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# The effect of educational game activities applied on the academic achievement of secondary students in science education

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**ABSTRACT**

The research aims to examine the effect of educational game activities on academic achievement in secondary school 5th-grade science lessons. The study group of the research consists of 71 5th-grade students studying at a public school in Turkiye in the 2017-2018 academic year. In the research, the pre-test and post-test comparative design group, which is one of the quantitative research methods, was used to achieve the research objectives. A random sampling technique was used to determine these two groups. In the experimental group (EG), the lessons were enriched with educational game activities (EGA). The control group (CG) taught the courses based on the current science teaching program (CSTP). An academic achievement test (AAT) has been prepared for the unit goals of the 5th-grade science course "Spreading of Light". AAT was applied to the groups before and after the experiment ındepended samples t-test and Whitney u-test were used in the analysis of the data. The data showed that the EGA used in the science course has a positive effect on academic achievement.

**Keywords:** Academic achievement, educational game activities, science education, secondary school.

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## INTRODUCTION

In today's information and technology age, changes are seen in every field in line with the needs. In the developing and changing world, education systems, curricula, teaching methods and techniques, and measurement tools used in the evaluation phase are subject to regular changes in education (Taş et al., 2016). The change in information and technology shows its effect in education as well as in many fields at present. This situation causes changes in education systems, curricula, teaching methods and techniques, and measurement tools used for evaluation. Learning environments should be provided where students take an active role, are responsible for their learning, can transfer what they have learned to daily life, are open to cooperation, have a pleasant time with their peers, express their ideas comfortably, contribute positively to their development areas, and increase academic success. Teachers should prefer appropriate methods, techniques, and approaches, which will lead students to think and develop their creativity by providing pleasant environments for targeted knowledge, skills, and behaviors (Tezel, 2018). The science course includes abstract, complex subjects and concepts. The age range of students training in secondary school is 10 to 14. Therefore, it is seen that students in this age group rarely have the ability to think abstractly, so they cannot learn meaningfully during the learning period, they choose to memorize, or they move away from the lesson and become indifferent to the lesson and cannot be motivated (Çavuş et al., 2011). Using games, which are accepted as an inevitable part of students' daily lives, as a tool in the education process, is of great importance (Önen et al., 2012). The game provides a fun environment that facilitates learning and comforts students while teaching new concepts (Romine, 2004). Games not only make it easier for students to learn new concepts but also

provide learning environments that allow students to relax (Huyen and Nga, 2003). it has been determined that games have a direct or indirect effect on many developmental areas of children such as the physical and psychomotor and social (Kuru and Köksalan, 2012), cognitive (Sun et al., 2021), emotional (Çalışkan and Karadağ, 2014) and language (Akandere, 2013). Student-centered EGA is one of the methods in which students are responsible for their learning, learn by having fun, feel comfortable, develop communication skills, problem-solving skills, and creativity, and learn individually or cooperatively. It is important to play EGA in the teaching process for making students comprehend abstract or concrete concepts that are difficult to understand in science lessons (Korkmaz, 2018).

As it can be understood from the information given above, when the literature is examined, the interest in research on EGA is constantly increasing. However, the integration of games into teaching is still a somewhat unexplored field of study and has received limited attention in the research field (Kangas, et al., 2017). Teaching through games is a holistic strategy that increases classroom participation and student engagement and is more involved in their learning (Higueras-Rodríguez et al., 2021). In a study by Gaydos (2015) on educational games, the interest in using games to help students learn in the last decade stated that games can be effective educational tools. If the teachers want to create an interesting atmosphere, they should include games in the classroom environment (Nguyen and Khuat, 2003). In Radulavic's (2021) research on the game-based student response system approach, this approach combines the entertaining power of digital games and teaching content. Radulavic observed a positive impact of the approach on student engagement and success however, educational efficiency and student engagement were not fully evaluated. EGA used in science lessons provides reinforcement and repetition of information in a comfortable environment. In addition, EGA prevents students' prejudices against science course subjects and enables them an active learning environment that will increase their interest in the course. As the number of games used in the lessons increases, the interest and motivation of the students towards the lesson increases at the same rate (Korkmaz, 2018). Teaching the lesson through EGA will facilitate an active participation environment for passive or introverted students, and will support communication, creativity, teamwork, obeying the rules, and respect skills (Beker Baş and Karamustafaoğlu, 2020; Demirel et al., 2004). The main benefit is related to learning motivation and student success in education, therefore, the educational game presents tasks and activities in an attractive way for students. As can be seen from the literature given above, many authors have found that incorporating educational games into the pedagogical field has many benefits. The student's active participation in the lesson and the academic success achieved in the lesson contributes to the learning motivation (Moriarity et al., 2001). According to Tuan et al. (2005), there is a positive correlation between students' attitudes, motivation, and achievements in teaching with EGA in science lessons. According to Kebritchi and Hirumi, (2008), the essence of educational games is: (a) the ability to replace words with actions and provide students with an interactive teaching environment; (b) it is suitable for trainers of various knowledge and skills and has strong adaptability; (c) they are indispensable and effective learning tools for students. At the same time, Parra-González and Segura-Robles (2019) defined educational games as gamification. According to these researchers, gamification is a new methodology that consists of using games or game mechanics in non-game contexts, thus providing motivation for students in education. This phenomenon has led not only to its use as concrete experiences in the classroom but also to more research on educational gamification in the scientific field in recent years. In recent years, game-based digital learning has become a popular solution for the lack of motivation and guidance in e-learning environments. There are also studies on educational computer games (Yeşilbağ et al., 2020), computer games, and digital games. The findings in the research conducted by Tsai and Hsu (2020) on computer games showed that when students play the proposed "Science Detective Squad" game alone, guiding process constraints and directions can affect students' problem-solving performance.

Although science is taught or done with computer-based games in the digital age, it is thought that it will make a child in the age of play love science and make learning more permanent with educational game activities by doing and living. For this purpose, this study was carried out. In the study, a unit was discussed, and educational game activities were prepared by taking into account the achievements in this unit. Moreover, science teaching has been gamified. With the increase in urbanization, children cannot find enough playgrounds and cannot spend enough time with their peers. The student who tries to make up for this deficiency in the school environment gets bored with the current science curriculum and cannot get enough efficiency from the lesson. In addition, the rapid development of technology keeps children connected to their homes and causes them to play games on computers, phones, and tablets for hours. Presenting the games that children enjoy and play tirelessly to educational environments becomes fun and attractive by getting rid of the traditional classroom environment.

In the 2012-2013 academic year in Türkiye, a transition to 12-year compulsory education was made. After this date, the age of starting secondary school has been lowered. Therefore, students between the ages of 10-11 have started the 6$^{th}$ grade of secondary school. For these students, who are in the first step of secondary school,

this period is the concrete operational period in which abstract learning is not fully realized according to Piaget (Karamustafaoğlu and Kaya, 2013). The fact that the scope of the science course includes abstract concepts causes students to exhibit negative attitudes and decreases their motivation and academic success (Önen et al., 2012). Examination of the literature shows that the spread of light unit is not a subject to be studied much in the science lesson (Teker et al., 2017). Students have difficulty in understanding and expressing the spread of light and reflection subjects included in the spread of a light unit in the science curriculum implemented in Turkey in 2017 (Kaya, 2010). In science teaching, what students do to learn and what kind of skills they acquire are of great importance. Although the importance of science lessons is known, there are very important problems in science classes today. Students think that science lesson is boring, difficult, and complicated and they do not have enough skills for science. This situation shows us that students do not have enough motivation and courage to learn science and they develop negative attitudes (Dilşeker and Serin, 2018). It is believed that the use of different teaching methods and techniques such as the educational game method in order to change this negative situation for science teaching will be beneficial in terms of both facilitating science teaching and destroying negative attitudes. This study aimed to teach our science lesson to 5th-grade students who have finished primary school and started secondary school in Türkiye by applying EGA. For this purpose, we examined whether the EGA developed within the “spread of light” unit in the 5th-grade science lesson affects the academic achievement of the students. It has been chosen for 5th-grade students who have just started secondary school because there are too many abstract topics in this unit. The main fundamental question of our work is: “Does EGA applied to secondary school students affect academic achievement?” To answer the main question, the following sub-questions were considered:

1. Is there a significant difference between the academic achievement pretest scores of the control group and the academic achievement pretest scores of the experimental group?
2. Is there a significant difference between the academic achievement post-test scores of the control group and the academic achievement post-test scores of the experimental group?

## MATERIALS AND METHODS

### Research design

This research was carried out in Turkiye in the 2017-2018 academic year. In this study, a comparative design group (Davids and Roman, 2013) was preferred with the pre-test and post-test control group to find answers to the research problem and its sub-problems. A comparative design group is a valid and reliable model that can test the cause-effect relationship (Büyüköztürk et al., 2019). Considering the unit gains, while science was taught to the CG with the existing science curriculum, science was taught to the EG with 7 EGA prepared by the teacher. The AAT was prepared to find answers to the main problem and sub-problems. Data were collected by applying this test to both groups before and after the educational games were played.

### Sample and data collection

The participants of this study comprised 71 students training in the 5th grade of a state secondary school in Türkiye. In the 5th grade level created by the school administration, 2 classes from 5 classes were randomly assigned as the EG and CG. The academic achievement averages of these five classes were close to each other. The experimental group consists of 36 students and the control group consists of 35 students.

The experiment covers 5 weeks within the scope of the "the spread of light" unit. Lessons were conducted with the current curriculum in CG and EGA in EG within the scope of the relevant unit. In the study, the data obtained from the AAT used before and after the experiment were evaluated with the SPSS 24.0 statistical program. Descriptive analysis was performed to determine equivalence between groups. To evaluate the data obtained for the sub-problems of the study, Independent Samples t-test and Independent Samples Mann Whitney u-test analysis were performed and the level of significance was taken as 0.05.

### Preparation of the EGA

Ministry of National Education (MoNE) Science Curriculum (2018) secondary school 5th grade the spread of light unit gains are as follows: to discover how light propagates in different environments, to comprehend that light propagates linearly, and to show this situation with simple ray drawings, to comprehend the reflection of light, to show the ability to classify materials according to light transmittance, to predict how full shadow is formed and to discover the factors affecting the full shadow length of objects.

EGA has been prepared in line with the above objectives and under the unit outcomes. The researchers designed 7 games for the 6 targeted acquisitions related to the unit. Related objectives or “outcomes and the names of these games are shown in Table 1. The light transmittance game, which is among these games, is an exemplary game experiment. The preparation and experiment stages of the games were made according to

**Table 1.** The game name and the “objectives” or “outcomes” to which it relates.

| The game name | Relevant gain/gains |
|---|---|
| 666 | -Shows with drawings by observing that the light emanating from a source follows a linear path in all directions. |
| Is it Flat? Messy? | -Shows the reflections of light on smooth and rough surfaces by observing and drawing. |
| Is Incoming Reflected Normal? | -Explains the relationship between the incident ray, the reflected ray, and the normal of the surface in the reflection of the light. |
| Suspended substance | -Classifies materials according to their light transmittance. |
| Light transmittance game | -Classifies materials according to their light transmittance. |
| Drawing rays with playdough and | -Shown with simple ray drawings by observing how the full shadow is formed.<br>-Explore the variables that affect the full shade by experimenting. |
| Is it correct? Is that wrong? | -It is a general replay game with all 6 gains above. |

the method of Akardere (2013).

**Sample game experiment**

***Introduction of the game***

The name of the game is “Light transmittance game”. The game was performed in a classroom setting. The students are asked to play the "Light transmittance game" and the desks in the classroom are arranged before the lesson. It is announced that the winner of the game will be awarded a prize.

***Explanation of the game rules***

Considering students ‘requests, the teachers form groups of 4 students. They determine one willing person from the group as a clerk. According to the permeability status, matching the correct text with the visual is 1 point. The student who matches correctly continues the game. Matched cards are removed from the game. Mismatched cards are closed again and passed to the other student. There are 3 stages with 4 rounds each in the game. In each round, a different student starts the game. In case of a tie in the stages, the game is repeated until the tie is broken. Students who get the most points in their groups in the 1st stage are included in the groups by drawing lots in the 2nd stage. In the 3rd stage, the group winners in the 2nd stage are complete. The student with the most points wins the game.

***Implementation of the game***

The desks in the classroom are arranged in such a way that 4 people can sit opposite each other. In each group, a willing student is assigned as a clerk and is provided to take notes. Each group is dealt 12 cardboard square cards. In these cards, there are 2 transparent material texts and images, translucent material texts and images, and opaque material texts and images. In the first round of the game, the student who will start the game is determined by drawing lots. The student who starts the game turns over the 2 cards, takes the cards if the matching is correct, and the game continues with the remaining cards. 1 point is earned for each correct match. In case of a mismatch, the cards are closed again. The student to the right of the student who made the wrong match continues the game. When the pairings are completed, the game is over. The game is repeated for 4 rounds and the student with the most points becomes the group winner. 2 new groups are formed by drawing lots from the group winners in the 1st stage and the game is played in 4 rounds. At this stage, the students who earn the most points in their groups face each other in the 3rd stage. The winner of the game with the most points at the end of the 4-round stage repeated for the last time is declared.

**Preparing and implementing an academic achievement test (AAT)**

The researcher prepared a multiple-choice academic achievement test for 6 goals in line with the topics in the spread of light unit in the 5$^{th}$-grade science lesson. A pool of 70 items was created by examining auxiliary resources and previously asked exam questions. By taking the opinions of 4 science teachers and a subject academic expert, and paying attention to the content validity, this question pool was reduced to 34 questions. To determine

the validity and reliability of the prepared test, a pilot application was made to 110 students in the research school. The results of the pilot study excluded 12 items with discrimination of less than 0.30 from the test. The average difficulty of the test with 22 questions remaining in the last state of the test was calculated as 0.676 and the item distinctiveness as 0.439. According to Kuder-Richardson-20 (KR-20), the internal consistency value of the test was found to be 0.773. The KR-20 reliability coefficient is generally 0.70 for the original scale (Aksu and Kul, 2017). When this value is noted, it can be said that the reliability of the test is within acceptable limits.

### Analyzing of data

The data obtained from the AAT used before and after the experiment in the study were evaluated with the SPSS 24.0 statistical program. Descriptive statistics were performed before and after the experiment to determine the equivalence between the groups. To evaluate the data obtained for the sub-problems of the study, Independent Samples t-test and Independent Samples Mann Whitney U-test analysis were performed and the level of significance was taken as 0.05.

## RESULTS

To determine the equivalence of the groups in the comparative group design, descriptive statistics were performed both at the beginning and the end of the research. The pre and post-tests in both groups were compared separately (Tables 2 and 3).

**Table 2.** Descriptive statistics of the pre-test and post-test results of the CG in terms of AAT.

| | N | x | Sd | Min | Max | Skewness | Std Error | Kurtosis | Std Error |
|---|---|---|---|---|---|---|---|---|---|
| Pre-AAT | 35 | 9.542 | 2.671 | 4.00 | 15.00 | 0.219 | 0.397 | -0.665 | 0.777 |
| Post-AAT | 35 | 13.428 | 3.965 | 3.00 | 21.00 | -0.358 | 0.397 | -0.065 | 0.777 |

**Table 3.** Descriptive statistics of the pre-test and post-test results of the EG in terms of AAT.

| | N | x | Sd | Min | Max | Skewness | Std Error | Kurtosis | Std Error |
|---|---|---|---|---|---|---|---|---|---|
| Pre-AAT | 36 | 9.555 | 3.872 | 1.00 | 17.00 | -0.370 | 0.392 | -0.535 | 0.768 |
| Post-AAT | 36 | 17.5 | 4.171 | 7.00 | 22.00 | -1.357 | 0.392 | 0.869 | 0.768 |

Examination of the data in Tables 2 and 3 indicates that the post-test scores did not show a normal distribution, while the pre-test scores showed a normal distribution in terms of the AAT of the EG and CG. The fact that the Skewness and Kurtosis values obtained from a measurement tool are between ±1.5 indicates that the data show a normal distribution (Tabachnick and Fidell, 2013, cited by Karakaya et al., 2019). The values and test results of the findings we got for each of the two sub-problems under the main problem are given below.

**Sub-problem 1:** Is there a significant difference between the academic achievement pretest scores of the control group and the academic achievement pretest scores of the experimental group?

To answer this sub-problem data, independent samples from statistical analysis methods were analyzed using independent samples t-test and the results are shown in Table 4.

**Table 4.** Independent samples t-test results regarding pre-test AAT scores of CG and EG students.

| Group | N | x | ss | sd | t | p |
|---|---|---|---|---|---|---|
| CG | 35 | 9.54 | 2.67 | 62.28 | 0.01 | .987 |
| EG | 36 | 9.55 | 3.87 | | | |

As seen in Table 4, the pre-test mean score of the CG was determined as $\bar{X}$=9.54, and the mean score of the EG was determined as $\bar{X}$=9.55. According to the independent samples t-test results, there was no significant difference between the AA pre-test scores of the CG and EG (t=0.01 and p>.05). This shows that at

the beginning of the experiment, the existing knowledge of the CG and EG students about the unit "the spread of Light" is similar.

**Sub-problem 2:** Is there a significant difference between the academic achievement post-test scores of the control group and the academic achievement post-test scores of the experimental group?

To evaluate this sub-problem data, Independent samples from statistical analysis methods were analyzed using the Mann-Whitney u-test and the results are shown in Table 5.

**Table 5.** Mann-Whitney U-test results regarding pre-AAT scores of CG and EG students.

| Group | N | Mean Rank | Sum Rank | U | p |
|---|---|---|---|---|---|
| CG | 35 | 25.59 | 895.50 | 265.500 | .000 |
| EG | 36 | 46.13 | 1660.50 | | |

According to the data in Table 5, it was determined that the mean rank of the CG (25.59) was lower than the mean rank of the EG (46.13). When the post-AAT scores of the CG and EG were compared, it was determined that there was a significant difference in favor of the EG in which EGA was used ($U = 265.500$, $p < .05$).

## DISCUSSION

An examination of the studies on this subject reveals the effect of EGA on many variables, such as attitude (Gürbüz, 2019), motivation (Kılıç and Gürbüz, 2019), creativity (Bulut et al., 2022) at different levels, and courses. Our study shows parallelism with many studies on the significant difference that games create in academic achievement. Şaşmaz Ören and Erduran Avcı (2004) compared the effect of teaching with EGA and traditional teaching on academic achievement. In the “Solar System and Planets” unit of the 6th-grade science lesson, they stated that teaching with EGA makes a significant difference compared to the traditional method. Hanbaba and Bektaş (2007) investigated the effect of games on success and attitude in the 3rd-grade life studies lesson and found a significant difference in favor of the experimental group in which EGA was used. Gökçen (2009), in his study, concluded that game-based teaching in mathematics lessons is more effective than the traditional method of increasing success. Güler (2011) stated that the EGA was effective in increasing the targeted success of “Cells and Organelles” in the 6th-grade science and technology lesson. In the study by Coşkun et al. (2012), in which the effect of EGA containing scientific stories within the “Electricity in Our Lives” unit in a science lesson, on academic success, EGA in favor of the experimental group contributed significantly to success. Demir (2012) emphasized that there are many concepts in the systems unit of the 7th-grade science lesson, that the students could not make these concepts meaningful, and that they carried out the process by memorizing and were unsuccessful. An experimental study has shown that the game-based learning approach increases academic success in eliminating this problem. Kaya and Elgün (2015) conducted a study with primary school students using the pre-test post-test quasi-experimental design. They supported science teaching with EGA and examined its effect on academic achievement. It has been concluded that the games used effectively by the teacher will contribute to success. Işık and Semerci (2016) investigated the effect of EGA on the success of acquiring English words for 3rd-grade students. They taught vocabulary with EGA in the experimental group, and with non-game activities in the control group, adhering to the textbook. Meaningful vocabulary instruction was positively differentiated in favor of the experimental group. Beker Baş and Karamustafaoğlu (2020), used EGA in teaching the subject of the nervous system in a 6th-grade science lesson. Results of the interviews with the students and the informal observations of the process revealed the games motivated a sense of curiosity in the students, and the skills of teamwork, obeying the rules, and respect.

Kebritchi et al. (2010) examined the effect of computer games on success and motivation in mathematics lessons. In the experimental study, they saw that games affect success positively. According to Özkatar-Kaya et al. (2019), especially educational institutions should determine educational game activities for children parks where primary school children can play educational games should be built by children, and children in this age group should be provided to participate in such activities. There is a respective amount of studies signifying the positive effect of EGA on students’ attitudes towards the lessons (Gürbüz, 2019; Hanbaba and Bektaş, 2007; Holmes, 2012; Torun and Duran, 2014), and that EGA increases their motivation (Kılıç and Gürbüz, 2019; Romine 2004; Yenice et al., 2019) and ensure participation and permanence (Altınbulak et al., 2006; Boyraz and Serin, 2016; Demir, 2012).

## CONCLUSION AND RECOMMENDATIONS

In this study, the effect of EGA applied to 5th-grade students in a secondary school within the scope of " the spread of light " unit in science education was investigated. According to the data obtained for the 2 sub-problems examined, there was no significant difference in the pre-test scores compared to the experimental group and control group in terms of academic achievement variable, but a significant difference was found in favor of the experimental group in the post-tests. In this direction, it can be said that the educational games prepared according to the relevant subjects and achievements in the science lesson contribute positively to the success of the students.

With this research, it would be good to shed light on the future studies of the researchers and to advise them on information about the emergence of the spread of light. EGA can be applied in different units in science education and different courses such as mathematics, social studies, and computers. If we consider EGA as a method, it can be compared with different methods and techniques and their effects on the learning process can be compared. EGA can be done for children in the play age, especially in the units where abstract concepts are included, and the lesson can be made more fun. Instead of educating children in closed environments, open spaces should be created where children can play scientific games from time to time. Teachers should be supported to practice EG activities. Different techniques or methods should be applied to keep children away from technology addiction. It is thought that one of these methods is teaching with games. Whatever needs to be done should be done so that children, who are the bright paths of our future, receive a better education and make their learning permanent.

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