skills than the control group students in which the 2018 science curriculum-based lessons were taught. It is similar to the results of the studies conducted by Aktürk (2019), Ceylan (2016), Çelik (2016), Çelik and Tekbıyık (2016), Çümen (2018), Granger et al. (2009), Pompea and Gek (2002), Olsen and Slater (2009) and Olsen (2007) in which the science process skills of the students in the groups where the GEMS-based learning program was applied.

It was concluded that there was a statistically significant difference in favor of the post-SPST for the pre-SPST and post-SPST scores of the experimental group students in whom the GEMS-based learning program was applied in teaching the force and energy unit of the science course.

It was found that there was no statistically significant difference between the pre-test and post-test SPST scores of the control group in which 2018 science curriculum-based lessons were conducted in the teaching of the force and energy unit of the science course.

It is said that the activities prepared according to the GEMS (Great Exploration in Math and Science) based approach have a positive effect on the development of students' scientific process and skills, as students actively participate in learning, support them with worksheets, discuss with their groupmates, make inferences, make measurements and use all their senses.

## **5. Recommendations**

In order to examine the GEMS approach effectively, it can be applied in different units of the science course. Materials, tools, and equipment to be used in GEMS approach activities should be prepared in advance and their deficiencies should be eliminated. In the class where the GEMS-based learning program was implemented, the class size consisted of 16 students. The small class size provided convenience in terms of the efficiency of the application. It can be suggested that the classroom environments where the GEMS approach is applied should not be crowded. In order to use the GEMS (Great Exploration in Math and Science) based learning program more effectively, in-service training should be provided to teachers, and prospective teachers should be informed about the GEMS approach. Guidebooks on the GEMS approach can be prepared for science teachers.

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### Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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