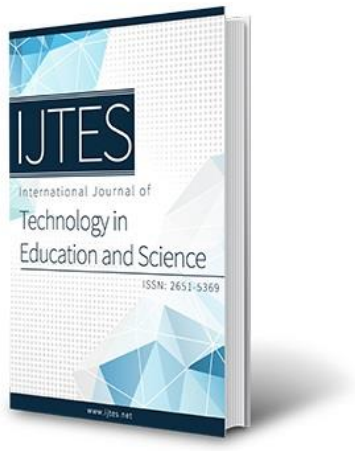


www.ijtes.net

Impacts of Serious Games on Middle School Students' Science Achievement and Attitudes towards Science

Emine Sena Toprak Yallıhep
Ministry of National Education, Turkey

Hakan Akcay
Yildiz Technical University, Turkey

Hasan Ozgur Kapici
Yildiz Technical University, Turkey

To cite this article:

Toprak Yallihep, E. S., Akcay, H., & Kapici, H. O. (2021). Impacts of serious games on middle school students' science achievement and attitudes towards science. *International Journal of Technology in Education and Science (IJTES), 5*(2), 203-212. https://doi.org/10.46328/ijtes.203

The International Journal of Technology in Education and Science (IJTES) is a peer-reviewed scholarly online journal. This article may be used for research, teaching, and private study purposes. Authors alone are responsible for the contents of their articles. The journal owns the copyright of the articles. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of the research material. All authors are requested to disclose any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations regarding the submitted work.

This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

International Journal of Technology in Education and Science (IJTES) is affiliated with
International Society for Technology, Education, and Science (ISTES): www.istes.org

IJTES

International Journal of Technology in Education and Science

2021, Vol. 5, No. 2, 203-212 https://doi.org/10.46328/ijtes.203

Impacts of Serious Games on Middle School Students' Science Achievement and Attitudes towards Science

Emine Sena Toprak Yallıhep, Hakan Akcay, Hasan Ozgur Kapici

Article Info

Article History

Received:

27 February 2020

Accepted:

2 December 2020

Keywords

Serious game

Educational technology

Science achievement

Attitude

Abstract

Developing students' attitudes toward science is an important issue because societies need individuals who can contribute to scientific and technological developments. That's why using various and different instructional tools in science education may have an impact on students' attitudes towards science positively. Within this respect, the goal of the study is to investigate the effects of serious games on primary school students' (fifth-grade) science achievement related to the topic of light and sound, and attitudes towards science. A quasi-experimental research design was used in the study. Fifth-grade students from two different classes were the participants in the current study. The data was gathered by the science achievement test and the attitude scale. The findings revealed that whereas students in the experimental group, who were taught by serious games, developed their attitudes towards science significantly positive, their counterparts did not. There was no significant effect of serious game on students' achievement. This result showed that serious games as a different instructional tool may have crucial impacts on primary students' attitudes toward science.

Introduction

Rapid improvements in educational technology show their impacts on learning environments (Akturk & Saka Ozturk, 2019; Cayvaz, Akcay, & Kapici, 2020; Demosthenous, Panaoura, & Eteokleous 2020; Ozkale & Koc, 2020; Salas-Rueda, Salas-Rueda, & Salas-Rueda, 2020; Seage & Türegün, 2020; Syafii, Kusnawan, & Syukroni, 2020; Thompson, & McDowell, 2019; Wallace-Spurgin, 2019). One of the recent educational technologies used in the learning process is serious games. Serious games are not only for entertainment purposes but also have a pedagogical design and aim to give information about a subject (Abt, 1970; Zyda, 2005). In other words, serious games are games that provide motivation as well as gaining knowledge during the gameplay. They can be played through the web, PCs, tablets and mobile phones. Serious games have been designed for different disciplines such as military education (Beligan, Roceanu, Barbieru, & Radu, 2013), language teaching (Palomo-Duarte, Berns, Cejas, Dodero, Caballero, & Ruiz-Rube, 2016), and history education (Huizenga, Admiraal, Akkerman, & Dam, 2009). Yet, there are limited studies in the related literature about the impacts of serious games in science education, especially in Turkey. Within this respect, we focused on the effects of serious games on students' (fifth-grade students) attitudes toward science.

Serious Games

Recently, the importance of scientific literacy is increasing because societies need individuals who can make sense of data, can able to understand science and technology properly and integrate them in daily life. Being able to use technology efficiently is one of the most important necessities to educate an individual as a scientifically literate person. To achieve this, individuals should be taught about technology from primary school years.

In a technological era, it is almost impossible to attract students' attention for a long time through direct instruction. Nemorin (2017) advocates that online learning platforms encourage students to feel that they belong to the course and to develop positive views about the learning process. One of the most common technological tools in learning environments is computers. A general term used in the literature for computers in education is "Computer-Supported Learning (CSL)". CSL involves presenting knowledge in different forms such as audial, visual or written through simulations or games. There are several advantages of using computers in the learning process. For example, invisible concepts can be transformed in concrete forms, students can study collaboratively, time efficiency and provide advantages for students to re-learn about the topic (Hsu & Thomas, 2002; Olympiou, Zacharia, & de Jong, 2013).

Serious games are one of the ways about the implementation of CSL in classes. The concept of serious games was firstly used by Abt in the 1970s. He defines serious games as games that aim not only entertainment but also have educational objectives (Abt, 1970). Yet, due to a lack of computers and limited game productions, the concept had not been widely used until the 2000s. For example, one of the successful and famous serious games, the American's Army, was released as an educational tool in 2002 and the serious games movement got started (Gudmundsen, 2006; Susi, Johannesson, & Backlund, 2007).

The aim of serious games is not only entertainment but also teaching. Yet, one of the most important features of serious games is that they are not didactic. In order to continue the game, it is necessary to learn and use the knowledge required to complete the tasks or to complete the section. In this way, the pleasure of playing does not decrease. For the gamer, there is both a pleasant time and an acquisition of an objective. The fundamental message of serious games is "you can't play if you don't learn" (Gee, 2007). Thus, learning takes place in a natural process during playing (Squire, Jenkins, Holland, Miller, O'Driscoll, Tan, & Todd, 2003).

One of the important advantages of serious games is that knowledge is implicitly presented in the game. The main elements of serious games are interaction, context, feedback, multiple perceptions, struggle, adaptation, and motivation (Akgün, Nuhoğlu, Tüzün, Kaya, & Çınar, 2011). One of the crucial functions of serious games is motivating students. That's why the language of the game shouldn't be heavily didactic. Furthermore, a student's web-based serious gaming experience progresses depending on his/her learning speed. This is also seen as positive in terms of students' motivation (Uşun, 2000).

Importance of Study and Research Questions

The number of studies related to serious games is rapidly increasing. Although STEM-related subjects constitute the majority of the studies (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012), there are limited studies about serious games in national literature (e. g., Kula & Erdem, 2005; Yallıhep, 2018). It is also difficult to reach studies done in science education. Understanding the effects of serious games in science learning is also a guide for both educators and software developers. Within this respect, the purpose of this study is to investigate the effects of serious games on primary school students' (fifth-grade) achievement and attitudes towards science. The research questions were determined as follows:

- How do serious games affect fifth-grade students' attitudes toward science?
- How do serious games affect fifth-grade students' science achievement?

Method

Participants

The study was done with fifth-grade students from two different classes in a private school. The reasons for choosing a private school are having computers and internet connection, and teaching English intensively. These were important prerequisites for the implementation of the study. Each student used a computer individually and the games were in English, so each student had to know English very well. Whereas one of the classes was assigned as a control group randomly, the other one was determined as an experimental group. A quasi-experimental research design was used in the study. In the control group, there were 12 students at the beginning of the study but three students did not attend the school in the last week. That's why the group involved nine students at the end of the study. In the experimental group, there were 11 students at the beginning of the study but two students did not attend the school in different weeks of the research implementation process, so they were removed from the study. There were nine students in the experimental group at the end of the study.

Instruments

Achievement Test

The achievement test was developed by Dilşeker (2008). There are a total of 25 multiple-choice questions in the test. The questions are related to light and sound. Each correct answer was given four points. KR-20 coefficient was calculated as .82 by Dilşeker (2008).

Attitude Scale

The original form of the attitude scale was developed by Enger and Yager (2001). It was translated into Turkish by Kapıcı and Akcay (2016). The scale involves 18 items under four sub-dimensions: Science Teachers (ST), Science Classes (SC), Usefulness of Science Study (USS), and Perceptions of Being a Scientist (PBS). The distributions of the items with respect to the sub-dimension are given in Table 1. The Cronbach's alpha coefficient was found as .76 for the scale by Kapıcı and Akcay (2016).

Table 1. The Sub-dimensions and Related Items

Attitude Scale	Number of the Item
Science Teachers (ST)	5, 10
Science Classes (SC)	1, 2, 7, 8, 9, 14
The usefulness of Science Study (USS)	3, 4, 6, 11
Perceptions of Being a Scientist (PBS)	12, 13, 15, 16, 17, 18

Research Design and Implementation

In the first week of the study, the achievement test and the attitude scale were administered as pretests. Then, students in the control group continued to study based on the science textbook and carried out experiments in a hands-on laboratory for the following three weeks. In addition to the methods and activities mentioned above, students in the experimental group played a serious game for one hour per week related to the objectives of the topic. In the fifth week of the study, the same tests (the achievement test and the attitude scale) were implemented as posttests. Table 2 shows the process of the implementation of the study.

Table 2. The Research Design of the Study

Week	Experimental Group	Control Group
1st week	Pretests	Pretests
2nd week	How do we see things? + Textbook	Textbook
3rd week	Spooky Mansion + Textbook	Textbook
4th week	Lights and Shadows + Textbook	Textbook
5th week	Posttests	Posttests

Three serious games were used in the current study. The games were reached through literature review and web-pages searching. The first author examined the three websites that gave the most results in search engines. All the games on the websites that appeal to the target age group were played by the first author and their contents were examined. At the end of these evaluations, three games were selected concerning the students' age, English language proficiency, and relatedness to the topic when played sequentially. The names of the games were as follows: "How we see things?", "Spooky Mansion", and "Light and shadows".

The first game "how we see things?" is related to the objective 'students will be able to draw that the light coming from a source follows a linear path in every direction'. The game starts with a light source and many objects on the screen. Students were first asked to examine the change in the path of light when they place the mirrors in different positions. Figure 1 shows a screenshot of the game. The tasks in the game are given in the row at the top of the screen, respectively. When a task is completed, the illuminated object becomes brighter than the others and this shows that the player has reached the right result. The player can then move on to the next task.

The mirrors to direct the light to the object and make it visible are displayed with the right and left arrows at the

bottom of the game screen. Students, who discover that the light can change the way by the mirror, try to illuminate the objects on the screen in the next stage. The first tasks begin with directing the light by using a single mirror. Upon successful completion of this stage, students are asked to illuminate objects that require a more complex mechanism with the help of mirrors. The game is complete when all objects on the game screen are highlighted. At the end of the game, a discussion was done in the class to realize what the students learned.



Figure 1. The Screenshot from the Game of "How We See Things?"

The second game "spooky mansion" is about how to classify the light sources. The game consists of three difficulty levels. The game was started by selecting the most difficult level which was found to be more appropriate for the age of the students. During the game, students must provide the correct answers to escape from a mansion. There are three light sources in each scene and students are asked to choose the natural light source(s). Figure 2 shows a screenshot of the game. The game consists of five stages. The student who gives the wrong answer starts the game from the beginning and tries to find the right answers. Bonus stages are opened for the student who has completed the five stages of the game correctly. In this part of the game, the shadow reflected on the wall is asked to find out what the object is. This part of the game is related to the objective 'students will be able to predict when light encounters the matter.'



Figure 2. The Screenshot from the Game of "Spooky Mansion"

The third game "light and shadows" is related to the objectives 'students will be able to observe how the complete shadow is formed and shows with simple beam drawings' and 'students will be able to find out what variables are affecting the complete shadow by designing and implementing experiments.' In this game, students are aimed to observe shadow formation by using light source, curtain, and object. The game allows students to change the position of the light source, the distance between the object and the light source, and change the object used. During the game, students can conclude that the shape of the shadow depends on the shape of the object. By changing the position of the object or light source, students are able to observe the effects of the light source and the relative position of the object on the size of the shadow. Figure 3 shows a screenshot of the game. In the next stage of the game, the students observe the brightness of the different light sources and interpret the differences between reflective and glossy surfaces.



Figure 3. The Screenshot from the Game of "Light and Shadows"

Data Analysis

Because of the limited number of the participants, Mann Whitney-U and Wilcoxon-Signed ranks as a non-parametric test were implemented in the current study. Mann Whitney-U test was used to compare control and experiment groups' pretests and posttests scores. Wilcoxon-Signed ranks were used to reveal whether a group (control or experimental one) significantly increased their achievement or attitudes positively throughout the study.

Results

Firstly, the results for the achievement test are given. After that, the findings based on the attitude scale are presented.

Findings Based on the Achievement Test

The test was administered as both pretest and posttest. Table 3 indicates the descriptive results of the test. Mann Whitney test result showed that there was no significant difference between the groups at the beginning of the

study (*U*=-1.072, *p*=.284).

Table 3. Average Scores for the Achievement Test

Achievement Test	Control Group (*n*=9) Mean (SD)	Experimental Group (*n*=9) Mean (SD)
Pretest	41.33 (12.49)	45.33 (5.66)
Posttest	48.44 (7.86)	50.22 (9.62)
Mean Difference	7.11	4.89

At the following stage, Wilcoxon tests indicated that students in both of the control and experimental groups did not increase their science achievement scores significantly throughout the study (for the control group: *Z*=-1.843, *p*=.065; for the experimental group: *Z*=-1.476, *p*=.140).

Findings Based on the Attitude Scale

The attitude scale was implemented as both pretest and posttest. Table 4 shows the descriptive results of the scale. The two groups' pretest scores were compared by Mann Whitney-U. The result indicated that there was no difference between the groups at the beginning of the study (*U*=-.884, *p*=.376).

Table 4. Average Scores for the Attitude Scale

Attitude Scale	Control Group (*n*=9) Mean	Experimental Group (*n*=9) Mean
Pretest	70.22	67.11
Posttest	71.22	72.66
Difference	1.00	5.55

At the following stage, Wilcoxon tests indicated that whereas students in the experimental groups increased their attitudes towards science positively scores significantly throughout the study (*Z*=-2.201, *p*=.028), students in the control group did not (*Z*=-.475, *p*=.635).

Discussion and Conclusion

The importance of science education in the curriculum cannot be only limited to academic achievement but also should include environmental and individual relations and cultural and ethical values. Because of these, students' attitude towards science becomes an important issue. It is crucial to encourage students to develop their attitudes toward science positively. Using educational technology in science courses may be an effective way to develop students' attitudes towards science. In the current study, we investigated the effects of serious games on primary school students' attitudes towards science and science achievement.

The results revealed that whereas students in the experimental group, who were taught by serious games, developed their attitudes towards science significantly positive, their counterparts did not. This finding showed that serious games as a different instructional tool may have crucial impacts on primary students' attitudes. This

result is also compatible with the other studies in the literature (Durkin, Boyle, Hunter, & Conti-Ramsden, 2015; Huizenga et al., 2009; Palomo-Duarte et al., 2016, 16).

Students' interest in computer and mobile games is known. Providing educational games as an alternative instructional tool for students to spend a certain part of the week may help them to have a pleasant time and have a positive impact on their perspectives on their lessons. In the long term, it can be investigated how serious games affect students' achievement in their science courses in which they develop a more positive attitude.

On the other side, the results gathered from the achievement test were unexpected. Although students, who were instructed through textbooks or serious games, descriptively increased their achievement scores from the beginning to the end of the study, a significant difference in their science achievement test scores did not reveal. The possible reasons for such findings might be possibly statistical errors due to a very limited number of participants. This is also one of the limitations of the current study. It limits the generalizability of the results. A similar study is recommended with a higher number of participants. Furthermore, the duration of the study implementation process was relatively short. This did not help to understand the long-term effects of serious games. Even if the short-term effects are examined, it should be recommended to examine how serious games will have long-term consequences on students' achievement. It is also difficult to reach serious games in Turkish, so it may be another recommendation for software developers to produce such games in Turkish. There is a need to research serious games, especially on topics that are difficult to understand by students.

Notes

This study is derived from the first author's master thesis.

References

Abt, C. C. (1907). *Serious Games*. New York: The Viking Press.

Akgün, E., Nuhoğlu, P., Tüzün, H., Kaya, G., & Çınar, M. (2011). *Bir eğitsel oyun tasarımı modelinin geliştirilmesi* [*Development of an educational game design model*]. *Eğitim Teknolojisi Kuram ve Uygulama, 1*(1), 41-61.

Akturk, A.O. & Saka Ozturk, H. (2019). Teachers' TPACK levels and students' self-efficacy as predictors of students' academic achievement. *International Journal of Research in Education and Science (IJRES), 5*(1), 283-294.

Beligan, D., Roceanu, I. Barbieru, D., & Radu, C. (2013). Features of using serious games in military education and training. *eLearning & Software for Education, 2*, 61-66.

Cayvaz, A., Akcay, H., & Kapici, H.O. (2020). Comparison of simulation-based and textbook-based instructions on middle school students' achievement, inquiry skills and attitude. *International Journal of Education in Mathematics, Science and Technology (IJEMST), 8*(1), 34-43.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education, 59*(2), 661-686.

Demosthenous, G., Panaoura, A., & Eteokleous N. (2020). The use of collaborative assignment in online learning environments: The case of higher education. *International Journal of Technology in Education and Science (IJTES), 4*(2), 108-117.

Dilşeker, Z. (2008). *The impact of the use of project-based learning method in science and technology lesson on the 5th grade primary school students' attitudes, successes in lesson and elimination of misconceptions towards science and technology lesson* [*Fen ve teknoloji dersinde proje tabanlı öğrenme yöntemi kullanımının ilköğretim 5.sınıf öğrencilerinin fen ve teknoloji dersine yönelik tutumlarına, ders başarısına ve kavram yanılgılarının giderilmesine etkisi*]. Unpublished master thesis. Dokuz Eylul University, Izmir.

Durkin, K., Boyle, J., Hunter, S., & Conti-Ramsden, G. (2015). Video games for children and adolescents with special educational needs. *Zeitschrift für Psychologie, 221*, 79-89.

Enger, S. & Yager, R. (2001). *Assessing Student Understanding in Science*. Thousand Oaks, CA: Corwin Press.

Gudmundsen, J. (2006). *Movement aims to get serious about games.* Retrieved January 9, 2020, from http://www.usatoday.com/tech/gaming/2006-05-19-serious-games_x.htm.

Gee. J. P. (2007). *Good Video Games+ Good Learning: Collected Essays on Video Games, Learning, and Literacy*. New York: Peter Lang Publication.

Hsu, Y. S., & Thomas, R. A. (2002). The impacts of a web-aided instructional simulation on science learning. *International Journal of Science Education, 24*, 955-979.

Huizenga, J., Admiraal, W., Akkerman, S., & Dam, G. T. (2009). Mobile game- based learning in secondary education: engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning, 25*(4), 332-344.

Kapici, H. Ö., & Akçay, H. (2016). Middle school students' attitudes toward science, scientists, science teachers and classes. *Asia-Pacific Forum on Science Learning & Teaching*, 17(1), 1-10.

Kula, A., & Erdem, M. (2005). The effect of educational computer games on the development of basic arithmetical operation skills. *Hacettepe University Journal of Education, 29*, 127-136.

Olympiou, G., Zacharia, Z. C., & de Jong, T. (2013). Making the invisible visible: Enhancing students' conceptual understanding by introducing representations of abstract objects in a simulation. *Instructional Science, 41*, 575-596.

Ozkale, A. & Koc, M. (2020). Investigating academicians' use of tablet PC from the perspectives of human computer interaction and Technology Acceptance Model. *International Journal of Technology in Education and Science (IJTES), 4*(1), 37-52.

Palomo-Duarte, M., Berns, A., Cejas, A., Dodero, J. M., Caballero, J. A., & Ruiz-Rube, I. (2016). Assessing foreign language learning through mobile game-based learning environments. *International Journal of Human Capital and Information Technology Professionals, 7*(2), 53-67.

Salas-Rueda, R. A., Salas-Rueda, E. P., & Salas-Rueda, R. D. (2020). Analysis and Design of the Web Game on Descriptive Statistics through the ADDIE Model, Data Science and Machine Learning. *International Journal of Education in Mathematics, Science and Technology (IJEMST), 8*(3), 245-260.

Seage, S.J., & Türegün, M. (2020). The effects of blended learning on STEM achievement of elementary school students. *International Journal of Research in Education and Science (IJRES), 6(*1), 133-140.

Squire, K., Jenkins, H., Holland, W., Miller, H., O'Driscoll, A., Tan, K. P., & Todd, K. (2003). Design

principles of next-generation digital gaming for education. *Educational Technology*, *43*(5), 17-23.

Susi T, Johannesson M, & Backlund P. (2007). *Serious Games—An Overview. Technical Report HS-IKI-TR-07-001*. School of Humanities and Informatics, University of Skövde: Skövde.

Syafii, M. L., Kusnawan, W., & Syukroni, A. (2020). Enhancing Listening Skills Using Games. *International Journal on Studies in Education (IJonSE)*, *2*(2), 78-107.

Thompson, V. L. & McDowell, Y. L. (2019). A case study comparing student experiences and success in an undergraduate course offered through online, blended, and face-to-face instruction. *International Journal of Education in Mathematics, Science and Technology (IJEMST)*, *7*(2), 116-136.

Uşun, S. (2000). *Dünyada ve Türkiye'de Bilgisayar Destekli Öğretim*. Ankara: Pegem A Yayıncılık.

Wallace-Spurgin, M. (2019). *Measuring student cognitive engagement when using technology*. I. Sahin & V. Akerson (Eds). Monument, CO, USA: ISTES Organization.

Yallıhep, M. (2018). *Mobile serious game: Effects on students' understanding of programming concepts and attitudes towards information technology.* Unpublished master thesis. Bogazici University, Istanbul.

Zyda, M. (2005). From visual simulation to virtual reality to games. *Computer*, *38*(9), 25-32.

Author Information

Emine Sena Toprak Yallıhep
https://orcid.org/0000-0002-8210-2072
Ministry of National Education
Turkey

Hakan Akcay
https://orcid.org/0000-0003-0307-661X
Yildiz Technical University
Turkey

Hasan Ozgur Kapici
https://orcid.org/0000-0001-7473-1584
Yildiz Technical University
Turkey
Contact e-mail: *hokapici@yildiz.edu.tr*