International Technology and Education Journal
Vol. 4 No. 1; June 2020
ISSN: 2602-2885
URL: http://itejournal.com/

Abdusselam, M. S. (2020). The effect of serious games on the awareness of energy sources consumption. International technology and education journal, 4(1), 36-42.

The Effect of Serious Games on the Awareness of Energy Sources Consumption

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SUMMARY

This research aims to investigate the effect of a serious game on the awareness of energy sources consumption. A weak experimental research design with one group, pretest, posttest, and formative test was used in the study. The research group consist of 17 students who attending a public secondary school in Giresun during the second semester of the 2018-2019 academic year. Students' energy source consumption and their views on this consumption establish the data of the study. The same data collection tools were applied to the research group in the form of pre-test, post-test, and formative tests. The quantitative data obtained in the experiment within the scope of this research, which was conducted in three-stages, was backed by qualitative data. SPSS v22 analysis software was employed to analyze the quantitative data of the study. The Friedman and Wilcoxon tests were used to reveal whether there was a significant difference in the energy consumption scores of the three tests of the study group. The expression frequency of the qualitative data was calculated within the framework of codes determined by content analysis. The study concluded that students' use of energy sources varies with the effect of serious games. It was also revealed that serious games affect students' use of energy sources during experiments and that behavior changes occur in line with the purpose of the game. Finally, it was concluded that the effect of a serious game on students' views of appreciating and esteeming energy sources was at first due to affective intensity, and then then it was behaviorally shaped.

Keywords: Serious Games, Energy Sources, Awareness, Energy Consumption, Impact

INTRODUCTION

The digital games market, one of the most growing sectors in the media and entertainment industry, generated revenues of $93.89 billion in 2016 and is anticipated to reach a global market size of $272.24 billion by 2022 (Kenneth Research, 2020). The digital games market also contributes to the growth of the serious game market by intersecting with the education and training market, which is growing day by day and taking shape in new forms (Michael & Chen, 2006). Serious games have spread and been at the forefront in many areas as educational applications simulating real-world events and processes with examples in the military, education, health, management, and engineering (Cheng, Wang & Sankar, 2018). Serious games, which have become one of the most important application areas, have been adopted to meet the need to improve existing education and have been frequently used in providing education by considering its potential (Van Eck, 2006; Johnson, 2007). Researchers have identified the framework for the use of serious games in teaching (Annetta, 2010) and investigated the implications of students' learning experience (Cheng et al., 2018), their potential in use (Giessen, 2015), learning outcomes and attitude perceptions (Cheon, Chung, Song & Kim, 2015), its relationship with motivation (Nantakaew & Srisawasdi, 2014). As a result of the studies, serious games were revealed to have Physiological effect (Burns et al, 2017), Social effect (Van der Stappen et al., 2019), Cognitive effect (Lamb, Annetta, Firestone & Etopio, 2018), Affective effect (Ahmad, Hamid, Abdullasim & Jaafar, 2017), and Motor skill effect (Enochsson et al., 2004).

Moreover, students' perception of the environment has recently become an issue of interest in the field of education. Researchers have sought to raise students' awareness about environmental issues (Rossano, Roselli & Calvano, 2017), environmental awareness on climate change (Chen, Bodicherla, Scott & Whittinghill, 2014), sustainability (Ouariachi, Olvera-Lobo & Gutiérrez-Pérez, 2018), energy consumption (Madeira et al., 2011), and conducted studies to inform, train and educate students (Bellotti, Kapralos, Lee, Moreno-Ger & Berta, 2013). However, the lack of studies combining serious games with environmental awareness was observed in the literature research(Cheng & Annetta, 2012). Since human behavior plays a decisive role in energy use, studies examining behavior change are needed in this regard (Abrahamse, Steg, Vlek & Rothengatter, 2005).

Serious games are used for educational intention rather than entertainment under certain rules (Ulicsak & Wright, 2010; Bellotti et al., 2013), focusing on the solution of a particular problem and are seen as part of learning (Susi Johannesson & Backlund, 2007). Serious games are interactive for students, engage them in the process and involve immersive activities, and are scripted with real-world issues, which play an important role in providing an effective learning environment (Ulicsak & Wright, 2010; Gugerell & Zuidema, 2017). Also, serious games can be designed as mini-games based on the need to focus on a single concept or a specific learning goal, and they can be a suitable alternative based on the mobile technologies used today (Illanas, Gallego, Satorre & Llorens, 2008).

Research Article. Received: 05/29/2020 Accepted: 06/29/2020 Checked with a plagiarism detection software

With the development of technology, especially energy sources are needed more. Electricity consumption increases rapidly because many technological devices work with electricity. With this increase, the energy sources used to generate electricity are rapidly depleting. The dissemination of serious games is a valuable step to prevent waste in the use of energy sources by raising awareness of communities. Given the increasing value of energy sources today and the training given for future generations to maintain these sources, it is important to develop serious games on the use of energy sources and to examine the uses of these games. In this process, it is important for students to play serious games and to show how awareness of energy sources consumption has changed with time. Especially with the development of technology, serious games can be used to solve social problems more easily as learning becomes free from traditional teaching and becomes more student-centered and shaped according to the interests and needs of the students. Based on the literature review, this research was carried out to question the use of serious games on environmental issues and to question the existence of possible behavior change. In this context, this study aims to examine the awareness behaviors of students in the consumption of energy sources through a serious game whose topic is the use of energy sources. In parallel with this goal, the problem question was formed to be “what is the impact of serious games on students' awareness of energy sources consumption?".

METHOD

A weak experimental research design with one group, pretest, posttest, and formative test was used in the study (Cohen, Manion & Morrison, 2013). The study group consists of a volunteer teacher at a secondary school in the province where the researcher was and his classroom that was determined without a selection from the branches where he gave his course.

As part of the study, the content of the game “Cansuyu Elektrik”, which is available on the Android market, was taken into account, and the 7th class level was preferred for the experiment as the study group should have been followed for two semesters.

The story of the game "Cansuyu Elektrik" is set in a house and a coal quarry that is connected to the house. The game starts at home and the player has to keep the lighting on at all times to keep the ghosts in the game away from him. For this reason, he can keep the lighting of the house on if it continuously feeds the power plant with coal in the house. If the coal owned in the game runs out, the player must go to the coal mine and extract coal using a pickaxe and shovel. Depending on the game's purpose for survival, the player is expected to continue the cycle (Abdüsselam & Novruzlu, 2019).

The study was carried out in three phases. In the first phase, the work schedule was determined and the data collection tools were applied to the study group as a pre-test. In the second phase, “Cansuyu Elektrik” game was introduced by researcher to the study group and the game was played by all students individually on mobile devices in the laboratory environment. A week later, the same data collection tools were applied as the post-test. In the final phase, six months later, the same data collection tools were applied to the same study group as a formative test.

Study Group

The experimental group consists of 7th-grade students studying at a public secondary school in Giresun during the second semester of the 2018-2019 academic year. A formative test was conducted with the same students in the first semester of the 2019-2020 academic year. This group was determined without selection and all applications were conducted with the same students. The study group initially consisted of 18 students but continued with 17 students as a result of one student leaving the school in the next semester. The results of the research do not claim to be generalized for any population. In the analysis of quantitative data, the average values of the scores that students received from the pre-test, post-test, and formative tests were reported, and comparisons were made between the scores of the tests. Table 1 provides information on the gender and family income status of the study group.

Table 1. Information About the Study Group

Gender	Frequency	Percentage
Female	10	59
Male	7	41
Family Income Status	Frequency	Percentage
500TL- 2.000TL	3	18
2.001TL - 5.000TL	10	59
5.001TL -10.000TL	4	23

Data Collection and Analysis

In this study, to determine the energy source consumption of secondary school students, they were asked questions by the researcher to fill the questionnaire of energy consumption in the 10-point Likert scale form, in which "1" suggests consuming too little" and "10" suggests consuming too much. At the same time, the quantitative data obtained in each application was supported by qualitative data. The Questionnaire of Energy Consumption (QEC), which was used as a qualitative data collection tool, was developed by the researcher and revised according to two experts' opinions. The QEC applied in each test consists of semi-structured questions. With these questions, the student's views on energy sources consumption were determined.

The SPSS analysis software v22 was used to analyze the quantitative data of the research. The overall distributions of the students' energy consumption scores were determined using descriptive statistics techniques and whether the quantitative data showed normal distribution was investigated. All analyses were evaluated at the level of .05 significance level (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz & Demirel, 2013). Because the number of people in the study group was less than 30, the normal distribution of the data obtained within the scope of the study was tested with "Shapiro-Wilks" method (Büyüköztürk, 2011). To determine whether the study group had significant differences in the energy consumption scores of the three applications, Wilcoxon Signed Rank Test from nonparametric tests was applied, since the data set was not normally distributed ($p < .05$) (Can, 2014). Table 2 gives the results for the normality test.

Table 2. Normality Test Results

	Statistic	df	Sig.
Pre-test	.897		.06
Post-test	.878	17	.03
Formative test	.919		.14

In the analysis of the qualitative data of the research, the literature and the codes obtained before the research were utilized. These codes identified in Table 3 were studied to determine whether cognitive, affective, and behavioral correlations related to energy conservation were made, and the frequency of these correlations stated by the students was calculated.

Table 3. Code examples for students' making associations with energy conservation

	Cognitive	Affective	Behavioral
Code	Not to forget, to remember	caring, feeling sad	Shut down, clam up

RESULTS

The Friedman test was conducted to determine whether there was a significant difference between the pre-test, post-test, and formative test scores of serious games of experimental group students to determine the impact of serious games on students' energy sources consumption. In Table 4, the Friedman test results for the study group's three test scores are seen.

Table 4. The difference between pre-test, post-test, and formative test energy consumption scores

Tests	n	Mean	Std. Deviation	Mean Rank	X^2	df	sig.
Pre-Test		5,88	1,727	1,44			
Post-test	17	8,05	1,886	2,82	20,433	2	.000
Formative Test		6,23	1,147	1,74			

When Table 4 is examined, it is observed that there are a statistically significant difference between the study group's energy sources consumption in the pre-test, post-test and formative test scores [$X^2_{(df=2,\ N=14)} = 20,433$, p .000<.05]. The results of the Wilcoxon test, in which binary comparisons are made, should be examined to determine which scores reveal this significance. Table 5 gives the Wilcoxon test results.

Table 5. Wilcoxon test results for QEC applied to experimental and control groups

		Mean	Mean Rank	Wilcoxon (Z)	p
Post-test/Pre-Test	Negative Ranks	0	,00	-3,546	.000

	Positive Ranks	16	8,50		
	Ties	1			
Formative Test/Pre-Test	Negative Ranks	4	5,63		
	Positive Ranks	7	6,21	-,948	.343
	Ties	6			
Formative Test/Post-test	Negative Ranks	14	8,75		
	Positive Ranks	2	6,75	-2,847	.004
	Ties	1			

According to Table 5, the change in energy consumption levels of the experimental group students between pre- and post-test was statistically significant in the post-test compared to the pre-test [Z=-3.546, p=.000 <.05]. It is seen that playing a serious game on the use of energy sources has an effect on students' awareness of the use of energy sources. Through the serious game, students' awareness of the use of energy sources has increased. There was no statistically significant difference between the experimental group students' energy consumption awareness levels between the formative test and pre-test [Z=-,948, p=.343>.05]. It was found that there was a statistically significant decrease in energy consumption awareness level in the formative test compared to the post-test [Z=-2.847, p=.004<.05]. The findings suggest that the experimental group students' energy consumption awareness levels increased significantly from the pre-test to the post-test, but decreased significantly from the post-test to formative test. This can be explained by the length of time between the formative test and post-test. The persistence of the experiment did not last for six months. Due to serious game, students' awareness of the use of energy sources has increased, and playing the serious game must continue at regular intervals.

Based on the data obtained from the interviews conducted with the experimental group to support quantitative data, the frequency of cognitive, affective, or behavioral correlations in the use of energy sources of the students was calculated according to the student statements in QEC. The highest association was found in the cognitive (f=9) and least association in affective (f=2) category in the pre-test of QEC performed at the beginning of the study. At this stage, it can be said that students have thoughts and actions about energy conservation and its importance. With the post-QEC performed after using the serious game, it was found that affective expressions were obviously involved instead of cognitive expressions. This change can be explained by establishing an affective connection while the student plays the game “Cansuyu Elektrik” and forming this connection with expressions in the process. Six months later, when the data obtained with the formative test of QEC was examined, it was found that the behavioral association increased to a noticeable level (f=14). This change can be said to be due to the effect of the students' affective development in the savings of energy use during the serious game playing process on the change in their behavior. In Graph 1, the content analysis results of the statements obtained by QEC are visualized.

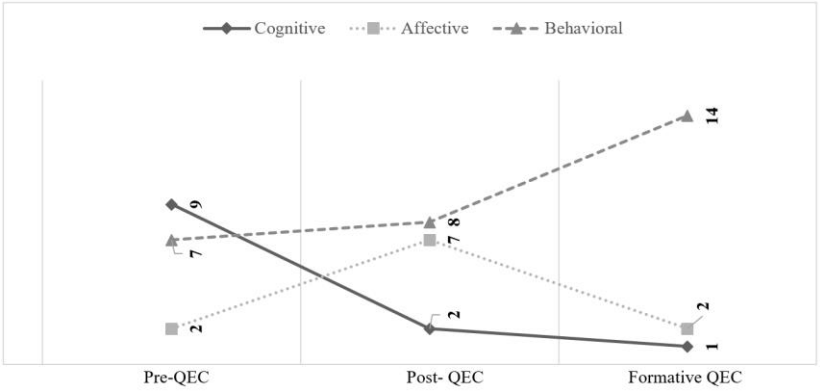

Figure 1. Content analysis of statements obtained with QEC

In the scope of the study, the change in the students' energy consumption levels in the post-test compared to the pre-test was found to be statistically significant (see Table 5). Students' assessment of energy consumption as higher in the post-test can be explained by the changes in their establishing relationship in the affective domain by realizing how much their energy consumption is actually in the game. The students assessed their energy consumption with a certain score before playing serious games, but questioned their existing energy consumption after the game and gave themselves higher consumption scores. In parallel, they stated to realize that they needed to consume less energy.

The increase in energy consumption levels in the formative test compared to the pre-test of the students was not statistically significant. However, the increase between the energy consumption levels of the post-test and formative test was found statistically significant. In the third phase of the study, it was determined that the behavioral associations shown by the students to pay more attention to the savings in energy use increased, their energy consumption scoring for themselves decreased compared to their post-test scores and approached their pre-test scores. In this context, the internal unrest that students experience after playing a game can actually be cited as the reason for the change in behavior in the process.

CONCLUSION AND DISCUSSION

In this study, the effect of a serious game related to energy sources consumption on students' awareness of energy sources consumption was investigated. Cheng and Annetta (2012) emphasized that the effects of serious games on students' understanding should be investigated in the long term, while Yang, Chien and Liu (2012) pointed out that serious games should be done in experimental studies with young age groups in the topic of environmental protection behaviors such as electricity saving. Taking into account these deficiencies, this study also contributed to the literature because it covers an early age group and is a long-term study.

The study concluded that students' energy sources consumption varies with the effect of serious games. At the first stage, students saw themselves as individuals who were paying attention to the use of energy sources, but after playing the serious game, they had the opportunity to reassess themselves and questioned their actual consumption and showed an act of restraint of energy consumption. Thus, serious games had a positive effect on the increase of students' awareness of energy use. De Vries et al. (2011) found that with the serious game they developed, students' attitudes towards saving energy at home increased. This effect can actually be explained by a positive influence in the motivation of learning after playing serious games, as noted in the study of Nantakaew and Srisawasdi (2014). In this respect, it can be said that the applications carried out in the research motivate the students to re-evaluate their own consumption. Bourazeri, Pitt and Arnab (2017) also state in their research that serious games can be used as an efficient educational tool in ensuring the desired change in people's behavior towards energy consumption.

In this study, it was revealed that serious games affected students' use of energy sources during applications, and that behavior change occurred in line with the purpose of the game. Serious games are also known to contribute to the development of students' behavioral skills (El-Beheiry, McCreery & Schlachta, 2017), and motivate people by increasing their interest in a particular topic (De Jans, Van Geit, Cauberghe, Hudders & De Veirman, 2017). Torres and Macedo (2000) concluded that serious games support positive attitude development as a result of studying on environmental protection, while Hansmann, Scholz, Francke and Weyman (2005) reported that serious games had a positive effect on students' attitudes towards environmental protection. Both in the literature and in this study, it is seen that serious games have affective effects even when played for short periods. In this study, it was revealed that this effect can be transformed into a behavioral dimension over a long period of time.

It was concluded that the effect of the serious game on students' views of appreciating and esteeming energy sources was at first due to affective intensity and then it was behaviorally shaped. Serious games are promising tools that students can use to raise their awareness even in a short period of time (Illanas et al., 2008). There is even some research showing that serious games have a positive effect on students in general (Barab, Thomas, Dodge, Carteaux & Tuzun, 2005; Ebner, & Holzinger 2007; Annetta et al. 2009). This study also showed that a well-developed serious game can lead to positive behavioral changes, as stated in the literature.

Serious games have received intense interest in industry and academia in approximately the last decade (Connolly, Boyle, MacArthur, Hainey & Boyle, 2012). Considering the fact that generations are increasingly predisposed to the digital world, it is thought that serious games are needed by them to provide motivation and to develop and transform themselves into useful individuals for society. To implement more realistic scenarios and use them in everyday life, serious game applications are also recommended to be supported by augmented reality technologies. With this context, serious games are expected to take a part in education and research.

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