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Socioscientific Issues-Based Popular Science Readings with Prospective Classroom Teachers

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Abstract

The aim of this study is to determine the effect of socioscientific issues-based popular science readings on critical thinking skills and reading habits-related attitudes of prospective classroom teachers. This quantitative research employed the one-group pretest-posttest research design, which is recognized as a weak experimental design. The research was conducted with 15 volunteered prospective classroom teachers. The "Critical Thinking Skills Questionnaire" and "Attitude Scale towards Reading Habits" were applied as a pre-test and post-test to measure variations in participants' critical thinking skills and reading habits. During the 10-week experimental process, articles about socioscientific issues from a popular Turkish science magazine (Science and Technique [Bilim ve Teknik]) were read with prospective classroom teachers. As a result, it was found that socioscientific issues-based popular science readings led to a statistically significant ($p<0.05$) increase in participants' mean scores from both post-test scales compared to their mean scores from pre-test scales. Also, the effect size ($\acute{\eta}^2$) of the difference between pre-test and post-test mean scores was found to be a large effect size. Socioscientific issues-based activities take the learning process to another dimension and can serve as a tool for students to gain a perspective towards the world and science and to question and interpret real-life situations. It is thought that such processes, which can be designed using various activities, can contribute to the professional development of prospective teachers. Using such activities in primary schools can make the teaching process more fun and increase students' interest and engagement in classes.

INTRODUCTION

With the science curricula published in 2013 and 2018, the Turkish Ministry of National Education (MoNE) defined the desired student profile as individuals who can research the source of information and question and discuss events and situations. To develop these expected skills, students need to be aware of the effects of developing technology on everyday life and being able to relate science subjects to daily living skills (scientific literacy). The skills that are desired to be developed by students are included in curricula as learning outcomes (Türksever et al., 2020). Real-life problems can be a tool in helping students relate what they have learned in science classes to the real world. Real-life problems are considered socioscientific issues, and they encourage students to establish and discuss relationships between daily life and science problems (Lin & Mintzes, 2010). Socioscientific issues are complex, socially relevant real-world problems, which are informed by science, and also contain ethical and other dimensions (Sadler et al., 2016). Socioscientific issues have long

been advocated as a context for students in order to promote scientific literacy and thus raise responsible citizens who can use science in their daily lives (Ke et al., 2020). In socioscientific issues, certain dilemmas, ethics, moral principles, and societal concerns are discussed in the context of sciences. When making decisions about socioscientific issues, individuals take into account different dimensions such as ethical, legal, psychological, and medical dimensions (Demiral & Türkmenoğlu, 2018). Activities based on socioscientific issues can provide rich content for students to gain a perspective on the world and science, and question and interpret real-world situations. This is because socioscientific issues-based learning provides students with meaningful contexts enabling them to contemplate how they might relate science to their own lives and communities. Thus, it guides students to evaluate the moral and ethical consequences of complex social problems in real life (Ke et al., 2020).

Having knowledge about socioscientific issues, the student can interpret, discuss, research, and critically think about events and situations, and take into account environmental, economic, and social dimensions in their decisions. The dilemma students face when discussing socioscientific issues and when making decisions about them can provide them with an opportunity to think critically about situations (Chang-Rundgren & Rundgren, 2010; Zeidler & Nichols 2009). Indeed, critical thinking helps individuals observe events and situations better and make more accurate inferences from their observations. Thus, they can test claims put forward and recognize contradictions and inconsistencies (Deniz, 2009). Halpern (2002) describes critical thinking as purposeful, reasoned, and goal-directed thinking that is involved in solving problems, formulating inferences, calculating likelihoods, and making decisions. From this point of view, in order to help students develop critical thinking skills, it is first necessary to create learning settings that promote critical thinking (Tok, 2008). This is only possible through activities to be carried out in democratic classroom environments where students can acquire many skills from an early age (Kaya, 2010). Such classroom environments should also be focused on key concepts such as reflective thinking, focusing on the subject, observing, questioning, judging, making inferences, using information, analyzing, evaluating, reasoning, problem-solving, assessing solutions, and empathizing (Akar, 2007). Thus, activities promoting critical thinking skills can serve as a bridge in achieving permanent and effective learning. Moreover, to achieve this, various activities should be included in formal and informal learning environments.

Today, articles about scientific developments, technological inventions, and natural events attract attention and are considered important in preparing children for the future (Turan, Kurt & Arslan, 2016). Behaviors desired to be developed by students are not only acquired through formal education activities but also through various stimuli. One of these stimuli is the media sources, which have a high potential to create public opinion and raise awareness among people (Doğu-Gültekin & Ünlü, 2020). Absorbing articles that arouse curiosity, in which technological inventions, scientific discoveries, or natural events are described, are frequently used by media sources (Demirel, 2011). Such issues, which are followed with interest by people, have been called popular science (Eroğlu & Sağlam, 2020). Newspapers, magazines, TV programs, and documentaries make publications on popular science to ensure that people could better follow scientific developments and to convey them to a broader range of audiences (Özsevgeç, Eroğlu & Öztürk-Köroğlu, 2017). Publications on popular science can highlight different topics such as the biographies of scientists, the emergence of scientific developments and interesting events of the period, the place of today's scientific developments in our lives and their effects, and funny experiments (Eroğlu & Sağlam, 2020). Such topics, which are complex by nature, and the language of science, in which technical terms are used frequently, can be easily understood by ordinary people with popular science

applications. Thus, a broader range of audiences becomes able to follow more closely current developments and discoveries in science and technology, as well as recent scientific claims (Özsevgeç et al., 2017).

Chowdhury and Halder (2016) argued that the traditional sources of educational guidance were no longer adequate to meet learners' fast-changing educational demands. The authors also suggested that informal sources like media, especially daily newspapers, could be used for a wider spread of education. Socioscientific issues are open-ended, unresolved problems comprising dilemmas (Levinson, 2006), and they are current and interesting because they can be evaluated by different, contradictory thinking structures. These issues can convey information to the public in various ways. Popular science publications, which are the most important organs of our daily life, also contribute to bringing these issues to the attention of people (Öztürk & Erabdan, 2018). The relationship among socioscientific issues, science, media, and people has been tried to be described in the following figure:

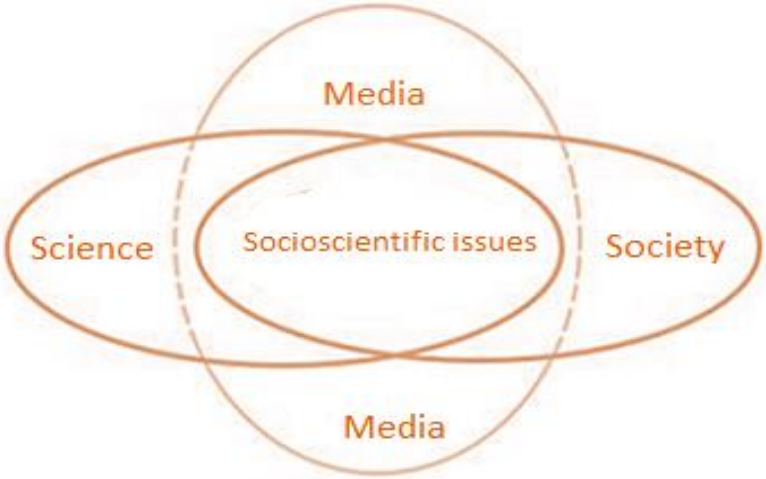

Figure 1. The relationship among socioscientific issues, science, media, and people (Öztürk et al., 2017)

Many socioscientific issues at the center of science and society, such as gene therapy, cloning, in vitro fertilization, genetically modified organisms (GMOs), nuclear energy, ozone destruction, fossil fuel use, are frequently discussed in the media, and as a result, in popular science publications.

For science to affect people positively, it must spread to a wider range of audiences and become a part of common thought (Karakuş & Ergün, 2016). In this regard, popular science publications are considered important in promoting this spread by being used effectively in teaching-learning processes (Çakmakçı, 2017). Science-based reading activities can both increase the popularity of science among people and bring it to larger audiences outside of school (Romance & Vitale, 1992). Thus, one's curiosity, interest and motivation for learning and research by reading will increase. One of the factors that motivate a person towards reading is their attitudes and curiosity about reading habits (Özbay, Bağcı & Uyar, 2008). Reading activities help students to visualize the learned concepts in their minds and provide them with the opportunity to establish a connection between their prior knowledge and newly learned knowledge (Güngör, 2009). It has also been emphasized that increasing academic reading experiences positively affect critical thinking skills (Büyükkanber & Makaracı, 2015). In addition, perceiving reading as an entertaining activity makes it an important tool for

learning innovations and following current developments (Yıldız, Ketenoğlu-Kayabaşı, Ayaz & Aklar, 2017). Supporting the reading experience with different tools comes into prominence in gaining reading habits, and this increases the desire to reach information by triggering curiosity. Students can take an interest in socioscientific issues and use discussion processes with their prior knowledge about a subject (Sandoval & Milwood, 2005; Khishfe, 2012). It is obvious that teachers and prospective teachers who are preparing for the profession are also exemplary models for the next generation and society. Therefore, it is important for them to gain reading habits with different reading experiences, question what they read, look critically and develop their decision-making skills. Socioscientific issue-based readings can be seen as valuable in terms of this experience.

Taking these as a starting point, the researcher presented a different reading experience to prospective teachers. The researcher designed the socioscientific issue-based article reading as an activity process, using a popular science magazine. Throughout the experimental process, the researcher also provided an opportunity for prospective teachers to question and interpret real-world situations. These activities were carried out with prospective classroom teachers, and it was aimed to determine the effect of the process on their critical thinking skills and reading habits. The reason why prospective classroom teachers were included in the study group is that they are expected to be the first persons who will raise awareness in children about socioscientific issues through courses such as social studies and science. Furthermore, the researcher deemed it important to include them in an experimental process, including student-centered activities which they can carry out with children in their future professional lives. Considering the relevant literature studies were examined, no study was found, especially in the sample of prospective classroom teachers, that designed socioscientific issues as a tool in the form of popular science readings, and thus measured critical thinking skills and reading habits. In this regard, the present study is expected to contribute to the literature by offering a teaching activity that teachers can use in classrooms. In this context, the aim of this study is to determine the effect of socioscientific issues-based popular science readings on critical thinking skills and reading habits-related attitudes of prospective classroom teachers.

Hence, the main problem statement was posed as follows: “Do socioscientific issues-based popular science readings affect critical thinking skills and reading habits-related attitudes of prospective classroom teachers?” The sub-problems posed based on this problem statement are listed below:

1. Is there a significant difference between prospective classroom teachers’ mean scores from the critical thinking skills before and after socioscientific issues-based popular science reading activities?
   Hypothesis (H_0): There is no significant difference between prospective classroom teachers’ mean scores from the critical thinking skills before and after socioscientific issues-based popular science reading activities.

2. Is there a significant difference between prospective classroom teachers’ mean scores from the reading habits-related attitudes before and after socioscientific issues-based popular science reading activities?
   Hypothesis (H_0): There is no significant difference between prospective classroom teachers’ mean scores from the reading habits-related attitudes before and after socioscientific issues-based popular science reading activities.

METHOD

Research Model

This quantitative research employed the experimental design. Initially, the researcher wanted to form an experimental and a control group; however, a control group could not be formed due to the low number of prospective classroom teachers who wanted to participate in the study. Thus, the study used the one-group pretest-posttest research design, which is considered a weak experimental design. In this design, the effect of the experimental process is tested on a single group. Measurements related to dependent variables are performed by using the same measurement tools on the same participants as pre-tests and post-tests before and after the experimental process (Büyüköztürk, Çakmak, Akgün, Karadeniz & Demirel, 2012; Creswell, 2017). The experimental process is presented in Figure 2:

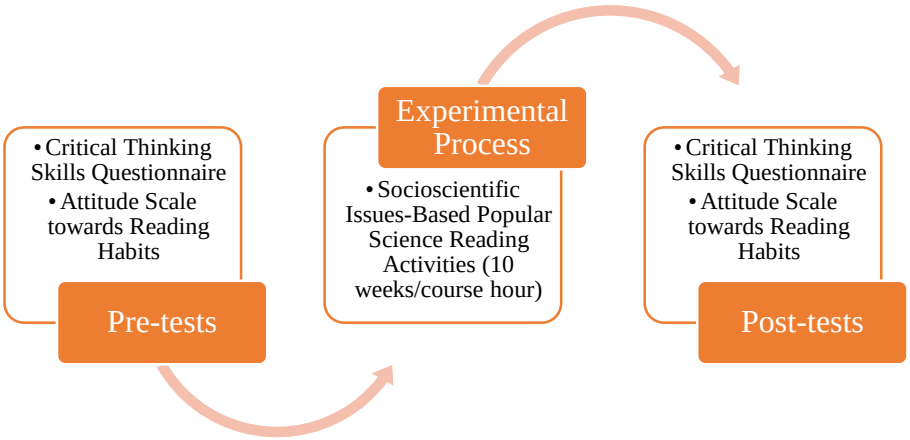

Figure 2. One-group pre-test / post-test research design

As seen in Figure 2, the Critical Thinking Skills Questionnaire and Attitude Scale towards Reading Habits were applied as a pre-test and post-test to measure variations on critical thinking skills and reading habits-related attitudes of prospective classroom teachers. During the 10-week experimental process, articles based on socioscientific issues from a popular Turkish science magazine (Science and Technique [TÜBİTAK - Bilim ve Teknik]) were read with prospective classroom teachers (1 course hour per week). After the experimental process, data obtained from the pre-tests and post-tests were analyzed and interpreted.

Study Group

This research was conducted with prospective classroom teachers. The criterion sampling method, one of the purposive sampling methods, was used to form the study group. The predetermined criteria for forming the study group were determined as follows: ease of accessibility, acceptance to participate in the study, and taking the Science Teaching course. The reason why "taking the Science Teaching course" was determined as a criterion was the fact that this course enables students to look at real-world problems from a holistic perspective and become more aware of socioscientific issues. In this context, the study group consisted of 15 third-year prospective classroom teachers studying at the Department of Classroom Teaching, Faculty of Education of a university located in Turkey's Central Anatolia Region. Of the participants, 11 were females and four were males.

Experimental Process

The experimental process started with the planning of a reading group consisting of prospective classroom teachers. The researcher informed the prospective classroom teachers

about the purpose of the study and determined the volunteering students. Then, the researcher informed these students about the experimental process. The process began at the day and time that was convenient for everyone.

The researcher preferred to read socioscientific issues-based articles from the "Science and Technique (Bilim ve Teknik)" magazine published monthly by the Turkish Scientific and Technological Research Council (TÜBİTAK). Although many popular science magazines are published in Turkey, Bilim ve Teknik, published since 1967, is the oldest science magazine in Turkey and is also recommended by the MoNE. Also, the purposes of the magazine include introducing scientific and technological studies to the public and explaining in a clear and understandable language the recent developments in basic and applied sciences and the inventions and innovations in these fields (Science and Technique [Bilim ve Teknik], 2020). The researcher decided on this magazine for these reasons and chose the articles about socioscientific issues in the magazine. These articles were about current and popular scientific developments that are discussed widely and that caused dilemmas among people. Once the articles were determined, they were submitted to an expert who was asked to examine them in terms of suitability for the purpose and comprehensibility. After receiving the expert's feedback, the articles were put in order to be read in the process. The articles based on socioscientific issues are presented in Table 1:

Table 1. Socioscientific issues-based articles

Activity No	Article Title	Impressum (Science and Technique) [Bilim ve Teknik]
1	Do Antidepressants Work?	Özlem Ak, Science and Technique (Bilim ve Teknik), May 2019, Issue 618, pp.40-46.
2	Super Soaps Cleaning Environmental Pollution	Özlem Kılıç Ekici, Science and Technique (Bilim ve Teknik), June 2019, Issue 619, pp.70-75.
3	Artificial Intelligence and Cyber Wars in the Future	Utku Köse, Science and Technique (Bilim ve Teknik), May 2019, Issue 618, pp.76-84.
4	SpaceX Has Launched Its First 60 Satellites for Internet Web	İlay Çelik Sezer, Science and Technique (Bilim ve Teknik), July 2019, Issue 620, pp.10-11.
5	Would You Wear Digital Clothing?	Gürkan Caner Birer, Science and Technique (Bilim ve Teknik), July 2019, Issue 620, pp. 14-25.
6	Deepfake Videos	Gürkan Caner Birer, Science and Technique (Bilim ve Teknik), August 2019, Issue 621, p.44.
7	Waterproof Fabrics Generate Energy from Wind and Rain	Tuncay Baydemir, Science and Technique (Bilim ve Teknik), July 2019, Issue 620, p.7.
8	Technological Steps in Combating Space Debris	İlay Çelik Sezer, Science and Technique (Bilim ve Teknik), July 2019, Issue 620, pp.10-11.
9	Global Health Under Threat: Anti-Vaccination	İlay Çelik Sezer, Science and Technique (Bilim ve Teknik), September 2019, Issue 622, pp.14-37.
10	Self-Destructing Plastics	Mahir E. Ocak, Science and Technique (Bilim ve Teknik), October 2019, Issue 623, p.7.

The socioscientific issue was informed to the prospective classroom teachers in advance, who were asked to read the articles so that they could have some prior knowledge. Each week the lesson started with an engrossing problem situation and then continued reading that week's article. The reading of the determined socioscientific issue-based article was tried to be supported by visual and auditory tools. Then, the participants discussed and analyzed the socioscientific issues (using brainstorming and buzz groups). Afterward, the participants were asked to present their decisions about the determined subject, situation, or event. Each week's activity ended with a general evaluation, feedback, and corrections (if needed). Each activity took about 45 minutes (1 course hour), and the whole process continued for 10 weeks.

Data Collection Tools

Data collection tools were the "Critical Thinking Skills Questionnaire" and the "Attitude Scale towards Reading Habits." The "Critical Thinking Skills Questionnaire" was developed by Sarıgöz (2014) to measure prospective teachers' critical thinking skills. The questionnaire consists of a single factor and 22 5-point Likert-type items (1=Strongly Disagree, 2=Disagree, 3=Undecided, 4=Agree, and 5=Strongly Agree). The questionnaire's Cronbach's Alpha internal reliability coefficient was calculated as 0.80 in the original study. The "Attitude Scale towards Reading Habits" was developed by Gömleksiz (2004) to measure university students' attitudes towards and opinions about reading. The scale consists of six sub-dimensions (like, habit, necessity, claim, effect and benefit) and 30 5-point Likert-type items. The positively-worded items on the scale are scored as 5, 4, 3, 2, 1 starting from the "Strongly Agree" whereas the reverse-coded ones are scored just in the opposite manner. The total score obtained from the scale expresses the reading habits-related attitudes of prospective teachers. The scale's Cronbach's Alpha internal reliability coefficient was calculated as 0.88 in the original study. The items in both data collection tools were examined by the researcher. After consulting with the experts about the suitability of the measurement tools, both data collection tools were applied to the participants as a pre-test and a post-test before and after the experimental process.

In this study, the internal reliability coefficients of the data collection tools were calculated. Critical Thinking Skills Questionnaire pre-test 0.80, post-test 0.78; Attitude Scale towards Reading Habits pre-test was calculated as 0.73 and the post-test as 0.79, and it was determined that the data collected from the data collection tools were reliable.

Data Analysis

The SPSS and Excel package software was used for the analysis of data obtained from the measurement tools. For data analysis, first, the reverse-coded items were evaluated. Afterward, Kolmogorov-Smirnov[a] and Shapiro-Wilk tests were conducted to test the normality of data distribution. Since the number of data was less than 29 in this study, the results of the Shapiro-Wilk test were evaluated, and it was found that the mean scores were normally distributed as the results were greater than 0.05 for both the pre-test and post-test, and the skewness and kurtosis coefficients were between +1 and -1. However, according to Tabachnick and Fidell, when it is not between +1 and -1, the range of +2 to -2 is acceptable (as cited in Demir, Saatçioğlu, & İmrol, 2016). Table 2 presents the results of the normality test applied to the pre-test and post-test scores from the "Critical Thinking Skills Questionnaire" and the "Attitude Scale towards Reading Habits."

Table 2. Results of the normality test applied to pre-test and post-test scores

		Kolmogorov-Smirnov[a]			Shapiro-Wilk			Skewness Values	Kurtosis Value
		Statistic	df	Sig.	Statistic	df	Sig.		
Critical Thinking Skills Questionnaire	Pre-test	0.170	15	0.200	0.943	15	0.423*	0.064/0.580	-0.658/1.121
	Post-test	0.215	15	0.060	0.886	15	0.059*	-0.955/0.580	0.311/1.121
Attitude Scale towards Reading Habits	Pre-test	0.133	15	0.200	0.951	15	0.542*	-0.301/0.580	-0.956/1.121
	Post-test	0.126	15	0.200	0.975	15	0.927*	0.314/0.580	0.640/1.121

*p>0.05

The results of the Shapiro-Wilk test yielded a normal distribution (p>0.05) for the pre-test and post-test critical thinking skills questionnaire and attitude scale towards reading habits, and the coefficients of skewness and kurtosis were found to be between +2 and -2. Hence, as a result of the analyses, it was decided to use parametric measurements for pre-test and post-test data analysis. A dependent sample t-test was used to analyze the difference between the participants' mean scores from the pre-tests and post-tests, and the effect size (eta squared [$\acute{\eta}^2$]) was calculated according to the variances between the scores. The calculation method (*Cohen's d* formula) suggested by Cohen was used in the effect size calculation.

FINDINGS

The present study was undertaken to determine the effect of socioscientific issues-based popular science readings on prospective classroom teachers' critical thinking skills and reading habits. Findings for the sub-problems posed for the purpose of the research are given below, respectively.

Prospective Classroom Teachers' Critical Thinking Skills Before and After Socioscientific Issues-Based Popular Science Readings

The participants' mean scores from the pre-test and post-test critical thinking skills questionnaire are given in Figure 3.

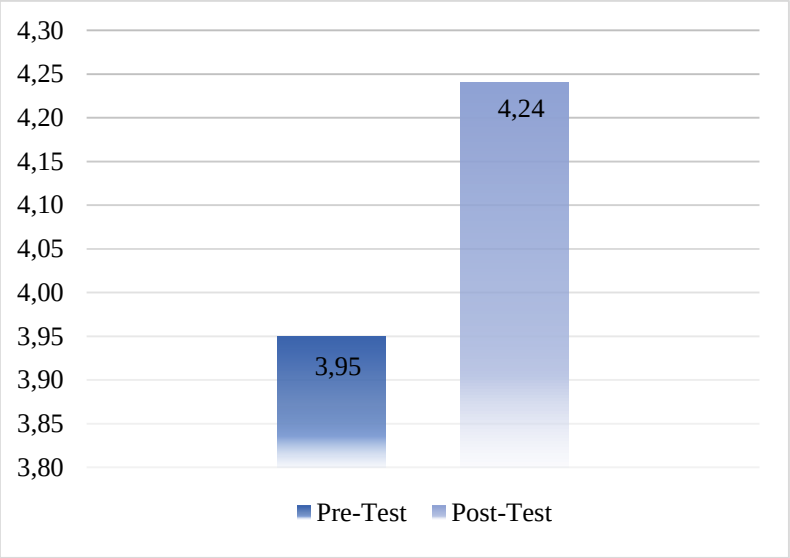

Figure 3. Mean scores from the pre-test and post-test critical thinking skills questionnaire

It was found that the participants' mean score from the post-test critical thinking skills questionnaire was higher than their mean score from the pre-test critical thinking skills questionnaire. Later, the participants' mean scores from the pre-test and post-test critical thinking skills questionnaire were compared using the dependent samples t-test. The results are presented in Table 3.

Table 3. Comparison of mean scores from the pre-test and post-test critical thinking skills questionnaire using the dependent samples t-test

	N	$\overline{X}$	**Standard Deviation**	**df**	**t**	**p**	$ή^2$
Pre-test	15	3.95	0.25	14	-3.179	0.007	1.14
Post-test	15	4.24	0.26				

t(14)=-3.179; p=0.007; $ή^2$=1.14

As can be inferred from Table 3, there is a statistically significant difference between the participants' mean scores from the pre-test and post-test critical thinking skills questionnaire ($p<0.05$). Thus, the H_0 hypothesis was rejected. The effect size ($ή^2$) of the difference between pre-test and post-test mean scores was calculated as 1.14 (*Cohen's d*), which indicates a large effect size since it is $d>0.8$ (Kılıç, 2014). Thus, it can be said that socioscientific issues-based popular science readings greatly enhanced the critical thinking skills of prospective classroom teachers.

Prospective Classroom Teachers' Reading Habits-Related Attitudes Before and After Socioscientific Issues-Based Popular Science Readings

The participants' mean scores from the pre-test and post-test scale towards reading habits related attitudes are given in Figure 4.

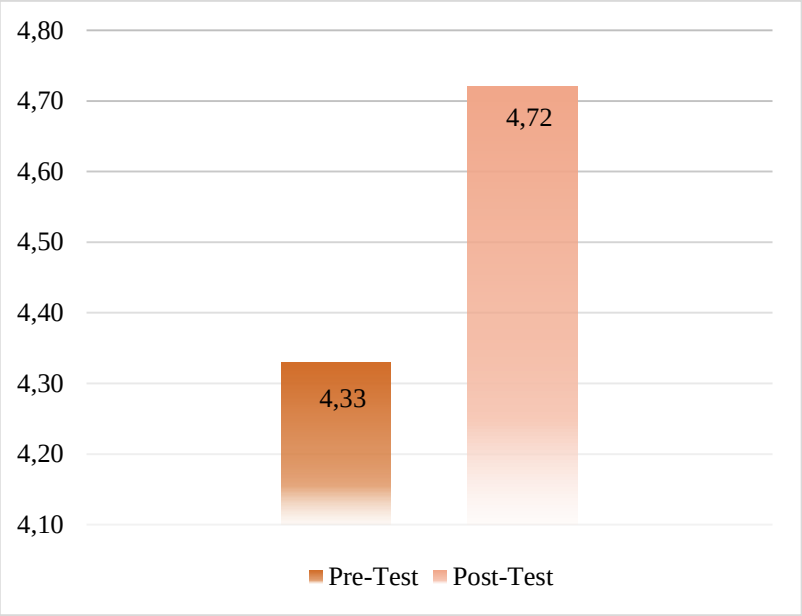

Figure 4. Mean scores from the pre-test and post-test scale towards reading habits-related attitudes

It was found that the participants' mean score from the post-test scale towards reading habits-related attitudes were higher than their mean score from the pre-test scale towards reading habits-related attitudes. Later, the participants' mean scores from the pre-test and post-test scale towards reading habits-related attitudes were compared using the dependent samples t-test. The results are presented in Table 4.

Table 4. Comparison of mean scores from the pre-test and post-test scale towards reading habits-related attitudes using the dependent samples t-test

	N	$\overline{X}$	**Standard Deviation**	**df**	**t**	**p**	$\acute{\eta}^2$
Pre-test	15	4.33	0.32	14	-3.815	0.002	1.59
Post-test	15	4.72	0.13				

t(14)=3.815; p=0.002; $\acute{\eta}^2$=1.59

As can be inferred from Table 4, there is a statistically significant ($p<0.05$) difference between the participants' mean scores from the pre-test and post-test scale towards reading habits-related attitudes. Thus, the H_0 hypothesis was rejected. The effect size ($\acute{\eta}^2$) of the difference between pre-test and post-test mean scores was calculated as 1.59 (*Cohen's d*), which indicates a large effect size since it is $d>0.8$ (Kılıç, 2014). Thus, it can be said that socioscientific issues-based popular science readings positively affected the reading habits-related attitudes of prospective classroom teachers.

DISCUSSION

This study investigated the effect of socioscientific issues-based popular science readings on critical thinking skills and reading habits-related attitudes of prospective classroom teachers. To this end, a reading group was formed with prospective classroom teachers, and the articles on socioscientific issues in the Science and Technique (Bilim ve Teknik) magazine were examined. Each activity took about 45 minutes (1 course hour), and the whole process continued for 10 weeks. Socioscientific issues-based teaching makes topics with scientific content, in which students are not interested and which may be considered

boring, more interesting and enjoyable (Dolan, Nichols, & Zeidler, 2009). Thus, the learning process is taken to another dimension, and socioscientific issues-based activities can serve as a tool for students to gain a perspective towards the world and science and to question and interpret real-life situations.

The study found a statistically significant difference ($p<0.05$) between the participants' mean scores from the pre-test and post-test critical thinking skills questionnaire applied before and after socioscientific issues-based popular science reading activities, and the effect size ($ή^2$) of the difference between pre-test and post-test mean scores was calculated as a large effect size. Critical thinking is not an inherited skill: it can be learned, taught, and improved (Göbel, 2013). Cleveland (2015) underlined the importance of using picture books in science teaching and argued that these books constituted a good context for science learning and could be used as an effective teaching tool to develop critical thinking skills in students. Büyükkanber and Makaracı (2015) stated that textbooks had an instruction style that does not allow students to think differently, and that includes precise judgments, suggesting that starting from kindergarten, it is necessary to create and use resources that can develop children's critical thinking skills. Theoretical courses taken by prospective classroom teachers during their undergraduate education have been deemed insufficient in terms of enhancing their critical thinking skills (Yeşilpınar, 2011). Moreover, faculties of education lack educational practices that support critical thinking skills in students (Özelçi, 2012). In this regard, the process designed in this study can be used to contribute to prospective teachers' critical thinking skills. Gray and Bryce (2006) stated that students should have the basic infrastructure and skills that are necessary to make informed judgments and decisions about the developments encountered in the media or everyday life. They also suggested that socioscientific issues containing social, moral, and ethical issues as dilemmas should be included in all educational processes. Açışlı (2016) found that prospective classroom teachers scored quite high scores from the "analytical thinking" sub-dimension of the "critical thinking dispositions" scale, attributing their high scores to their ability to be cautious, to reason, and to use objective evidence in potentially problematic situations. Similarly, in this study, prospective classroom teachers analyzed popular science articles about socioscientific issues, discussed them with others, and were able to look at the issues critically. In a study conducted by Pelger and Nilsson (2016), students were asked to write projects in a plain language that the people could understand, and then, using a questionnaire, they were asked to express how such a writing style contributed to them. The students stated that such a writing style enabled them to change their perspectives on issues, providing them with an opportunity to look at their projects from a different point of view. From this point of view, popular science readings, with their plain and simple language, can help one develop a critical look at issues and situations. In this study, the researcher supported popular science readings with socioscientific issues, the dilemmatic nature of which required the participants to use and thus improve their critical thinking skills.

The fact that the reading activities carried out in this study focused on socioscientific issues, which left the participants in dilemmas and therefore had them discuss the issues, may have been effective in improving prospective classroom teachers' critical thinking skills. After reading popular science articles, the participants shared their opinions with other participants, rejected or supported the ideas put forward in the articles, and had the opportunity to view socioscientific issues from different perspectives. Open-ended questions to be asked after reading popular science articles can be very useful in developing skills such as critical thinking, analyzing, developing original solutions to problems, and high-order thinking (Baştuğ, Hiğde, Çam, Örs, & Efe, 2019). In their study, which aimed to develop critical

thinking skills through group work, Fung and Howe (2012) found that discussions held during group work activities positively affected the experimental group's post-test scores from the critical-thinking test. In another study, Babacan (2017) asked middle school students to carry out a scientific argumentation in a group activity involving socioscientific issues. The author found that these activities improved students' critical thinking skills. Sevgi and Şahin (2017) asked students to discuss socioscientific issues in newspaper reports using argumentation, thus contributing to the development of students' critical thinking skills. Similarly, this study went beyond merely conveying information to students, which is a widely adopted traditional teaching method, and used socioscientific issues-based popular science readings, which increased active participation among prospective classroom teachers and created a learning setting that helped them think critically, discuss, and interact with others. Thus, the study contributed to the development of prospective classroom teachers' critical thinking skills.

Another noteworthy finding obtained in this study is that there was a statistically significant difference ($p<0.05$) between the participants' mean scores from the pre-test and post-test scale towards reading habits-related attitudes applied before and after socioscientific issues-based popular science reading activities, and the effect size ($ή^2$) of the difference between pre-test and post-test mean scores was calculated as a large effect size. Individuals improve their reading skills by increasing their vocabulary and using reading comprehension strategies to make sense of what they have read. In the following stages of education, the ability to make sense of what has been read deepens (Aşuluk, 2020). If individuals want to acquire reading habits and develop an attitude towards reading, it is necessary to make the act of reading enjoyable and interesting (Calkins, 2001). Thus, individuals start to see this as a part of their lives, develop a positive attitude to reading and in this way tend to continue the reading habit (Yıldız et al., 2017). Lai and Chan (2020) found that picture books helped children use their reading skills in science learning, thus providing more learning and increasing academic success. This is because the reading skill is not one-dimensional: it involves multidimensional mental processes that occur at different levels and highlights the interaction between the reader, writer, and text in all its dimensions (Aşuluk, 2020). In another study, it was found that reading scientific stories increased children's curiosity and interest in the lesson, made abstract concepts easier to understand, helped achieve permanent learning, and provided an enjoyable and positive learning environment. Thus, it was concluded that it affects students effectively by developing interest, curiosity, motivation and desire towards the lesson (Gölcük, 2017), and this result is considered important in providing reading habits-related attitudes. In primary schools, tales, stories, and informative texts are used widely in Turkish classes: through activities that require students to comprehend, interpret, and analyze what they have read, it is aimed to help students develop towards reading habits-related attitudes (MoNE, 2018). On the other hand, considering the features of popular science publications, they are more accessible than other books and can be understood by a wider range of people, which can be effective in helping students develop positive attitudes towards science (Eroğlu & Sağlam, 2020). Developed and developing societies use different methods and techniques and develop different projects in order to help individuals acquire reading habits, increase their interest in reading, and enable them to exhibit positive attitudes towards reading (Karadağ, 2014). When evaluated from this point of view, this reading experience supported by a different activity can be considered as an opportunity. Socioscientific issue-based popular science readings have attracted the attention of prospective classroom teachers and positively affected their reading habits-related attitudes. Moreover, the participants realized that, in addition to Turkish classes in primary schools, popular science readings that can be carried out in science classes could also be effective in helping primary school students develop reading habits. In a study by Majetic and Pellegrino (2014), undergraduate students

analyzed science-related news reports in the media according to certain criteria, and it was found that this had a positive effect on the reading skills of the undergraduate students participating in the study. Ünlüer (2008) used newspapers, which are considered one of the traditional media channels, in social studies classes in a primary school. At the end of the process, students stated that using newspapers in social studies classes improved their reading and reading comprehension skills.

Teachers who raise future generations are expected to gain awareness of socioscientific issues directly related to life and be able to understand, interpret, and critically evaluate popular media instruments (newspapers, science magazines, internet, etc.) (Öztürk & Erabdan, 2018). Students encounter many scientific issues and situations in their families, schools, and communities, have difficulty making decisions, and thus perceive these issues as a problem. Therefore, it is argued that schools and teachers must undertake the responsibility of addressing such issues (McCrory, 2020). Hence, while preparing for their future professional lives, prospective teachers need to experience the contribution of socioscientific issues to their educational process. Socioscientific issues-based activities that help students realize that such issues are present in the real world and that promote student engagement in classes should be increased (Sevgi & Şahin, 2017). In this way, students can be informed about both the world and the innovations brought about by the developing technology; moreover, they can be more motivated to follow studies on socioscientific issues (Gürbüzkol & Bakırcı, 2020). Therefore, socioscientific issues-based popular science readings should be evaluated by teachers as an opportunity to achieve this. Also, science magazines, posters, and newspaper articles, which are among the popular media instruments, can be used as an important resource for educational studies to ensure the sustainability of knowledge (Yazır & Yel, 2017).

In this study, it was found that socioscientific issues-based popular science readings significantly increased the critical thinking skills and reading habits-related attitudes of prospective classroom teachers. Socioscientific issues-based activities can promote students' critical thinking skills by helping them discuss complex issues more effectively. Such processes to be designed with various activities can make the teaching process more enjoyable and increase student engagement in the lesson. In addition, reading habit is one of the important behaviors that students should gain from the first years of primary school. Because the reading habits and diversity acquired at early ages have a very important effect on the mental development and social maturation of individuals. Considering that attitudes are formed late and are difficult to change, it will be beneficial to organize activities for reading books starting from younger age groups and to ensure the participation of students in activities for the development of this attitude (Arslan & Çelik, 2009). Martin et al. (2018) found that most of the illustrated children's books raised awareness in children about the effects of human activities on the environment, thus helping them become informed about recent developments. They also noted that interesting illustrated children's books increased student participation in classes by helping them have more fun. Yavuzoğlu and Pektaş (2020) examined the "Science Kids (Bilim Çocuk)" magazine published monthly by TÜBİTAK. They found that conceptual understanding was included more in the scientific stories in the magazine. Furthermore, they stated that the magazine also attached much importance to activities that enhance students' higher-order thinking skills, such as critical thinking, discussing, making inventions, researching, designing experiments, and applying. It is thought that socioscientific issues-based popular science reading activities carried out with a sample of prospective classroom teachers contributed to both the relevant literature and the professional development of prospective teachers. Various popular science magazines for prospective teachers (Science and Technique [TÜBİTAK Bilim ve Teknik], National

Geographic, Atlas, Popular Science [Popüler Bilim], etc.) and for primary school students (Science Kids [TÜBİTAK Bilim Çocuk], TRT Children's Magazine [TRT Çocuk Dergisi], National Geographic Kids Turkey, Atlas Kid [Atlas Çocuk], Wise Kid [Bilge Çocuk], Researcher Kid [Araştırmacı Çocuk], etc.) can be included in educational processes through in-class and out-of-class activities. Thus, students can be provided with funny and engrossing learning settings where they can gain awareness about, discuss, and analyze real-world problems. At the same time, the realization of different types of reading experiences in the education process can be seen as effective in gaining affective characteristics related to reading habits and developing positive attitudes and thoughts towards reading. In addition to this study, other research can be conducted with prospective classroom teachers and primary school students using popular science reading activities or socioscientific issues-based articles. Using different data collection tools in future studies can also help analyze different dimensions of designed activities. Finally, results from various studies can be compared to determine the effectiveness of designed processes.

REFERENCES

Açışlı, S. (2016). Sınıf öğretmeni adaylarının öğrenme stilleri ile eleştirel düşünme eğilimlerinin incelenmesi. *İlköğretim Online*, *15*(1), 273-285.

Akar, B. (2010). *Tıp fakültesi öğrencilerinin insan genetiği uygulamalarına yönelik risk algıları ve etik inançları arasındaki ilişkinin incelenmesi* (Master Thesis). Ankara Üniversitesi Biyoteknoloji Enstitüsü, Ankara.

Arslan, Y, & Çelik, Z. (2009). Üniversite öğrencilerinin okuma alışkanlığına yönelik tutumlarının belirlenmesi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 26*(26), 113-124.

Aşuluk, Y. (2020). *Zekâ oyunlarının ilkokul 3. Sınıf öğrencilerinin Türkçe dersinde okuduğunu anlama becerisine etkisi* (Master Thesis). Hacettepe Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Babacan, M. A. (2017). *Sosyobilimsel konulardaki etkinliklerin yedinci sınıf öğrencilerinin eleştirel düşünme becerilerine etkisi* (Master Thesis). Ömer Halisdemir Üniversitesi Eğitim Bilimleri Enstitüsü, Niğde.

Baştuğ, M., Hiğde, A., Çam, E., Örs, E., & Efe, P. (2019). *Okuduğunu anlama becerilerini geliştirme, stratejiler, teknikler, uygulamalar.* Ankara: Pegem Akademi.

Büyükkanber, C., & Makaracı M. (2015). Eleştirel düşünce ve eğitim uygulamaları. *Presented at ISCAT2015 Symposium*, 10-12 April 2015, Sakarya, Turkey,

Büyüköztürk Ş., Çakmak, E. K., Akgün Ö. E., Karadeniz Ş., & Demirel F. (2012). *Bilimsel araştırma yöntemleri* (12. Edition). Ankara: Pegem Akademi.

Calkins, L. M. (2001). *The art of teaching reading*. Prentice Hall.

Chang-Rundgren, S., & Rundgren, C.J., (2010). SEE-SEP: From a separate to a holistic view of socioscientific issues. *Asia-Pacific Forum on Science Learning and Teaching, 11*(1), 1-24.

Chowdhury, S., & Halder, S. (2016). Educational dissemination through newspaper daily. *Journal of Education and Practice, 7*(7), 1-12.

Cleveland, E. (2015). *Using children's picturebooks to develop critical thinking skills and science practices in grades 3rd-5th* (Master Thesis). University of Wyoming Science and Mathematics Teaching Center, USA.

Creswell, J. H. (2017). *Araştırma deseni, nitel, nicel ve karma yöntem yaklaşımları*. S. B. Demir (Çev. Ed.), Ankara: Eğiten Kitap

Çakmakçı, G., & Yalaki, Y. (2012). *Promoting student teachers' ideas about nature of science through popular media*. Trondheim, Norway: STEAM/NTNU.

Demir, E., Saatçioğlu, Ö., & İmrol, F. (2016). Uluslararası dergilerde yayımlanan eğitim araştırmalarının normallik varsayımları açısından incelenmesi. *Current Research in Education, 2*(3), 130-148.

Demiral, Ü., & Türkmenoğlu H. (2018). Fen bilgisi öğretmen adaylarının genetiği değiştirilmiş organizmalı besinler ile ilgili risk algılarının karar verme mekanizmalarıyla ilişkisinin incelenmesi. *Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi, 15*(1), 1025-1053.

Demirel, Ş. (2011). Çocuk edebiyatı. Ş. Demirel, (Ed.), In, *Edebi metinlerle çocuk edebiyatı* (p. 43-68), Ankara: Pegem Akademi.

Deniz, E. (2009). *Öğretmen adaylarının eleştirel düşünme beceri düzeyleri üzerine bir inceleme* (Master Thesis). Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü, Ankara.

Doğu Gültekin, E., & Ünlü, M. (2020). Media reflections of the environment and society unit in the geography curriculum. *International Journal of Geography and Geography Education (IGGE)*, 42, 72-90.

Dolan, T. J., Nichols, B. H., & Zeidler, D. L. (2009). Using socioscientific issues in primary classrooms. *Journal of Elementary Science Education, 21*(3), 1-12.

Eroğlu, B., & Sağlam, H. İ. (2020). Popüler bilim kitapları etkili bir öğretim aracı olarak kullanılabilir mi? *Cumhuriyet International Journal of Education, 9*(3), 656-678.

Fung, D. & Howe, C. (2012). Liberal studies in Hong Kong: A new perspective on critical thinking through group work. *Thinking Skills and Creativity*, 7, 101-111.

Halpern, D. F. (2003). *Thought and knowledge: An introduction to critical thinking (4th edn).* Mahwah, NJ: Erlbaum.

Güngör, E. (2009). *İlköğretim 5. sınıf öğrencilerinin kitap okuma alışkanlığı ile Türkçe dersi akademik başarıları arasındaki ilişkinin incelenmesi* (Master Thesis). Çukurova Üniversitesi, Adana.

Göbel, D. Ş. (2013). *Sınıf öğretmenlerinin eleştirel düşünme becerisi öğretimi yeterlilikleri ve uygulamaları* (Master Thesis). Sakarya Üniversitesi Eğitim Bilimleri Enstitüsü, Sakarya.

Gölcük, A. (2017). *Bilimsel hikâyelerle desteklenen fen eğitiminin öğrencilerin yaratıcılıkları ve duyuşsal özellikleri üzerindeki etkileri* (Master Thesis). Hacettepe Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Gömleksiz, M. N. (2004). Kitap okuma alışkanlığına ilişkin bir tutum ölçeğinin geçerlik ve güvenirliği. *Fırat Üniversitesi Sosyal Bilimler Dergisi, 14*(12), 185-195.

Gray, D.S., & Bryce, T. (2006). Socio-scientific issues in science education: Implications for the professional development of teachers. *Cambridge Journal of Education, 36*(2), 171-192.

Gürbüzkol, R., & Bakırcı, H. (2020). Fen bilimleri öğretmenlerinin sosyobilimsel konular hakkındaki tutum ve görüşlerinin belirlenmesi. *Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi, 17*(1), 870-893.

Karadağ, R. (2014). Okuma ilgisi, tutumları ve alışkanlığı konusunda yapılmış çalışmaların lisansüstü tezlere dayalı analizi: YÖK ve Proquest veri tabanları örneklemi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 35*(35), 1-17.

Karakuş, G., & Ergün, M. (2016). Bilimsel roman okumanın öğrencilerin bilimsel tutumuna etkisi. *Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi, 18*(1), 115-134.

Kaya, H. İ. (2010). Yapılandırmacı öğrenmeye dayalı uygulamaların öğretmen adaylarının eleştirel düşünme eğilimlerine etkileri. *Sosyal Araştırmalar Dergisi*, 9, 79-95.

Ke, L., Sadler, T. D., Zangori, L. A., & Friedrichsen, P. J. (2020). Integrating scientific modeling and socio-scientific reasoning to promote scientific literacy. Wardell A. Powell (Ed.), In, *Socioscientific ıssues-based ınstruction for scientific literacy development* (pp. 31-54), IGI Global.

Khishfe, R. (2012). Relationship between nature of science understandings and argumentation skills: A role for counterargument and contextual factors. *Journal of Research in Science Teaching, 49*(4), 489-514.

Kılıç, S. (2014). Etki Büyüklüğü. *Journal of Mood Disorders, 4*(1), 44-60.

Lai, C. S., & Chan, K. L. (2020). Enhancing science learning through science trade book reading for 5th graders. *Journal of Education in Science Environment and Health, 6*(1), 1-9.

Levinson, R. (2006). Towards a theoretical framework for teaching controversial socioscientific issues. *International Journal of Science Education, 28*(11), 1267-1287.

Lin, S. S, & Mintzes, J. J. (2010). Learning argumentation skills through instruction in socioscientific issues: The effect of ability level. *International Journal of Science and Mathematics Education*, 8, 993-1017.

Majetic, C., & Pellegrino, C. (2014). When science and information literacy meet: An approach to exploring the sources of science news with non-science majors. *College teaching, 62*(3), 107-112.

Martin, N. M., Hageman, J. L., Montgomery, S. A., & Rule, C. A. (2018). A content analysis of thirty children's Picture boks about ecology. *Journal of STEM Arts, Craft, and Constructions, 4*(1), 83-120.

McCrory, A. (2020). 'What a Coronacoaster!' Navigating primary science education in primary schools during the ongoing COVID-19 pandemic: EYFS and primary school teacher perspectives on the affective and pedagogical impacts of the pandemic. *Journal of Emergent Science*, 19, 6-18.

Turkish Ministry of National Education [MoNE] (2018). Türkçe öğretim programı (1.- 8. sınıflar). Ankara: MEB Talim ve Terbiye Kurulu Başkanlığı.

Özbay, M., Bağcı, H., & Uyar, Y. (2008). Türkçe öğretmeni adaylarının okuma alışkanlığına yönelik tutumlarının çeşitli değişkenlere göre değerlendirilmesi. *İnönü Üniversitesi Eğitim Fakültesi Dergisi, 9*(15), 117-136.

Özelçi, S. Y. (2012). Eleştirel düşünme tutumunu etkileyen faktörler: Sınıf öğretmeni adayları üzerine bir çalışma (PhD Thesis). Adnan Menderes Üniversitesi Sosyal Bilimler Enstitüsü, Aydın.

Özsevgeç, T., Eroğlu, B., & Öztürk Köroğlu, Y. (2017). Popüler bilim dergilerinin değerlendirilmesi: Bilim ve Teknik ve National Geographic örneklemi. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi*, 30, 619-630.

Öztürk, N., & Erabdan, H. (2018). Fen bilgisi öğretmen adaylarının gazetelerde yer alan sosyo-bilimsel konulara yönelik farkındalıklarının incelenmesi. *Sakarya University Journal of Education, 8*(4), 319-336.

Öztürk, N., Eş, H., & Turgut, H. (2017). How gifted students reach decisions in socio-scientific issues? Warrants, information sources and role of media. *International Online Journal of Educational Sciences, 9*(4), 1111 -1124.

Pelger, S., & Nilsson, P. (2016). Popular science writing to support students' learning of science and scientific literacy. *Research in Science Education*, 46, 439-456.

Romance N.R., & Vitale M.R. (1992). A curriculum strategy that expands time for in depth elementary science instruction by using science based reading strategies: Effects of a year long study in grade four. *Journal of Research in Science Teaching, 29*(6), 545-554.

Sadler, T. D., Romine, W. L., & Topçu, M.S. (2016). Learning science content through socioscientific issues-based instruction: A multi-level assessment study. *International Journal of Science Education, 38*(10), 1622–1635.

Sandoval, W.A., & Millwood, K.A. (2005). The quality of students' use of evidence in written scientific explanations. *Cognition and Instruction, 23*(1), 23-55.

Sarıgöz, O. (2014). Öğretmen adaylarının eleştirel düşünme becerileri hakkındaki görüşlerinin değerlendirilmesi. *Akademik Bakış Dergisi*, 41, 0-0.

Sevgi, Y., & Şahin, F. (2017). Gazete haberlerindeki sosyobilimsel konuların argümantasyon yöntemiyle tartışılmasının 7. sınıf öğrencilerinin eleştirel düşünme becerileri üzerine etkisi. *Journal of Human Sciences, 14*(1), 156-170.

Science and Technique [Bilim ve Teknik] (2020). Bilim ve Teknik Hakkımızda. Acessed from http://bilimteknik.tubitak.gov.tr/dergimiz/hakkimizda (Access date 01.08.2019).

Tok, E. (2008). *Düşünme becerileri eğitim programının okul öncesi öğretmen adaylarının eleştirel, yaratıcı düşünme ve problem çözme becerilerine etkisinin incelenmesi* (Master Thesis). Marmara Üniversitesi, İstanbul

Turan, E. D., Kurt, E., & Arslan, N. (2016) Mini Kumbara Dergisi'nin popüler bilim kaynakları kapsamında biçim ve içerik bakımından incelenmesi. *Ana Dili Eğitimi Dergisi, 4*(3), 326-336.

Türksever, F., Karışan, D., & Türkoğlu, A. Y. (2020). Öğretmen adaylarının sosyobilimsel konular hakkındaki görüş ve tutumları ile dünya vatandaşlığına dair değer yargılarının incelenmesi. *Başkent University Journal of Education, 7*(2), 339-354.

Yeşilpınar, M. (2011). Sınıf öğretmenlerinin ve öğretmen adaylarının eleştirel düşünmenin öğretimine yönelik yeterliklerine ilişkin görüşleri (Master Thesis). Çukurova Üniversitesi Sosyal Bilimler Enstitüsü, Adana.

Ünlüer, G. (2008). *Sosyal bilgiler dersinde gazete kullanımının öğrencilerin akademik başarılarına ve tutumlarına etkisi* (PhD Thesis). Anadolu Üniversitesi Eğitim Bilimleri Enstitüsü, Eskişehir.

Yavuzoğlu, Ç., & Pektaş, M. (2020). Investigation of science content in periodical children's publications in terms of science history. *TAY Journal, 4*(1), 1-16.

Yazır, G., & Yel, M. (2017). Biyoloji eğitiminde popüler medya kaynaklarının öğrencilerin biyoloji dersine ve bilime yönelik tutumlarına etkisi. *Al Farabi Uluslararası Sosyal Bilimler Dergisi, 1*(3), 364-380.

Yıldız, M., Ketenoğlu Kayabaşı, Z. E., Ayaz, E., & Aklar, S. (2017). Bazı çocukların kitap okumayı sevmeme nedenleri. *The Journal of Academic Social Sciences Studies*, 55, 507-524.

Zeidler, D. L., & Nichols, B. H. (2009). Socioscientific issues: Theory and practice. *Journal of Elementary Science Education, 21*(2), 49-58.

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Evaluations on an Educational Game Developed for Temperature Unit Conversions: CFK Survivor

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Abstract

Educational games are the planned and purposeful educational activities improving knowledge and skills via reinforcing the previous learnings. Therefore, "Heat and Temperature", one of the units where misconceptions are seen the most and concretization is the least, was determined under 9th grade Physics lesson and CFK Survivor educational game was developed under "The students make calculations related to temperature units." acquisition and "Unit conversions for ^{0}C, ^{0}F, K are provided to be done." acquisition explanation. To evaluate CFK Survivor, this study under the phenomenology method was designed. 13 physics teachers working in private educational institutions and attending online lessons were selected through an easily accessible sampling method and the study group was formed. The game was evaluated in various aspects as eligibility, gamification, rules and data were analyzed by content analysis. It is concluded that several cognitive, affective and psychomotor skills could be gained via this game, and enjoyable and permanent learning would be supplied. Sample suggestions for physics subjects where educational games could be designed and for further studies are also presented.

INTRODUCTION

In all periods of her/his history, humankind has been in a constant effort to spend quality time and have fun. One of the most important and effective ways that she/he has found in these pursuits is game. By offering various opportunities to learn with their own experiences, games have a certain place in every stage of human life. (Aksoy & Kaleli Yılmaz, 2011; Özyürek & Çavuş, 2016). Games have various features not only affecting most people physically, socially, mentally, psychologically and emotionally but also supporting their development (Özer, Gürkan & Ramazanoğlu, 2006). Because games are voluntary activities, the people playing them experience internal motivation (Ayan & Memiş, 2012). Thanks to this internal motivation, it is possible to establish a link between conceptual knowledge and its implementation (Bayat, Kılıçaslan & Şentürk, 2014).

In this day and time, textbook or teacher-based approaches where the students are passive are obsolete. Henceforth, there are new educational models where learners' interests, desires, curiosities and abilities are centered. In other words, modern approaches aiming to raise active, creative, innovative and critical individuals in which the student plays the leading role, take the stage (Sarı, 2007). In student-centered modern approaches, the aim is to use the most

appropriate and short methods to achieve the determined goals. Techniques, which are the application of methods, have also gained more importance in this context (Karaağaçlı, 2011). From this point of view, including the games, one of the favorite and entertaining things of students, into education is quite beneficial. The games played for educational purposes are called educational games (Aymen Peker, 2018). Applying games to learning activities disentangle educational environments from being a place where only memorized information is stored. They also enable students to learn the knowledge and abilities required for their lives in a natural process. Therefore, they can increase their specific learning capacity with educational games (Kefeli, Yalçın, & Taş, 2018). So, educational games can be considered as natural learning tools. Thanks to using the knowledge and skills they need, during the games, students can get such facts as gaining habits and experience, acquiring knowledge and helping each other by doing and experiencing (Kaytez & Durualp, 2014). For this reason, it is aimed to carry out learning activities in teaching environments where students can learn more eagerly, contentedly and actively (Yükseltürk & Altıok, 2016). Therefore, these games provide active participatory learning, which is planned for a specific purpose in accordance with the goals of the teaching (Dönmez, 1999). Consequently, several games played in daily life can be performed educationally in teaching the subject if they are properly designed for their purposes.

Educational games are the learning techniques enabling the education and training process to be more efficient for both teachers and students (Hazar & Altun, 2018). In addition, it is stated that mental skills may be improved thanks to such activities as developing tactics and strategies during the games (Özer, Gürkan & Ramazanoğlu, 2006). One of the most basic features of educational games is that they activate students in cooperation with a competitive spirit (Canbay, 2012). The findings that group-shaped activities are more effective on student achievement obtained in the research supports this assertion (Aydın & Balım, 2005).

It is known that the personality development of the children cooperating with their friends in the educational game process and playing according to the rules, is positively affected (Saracho, 2001). Because the essence of educational games is to reach students' goals according to their existing intelligence, knowledge, skills and psychomotor characteristics within the scope of certain rules (Altun, 2013). Accordingly, educational games also positively affect students' social, cognitive and affective skills such as expressing themselves, being aware of their abilities, being autonomous, having self-confidence.

In the light of all these, in order for science education in every field of life to be effective, the students should be ensured to be able to create meaningful learning by getting rid of memorizing and internalizing their knowledge. Non-concreted information does not stay in mind for a long time and even affects new information negatively (Maskan & Maskan, 2007). The developments and innovations in science and technology today, make updating the science curriculum necessary. Science education at schools is also revised within the framework of education programs in accordance with age. However, researchers working in the field of science have found that students do not like science subjects at schools (Erdemir, 2009). Likewise, because of being abstract and requiring intense effort physics, one of the science courses, is generally perceived as a difficult and incomprehensible lesson (Örnek, Robinson & Haugan 2008). Physics is a science-based on experimental and quantitative measurement for understanding natural phenomena. In other words, the things people see, do and use throughout their lives, constitute the subjects of physics. For this reason, the purpose of physics education is to provide students with scientific knowledge, attitude, mental process

skills and abilities necessary to solve the problems they scientifically encounter (Bayrak & Eden, 2007).

Due to their features such as providing active participation, being interesting and motivating, reducing forgetting and consequently accelerating learning, it is thought that educational games can also be effective in physics teaching. Because in a learning environment supported by concrete materials, it gives students the opportunity to learn by doing and experiencing (Gülsoy, 2013). For example, the educational games developed by Can and Yıldırım (2017), on "change of state" subject, by Yıldız, Şimşek and Araz (2016), on "circulatory system" subject and by Gençer and Karamustafaoğlu (2014), on "static electricity" subject were applied. Thanks to those educational games, a significant difference was found for the students' academic achievement in their research. In this way, educational games facilitate the learning of many rules and concepts that students have difficulty understanding and applying (Coşkun, Akarsu & Kariper, 2012). However, it is mentioned in the literature that among the physics topics, the concepts of heat and temperature cause such difficulties as being used interchangeably (Jara-Guerrero, 1993), misunderstanding (Jones, Carter, G. & Rua, 2000) and forming misconceptions (Ayvacı & Durmuş (2016); Yeo & Zadnik, 2001).

In this context, within the scope of the 9th grade Physics lesson "Heat and Temperature" unit, it was decided to develop an educational game on the *"The students make calculations related to the temperature units."* acquisition. For this reason, under the acquisition description, *"Unit conversions for ^0C, ^0F, K are provided to be done."* CFK Survivor game, which aims to learn the heat unit conversion calculations of Celsius, Fahrenheit and Kelvin thermometer types, was developed. Getting the opinions of the teachers, being both the practitioners and evaluators of the process, would be one of the most important tools in determining the effect of the developed game on the learning of the subject. However, it could not be possible to implement the game because schools were closed due to the coronavirus epidemic. Therefore, the physics teachers' views and evaluations were taken to determine the effects of CFK Survivor via interviews. In this context, the problem sentence of the research is *"What are the opinions and evaluations of physics teachers on the educational game prepared for calculations of heat unit conversion among Celsius, Fahrenheit and Kelvin thermometers?"*. In this research, it has been tried to reach the relevant acquisition in the physics lesson program through an original educational game "CFK Survivor". For this reason, it is thought that this research will make valuable contributions to the literature.

METHOD

Study Design

This study designed to take the views and evaluations of physics teachers for the developed game "CFK Survivor" whose stages as meeting the acquisition, preparation, rules and implementation are explained step by step in Annex-1, was conducted under qualitative research. Qualitative research methods can be used to show perceptions and events more clearly through examples, explanations and experiences (Özmen & Karamustafaoğlu, 2019).

Schools being closed due to the Covid-19 epidemic did not allow the game to be implemented. Therefore, the opinions of physics teachers giving 9th grade lessons online in this period, about the game were consulted. In the light of their professional experiences, the phenomenology method under qualitative research design was used in this study to reach their evaluations about the game firsthand. In phenomenology, data are collected at first hand by focusing on the facts that are recognized in daily life but are desired to be examined in depth

and detail (Yıldırım & Şimşek, 2018). Phenomenology makes it possible to reveal individual experience and the personal meanings attributed to them (Titchen & Hobson, 2005).

Sample

In line with the purpose of the study**,** under the 9th grade Physics lesson "Heat and Temperature" unit the acquisition of *"The students make calculations related to temperature units."* was focused elaborately. So, in accordance with the relevant acquisition description, *"Unit conversions for ^0C, ^0F, K are provided to be done."* The game "CFK Survivor" was developed. In order to get their opinions and evaluations about the game, all the physics teachers working in private education institutions in the central districts of a metropolitan city in the Middle Black Sea Region formed the universe of the study. Among those, the sample was determined with 13 teachers actively giving online 9th grade Physics lessons during the Covid-19 pandemic. In the selection of the sample, due to such factors as being available for the research, making video calls and reaching in a short time, easily accessible sampling, one of the purposeful sampling methods, was used. It is stated that the phenomenology samples are determined by the sampling method for the purpose, between 5 and 25 participants, which generally has a certain characteristic feature such as being a teacher (Creswell, 2013; Patton, 2015; Rubin & Babbie, 2016). The demographic features of the participant teachers in the sample were presented in Table 1.

Table 1. Demographic features of the participants

Participant	Gender	Age	Professional Experience (Year)	Employed Institution Type
P1	Female	41	18	Private Education Course
P2	Male	40	10	Private School
P3	Female	39	15	Private Education Course
P4	Male	46	22	Private Education Course
P5	Male	43	19	Private Education Course
P6	Female	31	6	Private School
P7	Male	45	21	Private School
P8	Male	43	21	Private Education Course
P9	Male	39	13	Private School
P10	Female	32	8	Private School
P11	Male	42	18	Private School
P12	Male	40	15	Private School
P13	Male	44	22	Private Education Course

As presented in Table 1, a total of 13 physics teachers, 4 females and 9 males, participated in the study. Professional experience of the participants, between the ages of 31 and 46, varied between 6 and 22 years. Six of them were working at private education courses while seven of them at private schools. All those private schools and private education courses continuing their activities in the central districts of a metropolitan city in the Middle Black Sea Region were under the Ministry of National Education General Directorate of Special Education.

Data Collection Tool and Process

In this study organized to determine teachers' views on the CFK Survivor game, the data were collected through a "Semi-Structured Interview Form" consisting of 7 questions prepared by the researchers. The interview questions were prepared in accordance with the necessary criteria as below factors to determine the effect of the developed game on learning the relevant subject:

- being appropriate to the purpose and method of the research,

- being clear and understandable,
- not leading the participants,
- not having conditional or complex statements,
- allowing participants to give comprehensive and detailed answers,
- ordering from general to specific and being consistent with each other,
- being correct in terms of grammar, spelling and punctuation.

So as to increase the content validity of the interview form, it was handed in to two professors who are experts in the field, for reviewing. Therefore, the relevant corrections were made according to their feedback and presented in Table 2.

Table 2. The feedback and corrections on interview questions

Q*	FEEDBACKS	CORRECTION
1	The first question should include the most general statements about educational games. Later, additional questions may be asked in terms of physics lesson (P1). At the beginning of the interview, the opinions of the participants can be revealed in a more comprehensive way thanks to the questions prepared from general to specific (P2)	The first question was revised as "What do you think about educational games, the use of educational games in physics teaching and the instruction of educational games?"
2	After getting their views on teaching with educational games, the physics teachers can be asked about what they are doing to use it in their lessons (P1). First of all, this question should be aimed at determining the competence of the participants to teach with educational games. Later, it can be asked to what extent he/she uses educational games (P2)	The second question was designed as: "How do you evaluate yourself about teaching via educational games? Do you apply educational games in your lessons, if so, how often?
3	The third question should be supported with additional questions to provide detailed data about the rules and gameplay of CFK Survivor. Therefore, more comprehensive answers can be obtained regarding the impact of the game on the subject (P1) A comprehensive question should be written to evaluate the general lines, advantages, disadvantages of the developed game. Also, whether it might be easy or difficult to be implemented can be asked (P2)	The third question was designed as "Are the gameplay and rules of CFK Survivor understandable? Are there any points that might not be understood or might force the teacher and/or students during the process? How might the game contribute to the teaching of the subject?"
4	I think the fourth question should be about getting the opinions of the teachers about to what extent the developed game could meet the acquisitions of the subject (P1). After evaluating the game in the third question, the participants may be asked to interpret the game in terms of the relevant acquisitions (P2)	The fourth question was designed as "Could CFK Survivor meet the acquisitions of the subject? If so, to what extent and how?"
5	This question can be prepared to provide extended data on how the developed game will have an impact on the students when applied (P1).	The fifth question was designed as "When applying CFK Survivor in your lesson, do you

	The most important thing is to be satisfied with the work you do. So, it can be asked how much fun the CFK Survivor will provide for students in the teaching of the subject (P2)	think students can learn the subject by having fun? If so, why and how?
6	Our aim is to enable the students to comprehend this subject in the best possible way. Therefore, this question should be about what skills and how the game can gain the students (P1). The questions should be asked about to what extent the relevant cognitive, affective and psychomotor skills can be gained thanks to this game (P2)	The sixth question was designed as; "What kind of skills do you think CFK Survivor provides to the students? Do you think this game upskill cognitive, affective, psychomotor skills? Explain please."
7	As the last question, it may be asked which classes, courses and subjects' educational games are suitable. Educational game sample suggestions can also be obtained with add questions (P1) They are the teachers who manage the process. Therefore, educational game suggestions should be taken from them at all levels that can be designed for the future (P2)	The seventh question was designed as: "To which grade level and subject do you think educational games are suitable? Explain by giving an example, please?"

**Q: Question*

The teachers, selected within the scope of the study, were contacted in a short span of time. The purpose, significance and content of the research were explained in detail and they were asked to review the game provided by e-mail thoroughly. Then, the semi-structured interviews were conducted with them on the determined days and hours with an appropriate video call program and their evaluations for the game were recorded. In this context, the interviews through a video call program between 09 - 16 April 2020, lasted for an average of 40-45 minutes. During the interviews, not only interrupting the teachers but also using gestures and mimics that could distract them were especially avoided. The interview questions that they could not understand were asked again and relevant explanations were made when necessary. Thanks to the interviews, it was possible to learn the opinions and evaluations of the physics teachers for CFK Survivor in a more natural and detailed way. The obtained data were transcribed and stored by using appropriate computer programs.

Data Analysis

The participant teachers' names were not used in the study, but they were given codes such as *"P1, P2, P3..."* for the order of the interview. In order to be understood more easily, the raw data obtained from the interviews were arranged according to the themes determined to include certain expressions and concepts and analyzed with content analysis. Tables were used in the presentation of the emergent codes and themes. The obtained data can be perceived differently by two different researchers (Yıldırım & Şimşek, 2018). Therefore, direct quotations may become more important. In the analysis of the collected interview data, consistency was achieved in the themes created by the consensus of two faculty members who are experts in field education. The reliability value between coders was calculated as .89 by using the formula "[Reliability = Consensus): (Agreement + Disagreement) x 100]" stated by Miles and Huberman (1994). In order to ensure coding reliability, the percentage of harmony between coders should be above .80 (Miles & Huberman, 1994).

In the abbreviations of the participants, in the sample, no distinction was made in terms of gender, age, experience or the institution of work. The codifications such as P1, P2 etc. were

added to the end of the quotations, considering only the interview order. During the interviews, the participants' statements regarding daily life as well as their professional experiences were also taken within the scope of the research. Therefore, it was aimed to increase the internal reliability of the study. As a result of the content analysis, the relevant codes and themes were presented in tables and figures via an appropriate computer package program.

FINDINGS

To present the data obtained from the study in a more detailed and clear way, this section was arranged into 7 subtitles within the framework of the interview questions.

Evaluations on Educational Games and Applying Educational Games in Physics Teaching

In line with the purpose of the study, the participants answered the question *"What do you think about educational games?"* defined educational games in different ways. For example, one participant (P5) described it as *"Educational games are the gamification of the activities such as experiments and demonstrations that can attract the attention of the students and make them learn entertainingly."* Another participant (P6) said, *"I think the educational game is a very effective teaching tool making the education process enjoyable, increasing the active participation of the students and enabling them to learn by doing and experiencing."*

According to a participant (P11) *"The gamified form of the phenomenon we call modeling in physics is called an educational game. Appealing to both eyes and ears, it is a tool that enables the students to learn by having fun.".* Another participant (P12) said *"The games making students available to learn not only visually but also through experience and have educational features are called educational games."* Another participant (P13) also made a definition as *"In a game without the teacher's expression, the activities providing the students to reach knowledge actively with their own efforts are called educational games."*.

The views and thoughts of the participants about applying educational games in Physics lessons were brought together under certain concepts and presented in Table 3.

Table 3. Participants' views on applying educational games in physics

Theme	f	Sample Sentence
Increasing active participation	13	"Educational games can stir up the students sitting in the classroom by only looking passively at the blackboard." (P10)
Increasing permanence	13	"Physics lessons consist of the subjects that need to be very closely related to each other. So, linking a topic to another or associating subtitles of a topic with each other increases the subject's persistence." (P11)
Ensuring concretization	13	"Such courses as physics, it would be very useful to concretize abstract concepts by associating them with daily life via a game. So, students can immediately understand what you try to explain rather than using thousands of words and sample questions." (P3)
Increasing motivation	12	"Students will get out of the mood as "Are we going to memorize lots of things again?" and get the hang of *"Oh, how good is this lesson, we will play a game too."* The rest is easy, whatever you give after that, they get it easily." (P7)

Decreasing memorization	9	"Physics concepts that students have difficulty in understanding and can simply be taught through gamification." (P5)
Breaking prejudices	9	"It breaks students' existing fears / prejudices and makes them willing to enter Physics lessons in a more motivated and lively mood." (P6)
Being time-consuming	7	"Educational games have many benefits, but the main disadvantage is consuming much time and requires much preparation for a little learning." (P5)
Being less effective without reinforcement	6	"After the game, reinforcing activities such as problem-solving, test or trial exam can be done. If not, the effect of educational games on teaching and permanence for complex subjects won't be high. (P12)
Not being applicable for all the subjects	3	"Of course, you cannot explain all physics subjects with games. Firstly, students should have a knowledge of history for the subject. In addition, they must have a mathematical infrastructure to perform mathematical operations on that subject." (P4)

As seen in Table 3, the participants thought that applying educational games in physics lessons could be greatly positive, such as *"Increasing active participation, Increasing permanence, Ensuring concretization, Increasing motivation, Decreasing memorization and Breaking prejudices".* On the other hand, they also expressed such concerns as *"Being time-consuming, Being less effective without reinforcement and Not being applicable for all the subjects".* In addition, all participants stated that educational games are more entertaining, participatory and instructive according to class level.

Evaluations on Applying Game-based Teaching

Within the scope of the second question of the interview, the participants were asked whether they had ever taught any subjects via educational games before. In line with the answers given, it was determined that none of the 13 teachers had applied educational games or used game-based teaching techniques. In addition, 6 participants stated that they had heard for the first time that lessons could be taught via educational games without teacher expression. Except for P6 who was continuing their doctoral studies, 12 participants stated that they had not been interested in an educational game before. On the other hand, all the participants declared that so as to make physics lessons permanent by concretizing them, making them enjoyable and increasing active participation, they had already used such tools and methods as posters, figures, graphics, slides, videos, simulations, experiments, storytelling.

Within the bounds of possibility, all 13 participants stated that they would like to design or apply an educational game one day in the future. Despite that willingness, they expressed their hesitations about designing or applying educational games as "I would like to use it, but ...". These expressions of the participants were brought together under certain concepts and presented in Table 4.

Table 4. Participants' hesitations about applying educational games

Theme	f	Sample Sentence
Intensive curriculum	11	"Physics is a very intensive lesson with a wide curriculum. Because there are too many abstract concepts and mathematical operations, we often have difficulties in finishing the subjects on time." (P5)

Insufficient lecture hours	11	"It doesn't necessarily need to be out-of-class, I would like to teach a topic or a part of it with a game that can be played in the class but, our lesson time is usually barely enough to teach the units. " (P7)"
Administration / parent / student expectation	9	"In private schools, parents and students are generally more exam-oriented as '*Firstly, we process and finish the subject, then we immediately solve all the questions of the tests or trial exams correctly'.* That's all they want, nothing more.*"* (P12)
Being time-consuming	8	"Educational games might be instructive, but we don't have the opportunity to play 50-60 minutes for a topic that we can tell in 10 mins. Instead, I do experiments, competitions and watch videos." (P5)
Being demanding	7	"Designing an educational game seems very demanding at each stage. The teacher has to devote a lot of time to this." (P13)
Being costly	3	"I feel myself qualified for preparing an educational game, but the financial situation is important. Also, keeping those after the game is another problem." (P8)

As seen in Table 4, the participants generally had hesitations about the intense curriculum of the physics course and the shortage of the lesson time allocated for the subjects. In addition, because of working in private institutions, the fact that expectations of school administrators, parents and students are more in the direction of solving questions for the university entrance exam also negatively affects their thoughts of using educational games. Moreover, when compared to the classical methods, they thought that educational games would be very time-consuming. According to them, in classical lessons the subjects could be explained in a shorter time and then reinforcement activities could also be made with extra questions or tests. Some participants also declared that because before, during and after activities, educational games could be more demanding and the procurement of the game materials might be costly. Only two participants (P6 and P10) stated that they were in the decision to design or apply an educational game without making any hesitations.

In addition, one participant (P4) implied that all the educational games cannot cover physics subjects and students also should have a sufficient level of readiness before the application as;

> "Of course, you cannot explain all physics subjects through games. First of all, the students must have a knowledge of history and mathematical background to perform mathematical operations on that subject. If not, how will you explain such topics as refractive to the students who cannot make addition and subtraction calculations?"

Evaluations on the Rules and Gameplay of CFK Survivor

Within the framework of the 3rd question of the interview, the participants were asked to evaluate how the rules and gameplay of the CFK Survivor game are. All the participants stated that the rules are clear and accurate and can be easily understood by the students. One participant (P6) said, *"I think the rules of the game are clear. How many times the referees will blow their whistles and even what the numbers of these whistles mean is explained line by line. Thus, students can easily understand the rules.*". Only one participant (P3) said *"That is to say, the rules of the game are clear and exact."* and asked, *"Will the game have a certain*

time, or will there be a period of time for the tracks to be prepared again?". Therefore, she replied by informing in detail.

Stating that the game could be easily understood and applied by students, the participants drew attention to the importance of the figures. In this regard, a participant (K10) said, *"Anyone looking at the figures could easily understand what to do in the game. In addition, short and clear sentences suitable for the level of 9th grade students are used.".*

8 participants emphasizing that the rules and gameplay of the game are clear and exact, drew attention to the fact that if these were supported with a poster, picture, video or simulation, the students could concentrate on those easier. At this point one participant (P7) said;

> "I could not understand the gameplay of CFK Survivor for the first time, but after looking at the visuals, I easily picture it for myself. However, it would be better if there were a simulation video about the gameplay. Because the students could easily imagine what they would do like watching a movie, before going down to the garden.".

In the continuation of the 3rd question of the interview, two extra questions were directed to the participants as *"Are there any parts of the game that are not generally understood or that you think will cause difficulty to the teacher and / or the students during teaching period? How do you think the game will contribute to the teaching of the subject?"* All 13 participants made evaluations regarding both explaining thermometer conversions in the classical methods and learning it via CFK Survivor. In this context, all the participants expressed their opinions on how the game would affect the teaching of the subject by giving such answers starting as *"In CFK Survivor game, the students / teachers have less / more difficulty because…."*. These expressions were brought together under certain concepts and presented in Table 5.

Table 5. Evaluations on CFK Survivor in terms of teachers/students

Concept	f	Sample Sentence
Students will get less mentally tired	13	"If you could teach the thermometer conversion units to students as a classroom lesson, they would get bored after 5-10 minutes. But thanks to this game, they will solve the problems by understanding the whole logic of transformation as if playing a game at the break." (P1)
Teachers will get more mentally tired	11	"I can't believe but if the 18 students there would be silent with the sound of the whistle would not interfere with the game, this would be perfect. The noise of the students constantly shouting and screaming with the excitement of the game would chew their ears off." (P11)
Lower-level students will have more difficulty	11	"The students might have difficulty in solving the questions in the first stage. It is important to look at the formula board, but even if an academically unsuccessful student looked, he/she wouldn't not pass the first stage and so would be eliminated." (P8)
Teachers will get more physically tired	10	"However, it could be more effective and permanent than learning in the class; designing the educational game, buying the materials, setting up the platform, managing the game, collecting

		the materials again after the game is over and finding a place to keep them would be a long and difficult process.” (P12)
Students will get more physically tired	9	“Because calculation errors, inability to overturn the bottles, late opening of the chest, incorrect placement of the wooden block on the board not only might cause students to lose time but also increase their stress levels. Moreover, following the other player and the referee could make the game challenging for them." (P13)
Teachers will have more difficulty	7	“How could the referees check not only two students playing but also 18 other students who are waiting or finished their game at the same time? How would they prevent chaos from breaking out in that noisy and cheering environment?” (P5)
Teachers will have less difficulty	6	“Two teachers will direct the game anyway. If they could maintain discipline and order in the game, they would more easily control both the players and those waiting their turn. I think it might be less tiring, because there would be two teachers.” (P2)
Students will have less difficulty	2	“In the first stage, the students could solve questions by looking at the formulas written on white cardboards and placed on the ends of the tables. This would also keep the formulas in mind and make calculations faster with the feeling of winning the game." (P3)

As can be seen in Table 5, the advantages and disadvantages of the CFK Survivor game were discussed in terms of students and teachers compared to the classroom lesson. In this context, 11 participants stated that the students with low academic achievement level or with insufficient processing skills would have more difficulty in the game. On the other hand, 2 participants stated that since there would be no level difference, they could only look at the formula cardboard and process, thus they would have less difficulty. 7 participants thought that teachers would have less difficulty in the game compared to the classroom lesson due to the presence of two teachers and the willingness of the students, while 6 participants claimed that the teachers would have more difficulty. In fact, most of the participants stated that both the teacher and the students might be physically tired as they would constantly be on the move in the game. In addition, there were 11 participants who stated that teachers would experience more mental fatigue than the classroom lesson. On the contrary, all the participants expressed that the students would experience less mental fatigue in the game compared to the classroom lesson.

In terms of the general rules and gameplay of CFK Survivor, one participant (P1) commented it positively as *“It is absolutely ideal for 9th grade students at both Science High Schools and Anatolian High Schools. It is a very exciting game that eliminates the level difference between students, therefore everyone can participate actively."* However, some admonitory comments were made regarding the structure of the game. For example, a participant (P8) emphasized the importance of post-game reinforcement as:

> “It would be perfectly instructive in terms of temperature conversion between thermometers, but only for the students at the intermediate and advanced levels. Even if you deal with this issue with a game, it would still be insufficient for the students who are unsuccessful or at lower levels and uninterested in physics lessons. For this reason, you either have to play this game a few times or assign homework with questions like in those envelopes."

Another participant (P5) expressed his criticism and suggestions for the rules of elimination as:

> "There is a rule saying, *'The player solving the questions in the envelopes at the first stage incorrectly 3 times or placing the wooden block at 4th stage incorrectly 3 times is eliminated.'* Okay, the rule is very clear, certain and logical for me. So, how will the student who has been eliminated after doing wrong, learn this subject? She/he couldn't do the questions because she/he doesn't have any knowledge about them. If that were not enough, she/he would be eliminated. First of all, this can disincline her/him from the topic or physics lesson. Secondly, if the students knew all the questions correctly and finished the stages, but the other player would pass her/him and she/he would still lose. This situation might affect her/him negatively both after the game and in her/his class life. Maybe she/he would become an object of derision. I am not talking about this game specifically, but every game with a winner and a loser creates psychological traumas in any case. In other words, the student who would be eliminated because she/he couldn't learn anything from the game or not to do it as fast as the other player, might be exposed to the teasing of his friends. Therefore, the games where there is no winner/loser but anyone can play easily or based on race against time might be more appropriate for education."

Thus, participant evaluations were taken regarding the impact of the CFK Survivor game on the teaching of the subject.

Evaluations Regarding the Game's Meeting of the Relevant Acquisition and Its Effect on the Lesson

Within the scope of the 4th question of the interview, the participants were asked to what extent the CFK Survivor game, prepared to provide unit conversions for ^{O}C, ^{O}F, ^{O}K, meets *"The students make calculations related to temperature units."* acquisition. All participants stated that the game would be suitable for the acquisition and could meet the acquisition.

Only 2 participants, (P1) and (P6) stated that the game could unaidedly meet the acquisition without any other activity as:

> "If we taught the subject in class, perhaps only a few students could respond to the written examples and most students would not even attend the lesson. But due to the nature of this game, all students will have to actively participate and solve four transformation questions. I mean CFK Survivor could strongly meet the acquisition of the subject." (P1).
>
> "We do not stay in our closed houses and go out into the open air at odd times. Therefore, the students would absolutely be more willing than a class-lesson. Since they would not have to do the conversion calculations by force. I think they would be able to gain the acquisition easily, without any necessity to anything." (P6).

The other 11 participants stated that thanks to the support to be given before and after the CFK Survivor game, it could fully meet the relevant acquisition and thus permanent learning for thermometer conversions could be realized. In this context, the suggestions of the 11 participants for both before and after the implementation of the game were associated with certain concepts and presented in Table 6.

Table 6. Suggestions on reinforcing activities for CFK Survivor

Concept	f	Sample Sentence
Solving extra questions in the class	11	"To gain the formulas in the acquisition and learn the subject very effectively, many questions should be solved in the classroom." (P3)
Giving homework as intensifier questions / tests	10	"Thanks to this game, each student will have to solve 4 questions. But the conversions learned in the game should definitely be reinforced at home with extra questions or tests". (P4)
Replaying the game	4	"Even if you dealt with this issue with a game, it would still be insufficient for the students who are unsuccessful or at lower levels or uninterested in physics. So, you either have to play this game a few times or assign homework like in the envelopes." (P8)
Announcing the game time in advance	4	"Since the playing time of each player would be 3-4 minutes, it would be very difficult for the students to improve themselves academically in this short time. Especially for lower-level students, if the time of the game was announced in advance and they prepared properly, they could not run away from the game and make conversion calculations." (P5)
Giving a project / term paper	2	"Since there might be no time left after the game, questions couldn't be solved in the classroom, therefore weekly projects or term papers should be given about conversions." (P2)
Making a quiz or oral exams	2	"The subject should be reinforced by assigning homework or similar questions like written on the envelope or wooden block. If not, the teaching would fall behind. So, reinforcement exercises ought to be done as a quiz or an oral exam." (P7)

As stated in Table 6, 11 participants, excluding the two teachers (P1 and P6) thinking that the CFK Survivor game could be enough for the acquisition without extra things, stated that some reinforcing activities should be done both before and after the game. Since the current education system is exam-based, 11 participants suggested doing reinforcement exercises as solving extra questions after the game, 10 of them as giving homework. 4 of them by replaying the game and 2 of them by giving the project homework and by doing a quiz/oral exam. They also added that the learned formulas gained in the game could be reinforced and so the acquisition could be fully understood. 4 of the participants stating that not all students are at the same level, said that by telling the game time beforehand, students with low academic achievement could prepare and thus, they could also gain the acquisition.

Supporting the statements in Table 6, a participant implied that the CFK Survivor game prepared for the relevant acquisition might also be effective and positive in terms of upper-class acquisitions as:

> "In addition, since they will process the remaining 6 weeks of the `heat and temperature` subject in the classroom, extra tests should be given to reinforce what they have learned in the game. If it were up to the student, she/he would demand playing games every week. However, according to current circumstances there is an existing curriculum and examination system in Turkey. Therefore, it is necessary to reinforce the acquisition."

P10, considering that the game would generally be sufficient in terms of meeting the acquisition suggested extra activities as *"The game is visually designed, but I think it would*

be more useful if the usage areas of thermometers in daily life could be added. For example, as 'Which thermometer measures air temperature, temperature of metals, LED lights?'.

In addition to these findings, one participant (P11) emphasized that the CFK Survivor game would not only teach the topic but also be very effective and useful for the subject and physics lesson as:

> "The game would be effective for thermometer conversions because the students could operate by just looking at the formula cardboards. In addition, it is a very simple acquisition anyway. But rather than doing those processes quickly, I think the most important advantage of the game is that it could show the student how easy and doable the thermometer and its calculations are. I am sure that even students complaining especially because they cannot do physics would say, "*Were we afraid of such an easy thing?*"

Evaluations for the Case of CFK Survivor's Implementation

Within the scope of the 5th question of the interview, all the participants stated that it would be enjoyable to learn the unit conversions for ^{0}C, ^{0}F, K via CFK Survivor, therefore the students participating actively could have more effective and permanent learning. One participant stated that CFK Survivor could increase the desire and motivation of the students and ensure their active participation, thus create permanent learning about thermometer conversions as:

> "In the game, there wouldn't be any student in front of you looking at the blackboard like looking at the smartphone. On the contrary, there would be active students completely involved in the process and could reach that information themselves. Moreover, they would also be in competition and then reach the award. As such, the game might be hundreds of times more useful than what you told for hours, all the questions you solved, even the videos you watched, the experiments you did. Because students could learn by having fun thanks to CFK Survivor. So, this could both increase their interests in physics and make them enthusiastic about other subjects. Do you eat the food you don't like? If there is no death on its end you wouldn't eat it, would you? Just like that, why would you learn the subject forcibly rather than grasping it joyfully?".

Another participant (P7) pointed out that each stage of the CFK Survivor game is exciting and it could make the subject enjoyable by saving it from boredom as:

> "Just going out of the 4 walls already brings happiness to the student. You could see this from their energy before the game begins. Bringing the Survivor, which the students admire on television, to them would of course make them excited. Therefore, they could learn word by word whatever the game would present to them by having fun and being thrilled to bits. I think this game will provide a very enjoyable lesson because it can both save the lesson from boredom and bring a different excitement to each stage.".

Another participant (P2) stated that he'd like to apply the developed CFK Survivor game in his own lessons as:

> "Rest assured that I read this game twice and every time I read it, I imagined that I could apply it to my own students. I want to implement this game if it's alright with you. If I get the chance to apply for it, I think they will definitely have fun and learn the subject easily.".

Apart from these expressions, the opinions and evaluations of 13 participants such as *"In the case of applying the CFK Survivor game for the issue of unit conversions for ^{O}C, ^{O}F, ^{O}K ..."* were associated with certain concepts and presented in Table 7.

Table 7. Participants' views on the implementation of CFK Survivor

Concept	f	Sample Sentence
It will increase active participation	13	"Even the students not raising a finger in the lesson, dozing off, waiting to leave for home would want to play this game once again. The reason is quite clear, they just want to have fun every time. I mean you would present the temperature unit conversions very complicated and detailed for them, via their favorite thing, the game. In addition, there will be active students completely involved in the process and reaching that information themselves." (P4)
It will increase the permanence level	13	"This game will be quite effective in students' permanent learning. The person learning with joy by doing, seeing, applying never forgets that information. Even when he gets older, every time he remembers this game, he could remember those transformation formulas gained in the game." (P11).
It will save the subject from boredom	13	"No student would want to stay in a closed class for 40 mins. to listen / watch if the best teacher even gave the most important information. Even we, teachers, are looking forward to taking leave off in the meetings with administrators. So, I am sure it would save these 14-15-year-old students from the boredom of the subject." (P3)
It will make students willing	13	"You not only could make the student willing but also have him do thermometer conversions enjoyably. This would enable them to learn very effectively and to participate voluntarily in future physics-related activities." (P2)
It will enable concretization	13	"Each stage requires attention and skill. This would allow students to engage in the game by always keeping their excitement above. Thinking as if they were playing both before and after the game will make them actually learn the CFK conversions joyfully. So, it would be a very comprehensive game making the subject concrete." (P10)
It will raise the perception level	12	"The students are generally happy with everything he does fondly. You would offer them to play the game on a platform similar to the Survivor game he always watches on TV. For having fun, whatever you would give them in the game with that enthusiasm, they could easily gain. Since their perceptions would be extremely open, they could actually learn without even realizing it." (P12)
It will increase the motivation level	12	"Perhaps half of the lesson time is spent motivating the students to the lesson and focus their attention. Therefore, even playing the game itself in the garden would automatically increase their concentration and motivation levels. Moreover, dreaming of playing games, they might come to lessons without a second thought." (P1)
It will increase interest and	11	"Just at the beginning of the heat and temperature subject, we teach these thermometers and conversion calculations between them.

curiosity levels towards the subject / lesson		Thanks to this game, the students might realize that they can do it by devoting themselves to the subject. Because of learning enjoyably, they will also gain self-confidence. They might also wonder about the rest of the subject. After the game ends and they return to the class, their desire and interest towards the subject will continue." (P11)
It will increase academic success	10	"Students whom we almost beg only to write the formulas in their notebook in class, might be prepared for thermometer conversions, perhaps for days to win a bottle cap. They would endeavor to make the right conversion in the fastest way, thinking as "I'll finish the stage before my friends". Is there a chance for such an eager student to fail? Even if his level is low, he could have the formulas down pat on that cardboard to win." (P13)
It will increase excitement and curiosity	10	"Every stage of CFK Survivor was designed so cleverly that the excitement and fun never decreased like the real Survivor. For example, in the first stage, you get excited to solve questions of different colors and get erasers in return. Then the excitement increases even more in the second stage as whether the player drops the right bottles and finds the key. In the third stage, you are waiting for whether he will be able to put the key in the correct box. At the last stage, you wonder whether he will be able to put the wooden block into the correct gap on the board. So, not only the players but also the audience can have fun and learn the relevant subject." (P6)
It will reduce memorization	9	"Believe me, they will know the formulas on those cartoons like their names even when this game comes to their minds even years after school is over. If they learned these in class, they would forget them the next day. But when they remember the game, of course, they will also remember the thermometer conversions." (P13)
It will break the prejudices	9	"In this game, memorizing the concepts or formulas or even being in the classroom isn't necessary. You say, *'Let's go out to the garden together, I will be silent as a referee while you are playing'*. Does a student learning a subject like this ever fear physics? Will his prejudice ever remain?" (P9)
It will give the students the opportunity to show themselves	6	"Since the students are in their adolescence period, they see life as a game consisting of only joking, laughing and having fun. They get bored very quickly and always aim to be free and pranksters. This game will offer them both the freedom and fun they want. Thanks to this game, they will show what they can do and we teachers will achieve our goal by getting the subject." (P2)
It will reduce the waste of time	6	"Thanks to this game we will not waste time telling them *'Don't talk!, Sit down!, Listen!'* during the lesson. We won't have a problem with students participating in the lesson anymore." (P7)
It will increase team spirit and a sense of responsibility	5	"The students should act in unison during the game. Because the player will play for his/her group not for himself in the game. For this reason, he/she will want to gradually succeed in the stages with a sense of responsibility. This will keep the adrenaline level high throughout the game and increase team spirit." (P3)
It will facilitate	4	"This game also covers thermometer conversions in the 12^{the} grade

information transfer on future issues	energy unit. Since the students will learn everything by doing and experiencing, they will easily remember this game and therefore the transformation formulas. This will also enable them to grasp the energy issue more easily." (P12).

All the participants stated that handling unit conversions for ^{0}C, ^{0}F, K via CFK Survivor game would be stirring and thus the students participating actively will have more effective and permanent learning. However, they drew attention to the possible disturbing situations that may occur due to presumptions like these,

- The game has the winner and loser person,
- Stages in the game require mathematical operations,
- Students have to play with each other regardless of their physical, social, academic success,
- Group leader selection is left to students,
- It is not certain whether group leaders will be competent enough to run their group,
- It is not clear how to control the students waiting their turn or their game is over,
- The duration of the stages / the game, and the setting up times of the platforms for replaying are not limited,
- The students are deeply affected positively or negatively by other students in the game,
- The students are more likely to turn the game into a competition to reach the award,
- No measures are taken for the psychological damage to those who will not be rewarded or lose the game.

After expressing that the game would be gripping and effective, one participant (P5) warned against possible negative situations that might be experienced as:

> "Of course, the winners will have fun in the game. However, the losers will necessarily conflict among themselves or with those in the other group and may even fight. After all, not everyone can tolerate losing. They fight all the time even in Survivor on TV. Let's be a little realistic here, they are 14-15 years-old teens and they will try to justify themselves in all kinds of ways. For example, in a class lesson, you can cheer the student when you make a few jokes but joking with the student who lost in the game, will cause more tension.".

In addition, the same participant (P5) drew attention to the situation of the students who do not play in the game as *"Always sitting on the sidelines, won't the 18 students waiting their turn or whose game is over get bored? How will they wait 50-60 minutes while their friends are having fun at the game, enjoying themselves?".*

Another participant (P8) pointed out that the duration of the game should be planned carefully and also made suggestions in this regard as:

> "In this game where the player replying to the questions in the fastest way gains an advantage, what will happen if both students cannot answer the questions correctly or if both think for a long time in replying to them? Then the game ends in 3 hours at the earliest. So, I think an upper time limit may be set for Stage 1. Likewise, the players finishing their game will be responsible for making the stages ready again. Maybe the losing student will not like it."

Evaluations for CFK Survivor on Cognitive, Affective and Psychomotor Skills

Within the scope of the 6th question of the interview, the participants were asked about their opinions on what skills the CFK Survivor game can provide to students. According to the evaluations of the participants, this section is organized in three sub-headings: "The Effect of CFK Survivor Game on Cognitive Skills", "The Effect of CFK Survivor Game on Affective Skills" and "The Effect of CFK Survivor Game on Psychomotor Skills".

The effects of CFK Survivor on Cognitive Skills

In the continuation of the 6th question of the interview, the participants were directed an extra question as "Do you think this game can provide cognitive skills? Please explain.". Therefore, all 13 participants answered this question elaborately. Their evaluations were associated with the concepts and presented in Figure 1.

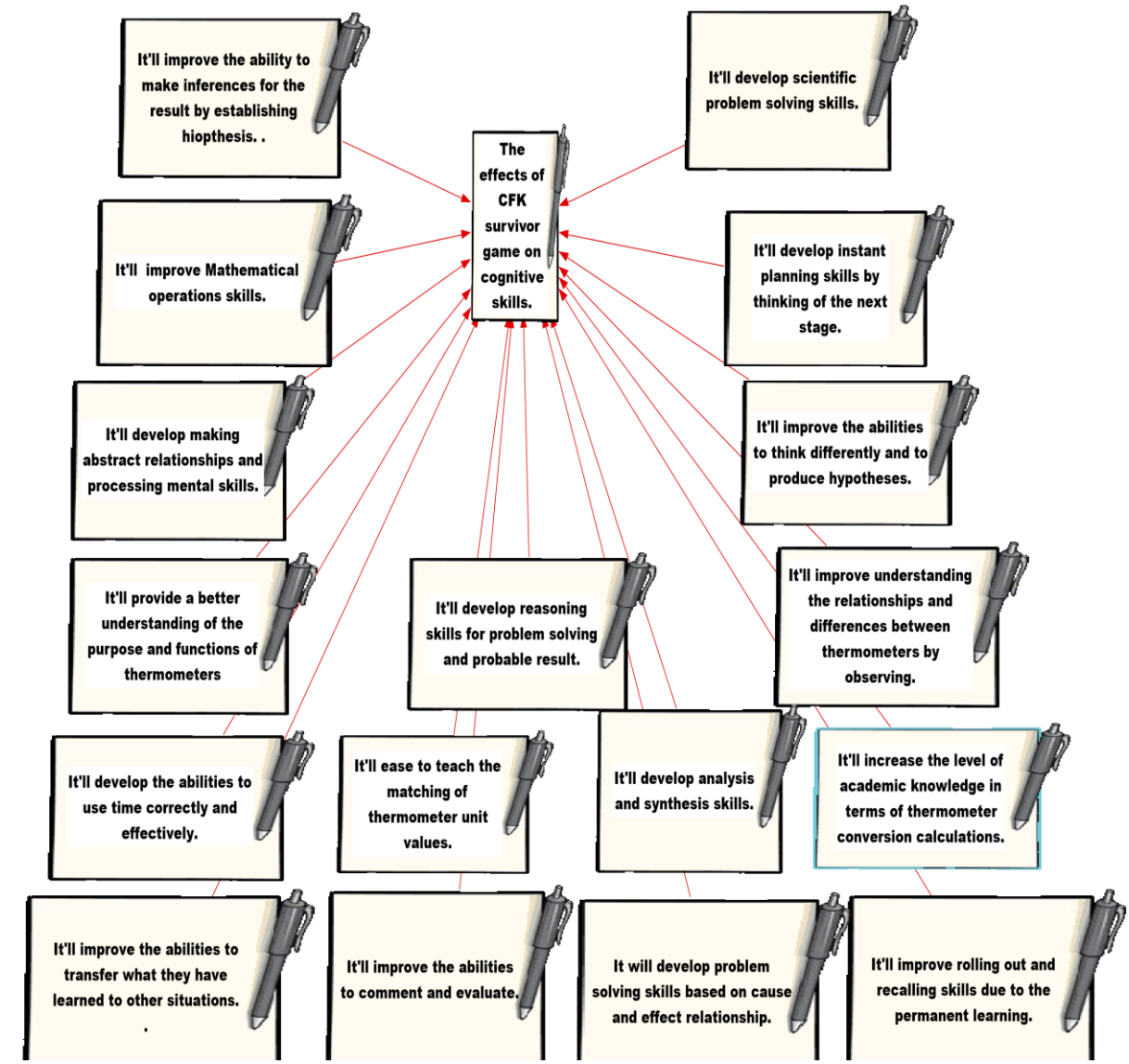


Figure 1. Evaluations for CFK Survivor on cognitive skills

In addition to the evaluations shown in Figure 1, one participant (P13) expressed his views on the cognitive skills that the CFK Survivor game could bring to the students as:

> "First of all, it will provide permanent learning and improve the students' information processing and interpretation skills. It will enable them to

> comprehend the subject and analyze the thermometer conversions. Since they will play the game themselves, they might also find the opportunity to practice on thermometers. Thanks to the activities in the first and last stages, problem-solving, decision making, inference and evaluation skills could also be developed.”.

Another participant (P10) evaluated the CFK Survivor game in terms of learning the subject as:

> “If this subject were handled in the classroom, maybe it would be taught with a few examples. Only a few of them might try to solve those, but the remaining students would count seconds for the lesson to finish without participating in the lesson. However, thanks to this game, the students will get the information themselves. Because they could learn entertainingly, more permanent learning would occur. Also, since each student would solve 4 questions, 80 questions could be solved totally. In this way, the student could learn the subject in a very comprehensive way. It might also be possible to use the prior knowledge that comes from secondary school."

P9, on the other hand, stated that the game could contribute to the multi-processing skill with her words as:

> “Thanks to this game, students could learn much about thermometers and realize that there must be a relationship between them. It is also important for mathematical computing skills. The 1^{st} and 4^{th} stages are based entirely on problem-solving skills. The students will have to follow the referee and the other player while solving questions in the stages while dropping the bottles, opening the chest and placing the wooden block on the board. Therefore, since they will have to perform more than one operation at the same time, it could also gain them many mental skills."

One participant (P1) emphasized that the game could appeal to upper-level cognitive skills as:

> “First of all, the students should be cognitively conscious of discipline and responsibility from the beginning to the end of the game. After all, it's a matter based on mathematical calculations. For this reason, this is a game that might also gain quick thinking and mental processing skills. While solving the questions in the envelopes correctly, the students could be able to analyze the relationships between Celsius, Fahrenheit and Kelvin thermometers simultaneously. In the 4^{th} stage, they will have to make a quick evaluation while placing the chosen wooden block in the right gap."

Evaluating the game in terms of permanent learning and transferability, one of the participants (P2) said:

> “Playing the game with relevant formulas is very important for mathematical process skills. The students’ learning the subject by doing and experiencing rather than getting it ready will enable them to code all the information more easily and permanently in mind. I mean when asked about CFK conversions in the future, the students will immediately think of this game, so the retrieval of the information will be faster and without loss. There is also this topic in secondary school units. Thanks to this game, they will be able to transfer what they have learned there and use them while making transactions.”

The effects of CFK Survivor on Affective Skills

In the continuation of the 6th question of the interview, the participants were asked an extra question as "Do you think this game can provide effective skills? Please explain.". All 13 participants answered this question comprehensively. Therefore, their evaluations were associated with the concepts and presented in Figure 2.

Figure 2. Evaluations for CFK Survivor on affective skills

Related to the affective skills that the CFK Survivor game could gain to the students, one participant (P9) expressed his opinions as:

> "I think our biggest problem is that the teachers are more willing and striving than students. I mean the students do not make even one percent effort to learn because they do not have the slightest willingness to learn. Since this game could awaken that desire in the student, they would voluntarily attend the class and thus, their self-confidence would be regained. Moreover, it might break their prejudices against physics lessons".

Another participant (P3) said:

> "Students have really great fears about physics. First of all, it seems like they were sitting by force in the classroom. I think the biggest benefit of the game will be that it could relieve physics lessons of boredom, break students' prejudices against physics and make them love the lesson. It might terminate their reluctance and indifference as *'I can't do it anyway!'*. Since the gameplay could increase their willingness and motivation, their perceptions and attitudes would also be affected positively. They might realize that they could be

> successful in a subject related to physics and therefore their self-confidence will also increase."

From a different viewpoint, a participant (P12) expressed his views as:

> "This game is also crucial for decision making and evaluation skills. Because the things they do or not do in the game concerns not only him/her but also his/her group. So, this could improve his/her such cognitive skills as taking responsibility, commitment to the group and team spirit. It is also a very important game in terms of sharing with friends, valuing their opinions, and criticizing."

Another participant (P10) said:

> "After finishing the game, the students' making the stages ready again is also important in terms of responsibility and team spirit. It becomes more of an issue thanks to valuing and belonging to the group, since he/she would play for his/her own group. So, this will be an extra opportunity for introverted students who want to prove themselves."

All 13 participants implied that the game would have positive features in terms of affective skills. On the other hand, one participant (P5) drew attention to the possible adverse situations that losers might experience as *"Those who are successful in physics could definitely increase their self-confidence. But, as in all the games with a winner and a loser, the loser might be subjected to psychological devastation there."*. In addition, the same participant stated that the game needs reinforcement activities in gaining effective skills as *"After all, even if the students would learn how to do thermometer conversions with 3-4 minutes of playing and solving 4 questions, they couldn't synthesize it or take it on themselves"*.

The Effects of CFK Survivor on Psychomotor Skills

In the continuation of the 6th question of the interview, the participants were directed an extra question as *"Do you think this game can provide psychomotor skills? Please explain."*. All 13 participants answered this question in depth. Their evaluations were associated with the concepts and presented in Figure 3.

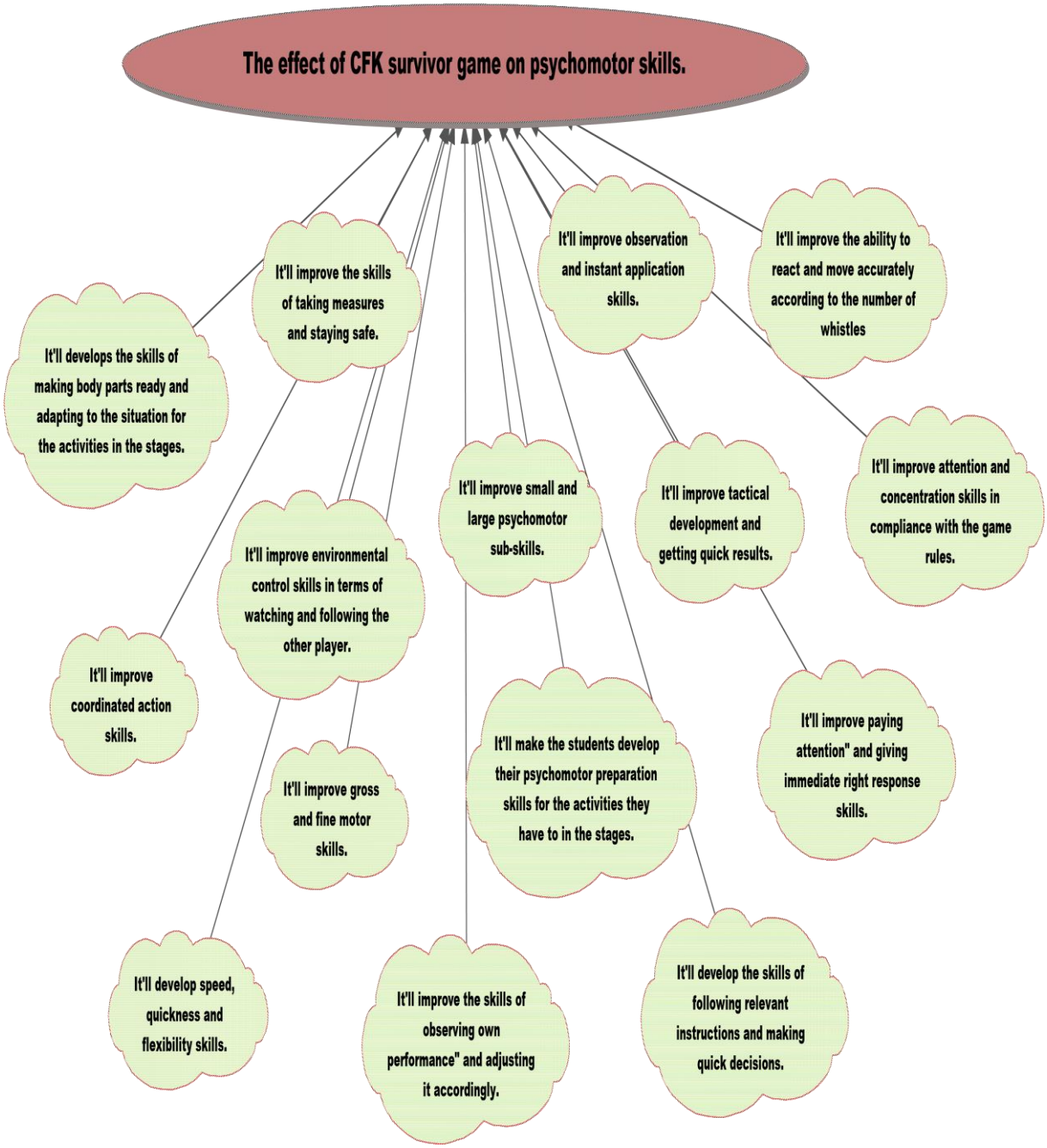


Figure 3. Evaluations for CFK Survivor on psychomotor skills

A participant (P7) expressed his views from the standpoint of psychomotor skills that the CFK Survivor game could provide students several advantages as:

> "Concentration and hand-eye coordination to pass the stages would be at the maximum level from the beginning to the end of the game. Since the students could plan their next move in advance, there would be an improvement in terms of using the time to notice and react. First of all, it would be a very important game for small and large muscle coordination. In addition, it would also be vital for their psychomotor skills for their ability to react and act quickly according to the referee's whistles.".

Another participant (P1) said:

> "In terms of psychomotor activity, as the students could play the game themselves, they would be active from start to finish. They wouldn't be passive like sitting at a desk in the classroom and looking at the blackboard passively. It would be effective for hand, arm, leg muscles and the harmony between them. I think speed and quickness would be the key points in this game to finish the stages first. There would also be many points that require attention, such as not pressing the line lines, tilting the bottle of your own color, acting on the referee's whistles. Through those several psychomotor skills could be gained effectively.".

One of the participants (P2) also expressed his views as:

> "Game basically means movement. In other words, the students would actively pass from this table to that table during the game. Therefore, many psycho-motor skills, especially hand-arm-leg coordination, could be gained. It would also be important in terms of hand-eye coordination, as the students will have to follow the other player constantly. In addition, they should both give instant responses to the whistles and according to it, they would either go to the other table or do the same task again. This would speed up their perceptions and make their bodies ready to do that job. Not only gaining self-control according to the rules and the order of play but also instant action skills could be listed as the other advantages of this game.".

Another participant (P4) said:

> "This is a game that requires students' hand-arm-leg coordination, rapid movement and instant reaction. Perhaps those who would play later, could make a new tactic for themselves by imitating their friends. This might also improve their analysis and interpretation skills. I think CFK Survivor is a game that could gain high-level skills by evaluating the situation especially when they lose.".

Suggestions for Designing an Educational Game for Physics Lesson

As part of the 7th question of the interview, the participants were directed an extra question as "*If you had to design an educational game for the physics lesson, what kind of game would you design? Can you explain."*. In this context, all the participants agreed that physics lessons have many suitable topics for educational games. In addition, one participant (P13) emphasized that physics subjects could be concretized thanks to educational games as:

> "No matter how much you explain, there are some subjects that cannot be fully coded in mind in physics. I think it would be more logical to design an educational game related to these. For example, even if the students understand such concepts as *'Pressure, Heat, Temperature, Force, Work, Energy, Power, Electrostatics'* they cannot concretize them. Unfortunately, they have to memorize formal information or formulas. So, a few days later or when they pass the exam, they cannot remember them again like the '*Power'* subject. When people are asked what power is, they firstly think of force. According to physics, the man doing a job in a shorter time is more powerful. Suppose that I painted on the chalkboard two men, one big and the other small and started running on a 100 metered road with the same weight sack on their backs. Assume that the big one ran for 3 minutes and the other one for 2 minutes. Then when asked *'Which one is strong?'*, perhaps the whole class would say

the big one. But physically, the man who did the same job in 2 minutes is powerful. The inability of students to envisage physics concepts causes such difficulties. So, we can teach these abstract concepts thanks to the relevant educational games.".

All of the participants expressed their opinions on the subjects that educational games could be designed for. Convenient subject suggestions for them were brought together within the framework of certain concepts and presented in Figure 4.

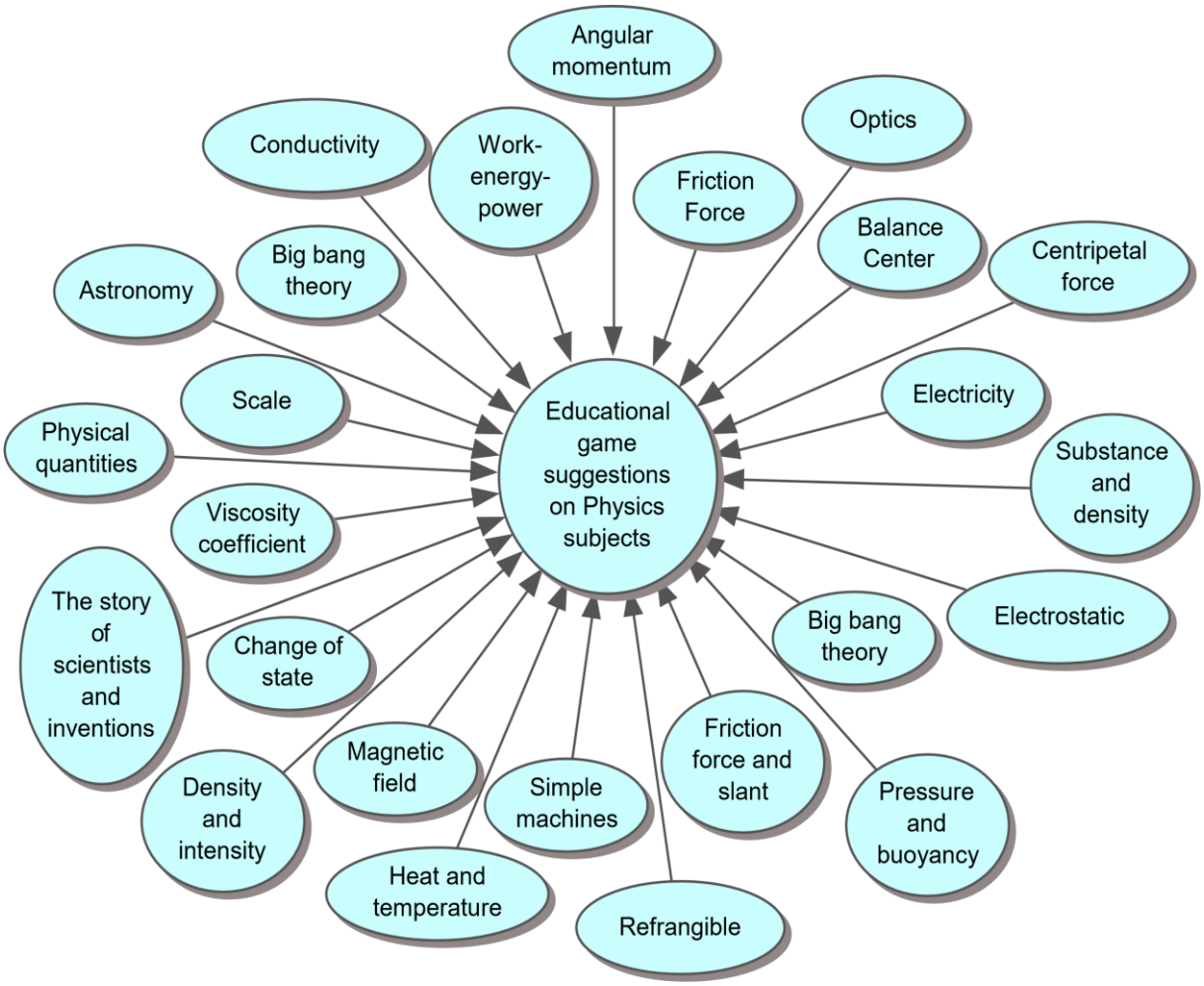


Figure 4. Educational game suggestions on physics subjects

As in Figure 4, Physics is a very rich lesson in terms of educational games. In this context, all participants, asked for an idea for an educational game, made at least 1 suggestion. Therefore, the educational game suggestions of the participants were brought together in the light of certain concepts and presented in Table 8.

Table 8. Educational game suggestions on physics subjects

Subject	f	Suggestion for Educational Game
Optics	4	"You can teach the refraction of light in optics via a game. Different colored but same sized balls will be given to the students and allowed to line up like a circle in the way they want. Then one student with a mirror comes into the midst of them. Each player will turn towards the ball and whoever has the

		bigger ball in the mirror wins the game. The logic here is that the image of the light changes when it passes from a highly refractive environment to a less refractive environment or from a less refractive environment to a more refractive environment. So, they can understand that if the light comes perpendicular to the surface, it is unbreakable." (P11)
Balance Center	3	"You may take the students to the park or, if you can, set up a seesaw in the garden. You form two groups and tell them who first touches the ground loses. Let them determine the first players to get on. Then the second and third students get on the seesaw before the others get off. Thus, they can learn by experiencing how the center of balance changes when there are 2 students, 4 students and 6 students on the seesaw successively." (P10)
Electricity	3	"A multimeter is brought to the classroom, and its positive end is connected to a copper plate while the negative end to a zinc plate. Line up the students and let the student in his turn, put one hand on the zinc plate and the other on the copper plate. Therefore, each student's volt values are measured and recorded. So, the one with the highest value wins the electrical current game." (P9)
Electrostatic	3	"Everybody is given papers representing 1, 5 and 10 banknotes. Each player gets enough money to match their own weight. Then the teacher puts on music and the players start dancing. When the music ends, as in the game "Musical Chairs", everyone sits on a chair. All the players exchange their banknotes according to the weight of the right-side player. The standing player is eliminated as he cannot exchange. It continues till two players and one chair remain. Those whose banknotes are more wins the game." (P11)
Friction Force	3	"The students put three stones on top of the different frictional floors and try to drop them with a ball. The same student always throws the ball at the same speed and you successively measure them. Because the surface is different due to the friction force, the distance taken changes. Thus, they can learn what the friction force is and how it affects the subjects." (P1)
Angular momentum	2	"Two students with "a ribbon in their hands" sit on the chairs. I want them to turn first in the same direction then in the opposite direction. I draw attention to the movements on the ribbon according to the rotational speed of the students holding the ribbon. So, they make calculations with simple operations for the angular momentum formula I wrote on the board before." (P2)
Physical quantities	2	"As in the "Super Mario" game, different materials in daily life are put in front of the player wanting to reach gold. To overcome these obstacles, two boxes named scalar and vectorial are placed on both sides of the screen. In the game that gets faster and faster, the players seeing the obstacle momentarily are expected to press the right or left box. Thus, the students will learn both scalar and vectorial classification and have the skills of making quick decisions, attention and operations." (P4)

Conductivity	2	“Students will be given different items to understand the rate of distribution in the conductor. The students hit the tables to understand the relationship between the intensity of the sound produced and the conductivity levels. In this way, they can concentrate on the relationship between them”. (P8)
Work-energy-power	2	“Form three groups among the students. One handball, football and basketball ball are placed at the starting level for each group. After point A is determined, then point B is determined 100 meters ahead. Boxes are placed at both points in sizes that these balls will put in. The first students of the groups take the handball balls from point A with the teacher's whistle and take the soccer ball out of the box at point B after throwing the handball ball into the box. The student who takes the soccer ball starts running to point A without waiting for the handball ball to settle in the box. The student reaching point A takes out the basketball after putting the soccer ball in the box. Then the third student picks up the basketball and starts running to point B. As soon as she/he puts the ball in the box, the game is over. Thanks to this game designed for the formula of "Work / Time = Power", they could learn the concept of power and which group is powerful." (P13)
Density and intensity	2	“Items for every student such as raw eggs, scrambled eggs, ping-pong balls with different density, such as the "Soaking test" related to density and intensity will be put on a desk. Then they will be immersed in liquids of different densities such as water and sunflower oil. Therefore, by asking the question ‘*Which student's belongings float better?*’, such a game can be designed for the relation between density and intensity." (P2)
Big bang theory	1	“In the teaching of Big bang theory, a game can be designed with balloons. For example, each student marks two points with a pencil before inflating his balloon. Then, the students blowing the balloon at different speeds see these two points starts diverging. Thanks to the connection of this speed with the speed of the stars in the galaxy diverging from each other, a very nice game can be designed and the subject can be concretized.” (P7)
Astronomy	1	“For example, for astronomy, several rings in the form of circular rings are drawn on the ground. A student takes a flashlight in his hand to symbolize the sun. Other students, symbolizing the planets, begin to move around the sun and around their own axes without leaving that ring, that is, their orbit. Among the players who wanted to turn faster, the one who left the ring was eliminated. The last remaining player wins the orbit game." (P3)
Scale	1	“To find a scale, two students hold a string or ribbon by the ends. Then you draw two lines parallel to each other on the ground, and the students start walking on that line. As the rope becomes loose or stretched as they walk, students could find the scale.” (P7)
Viscosity coefficient	1	“Open topwater pipes are brought to the classroom to gamify the viscosity coefficient. The students are given five beans each and

	asked to place them to slow the flow of water as they wish. Then an equal amount of water is released into the pipe at the same time. Whichever student's pipe drips on the table last, she/he wins the game. So, after supporting them with formulas to make transactions, they can learn the logic of the viscosity coefficient." (P11)

As seen in Table 8, the participants made educational game suggestions for such physics subjects as *"Optics, Balance Center, Electricity, Electrostatic, Friction Force, Angular momentum, Physical quantities, Conductivity, Work-energy-power, Density and intensity, Big bang theory, Astronomy, Scale and Viscosity coefficient".*

In the continuation of the 7th question of the interview, the participants were posed a question as *"What do you think about making this educational game you designed, available to other teachers?"*. All 13 participants stated that they would get support from group teachers before, during and after the game. They also stated that they would make their original game available for other Physics teachers, therefore all students in the same branches could benefit from it. A participant (P13) expressed his views on this subject as:

> "If I could develop a game, I would like my colleagues to use it. After all, this is not a state secret. Moreover, there may be something I cannot see, so I would immediately consult them first. After the game, I would also get their evaluations and comments."

Another participant (P12) said:

> "If I were to prepare an educational game, I would discuss it in detail with my physicist friends before the game. I would invite them to watch the game when available. In addition, I would make all 9th grade students in all branches of our school play this game. At the end of the game, we would also evaluate it all together. Therefore, I think that there should always be qualified communication and cooperation among teachers in the educational process not only for educational games but also for everything."

One of the participants (P10) expressed his views as:

> "If I designed such an educational game as a physicist, I would apply it to all classes I lecture anyway. I would want my other physicist friends to do it and even encourage them. I would do this cooperatively by taking their opinion. Therefore, for many eyes would evaluate it, possible mistakes could quickly be prevented in terms of skills and acquisition in the field. After the game, with colleagues, we could discuss and evaluate the game as *'How did it happen? What was missing? How can we do it better? What else can we design an educational game?'.* Since the students would play the game, I think they should make better and more effective evaluations. So, I would take their opinions because they must be regarded meticulously.".

Thus, the participants' evaluations and suggestions for educational games that can be designed on Physics subjects were received. In addition, during the educational game process, their opinions about the pre-game, during and after the game were determined in effective communication and cooperation with colleagues and students.

DISCUSSION, CONCLUSION AND SUGGESTIONS

It was decided to design an educational game for *"The students make calculations related to the temperature units."* acquisition within the scope of the 9th grade Physics lesson *"Heat and Temperature"* unit. Therefore, the "CFK Survivor" game, aiming to learn the temperature unit conversion calculations of the Celsius, Fahrenheit and Kelvin thermometer types, was developed under the acquisition explanation as *"Unit conversions for ^{O}C, ^{O}F, K are provided to be done".* During the development of the game stages, CFK Survivor's being able to gain targeted behaviors, being suitable for the age and level of the students, being easy to understand and applicable, not time-consuming in terms of playing the stages and making them ready again and allowing students to learn by participating with interest and enthusiasm were minutely regarded.

Due to the Covid-19 epidemic the schools were closed, so it was not possible to implement this game. Then, 13 physics teachers working in private educational institutions and attending 9th grade classes online were consulted to determine the effects of the CFK Survivor game on unit conversions for ^{O}C, ^{O}F, K.

Describing educational games in their own words, the participants stressed that the use of educational games in physics lessons would be greatly positive, such as *"increasing active participation, increasing permanence, providing concretization, increasing motivation, making lessons enjoyable, reducing memorization and breaking prejudices".* Educational games can establish a strong link between practice and learning by transforming abstract concepts and information into concrete experiences (Varışoğlu, Şeref, Gedik & Yılmaz, 2013). On the other hand, they also expressed their hesitations on educational games such as *"being time-consuming, having little effect without reinforcement and not being applicable for all subjects".* Since educational games may not be suitable for all subjects and learning styles, the level of the knowledge of all participants cannot be evaluated precisely and they also require more time. (Pehlivan, 2014) Their views stand with these statements.

All 13 teachers pointed out that they had not used educational games or teaching techniques with games by then but would like to use them if possible. Despite their willingness, they expressed their concerns about designing or using educational games as *"intensive curriculum, insufficient course hours, expectations of administration / parents / students, being quite a time consuming, being required too much effort, being costly".*

All 13 participants emphasized that the CFK Survivor game was easily understood thanks to not only supporting the rules and gameplay with visuals but also presenting them item by item. In addition, evaluating the game in terms of teachers and students, the participants expressed their views as "*Students will get less mentally tired, Teachers will get more mentally tired, Lower-level students will have more difficulty, Teachers will get more physically tired, Students will get more physically tired, Teachers will have more difficulty, Teachers will have less difficulty, Students will have less difficulty".*

The whole participants said that the game would be suitable for the relevant acquisition and could meet it. In this context, 2 participants stated that the game would meet the gain alone without the need for any other activity. On the other hand, 11 participants emphasized that before or after the game, some reinforcing activities should be done as "*Solving extra questions in the class, Giving homework as intensifier questions / tests, Replaying the game, Giving time to prepare students by announcing the game time in advance, Giving a project / term paper, Making a quiz or oral exams".*

For such reasons as "*"It will increase active participation, It will increase permanence level, It will save the subject from boredom, It will make students willing, It will enable concretization, It will raise the perception level, It will increase the motivation level, It will increase interest and curiosity levels towards the subject / lesson, It will increase academic success, It will increase excitement and curiosity, It will reduce memorization, It will break the prejudices, It will give the students the opportunity to Show themselves, It will reduce the waste of time, It will increase team spirit and sense of responsibility, It will facilitate information transfer on future issues"*, 11 participants stated that teaching unit conversions for ^{O}C, ^{O}F, ^{O}K via CFK Survivor educational game would be more enjoyable therefore, the students participating actively, could have more effective and permanent learning. Educational games can establish a strong link between practice and learning by transforming abstract concepts and information into concrete experiences (Varışoğlu, Şeref, Gedik & Yılmaz, 2013). Because educational games provide the opportunity to learn by doing and experiencing actively in real-like environments also ensure social interaction with their own rules (Gee, 2014). The students, whose communication and interaction with each other increase, may also show positive behaviors in obeying the rules thanks to educational games (Yıldız, Şimşek, & Araz, 2016). Active participation in the learning process is the main factor in educational games. The students learning by doing and experiencing can thus gain effective and permanent learning. The evaluations of the participants are in line with these statements in the literature.

On the other hand, the participants drew attention to possible disturbing situations that may arise as *"having winners and losers; stages' requiring mathematical operations; students' playing with each other without paying attention to their physical, social, academic achievement; leaving students to select group leader; group leaders' being skillful or unskillful to manage their groups; controlling of the students waiting for their turn or finishing it; not foreseeing playing time of the stages, the whole game and preparation time of the platforms for replay; players' being positively or negatively affected by other students during the game; the possibility of the students turning the game into a competition to reach the award; the psychological devastation that those who cannot get a reward or who lose it can suffer mentally."*. Because some educational games are competition-based, gaining awards or winning feelings may be predominating. These cases may lead to negative situations such as disappointment, aggression and loss of control for the losers (Canbay, 2012). Participants' hesitations about possible negative situations that may arise in the implementation of the game support these statements.

All participants draw attention that the CFK Survivor game would be effective in terms of gaining a large number of cognitive, affective and psychomotor skills expressed in Figures 1, 2 and 3. Thanks to educational games, many skills such as learning, sharing, helping each other, cooperation, decision making, ranking, organizing, respecting the rights of others are unwittingly learned and adopted (Çoban & Nacar, 2006). By virtue of the active participation of the students, high-level skills such as quick thinking, strategic thinking, ratiocination, rapid decision-making, taking responsibility and problem solving can be gained through educational games (Gürcan, Özhan & Uslu, 2008). As stated in the figures, the evaluations of the participants on the cognitive, affective and psychomotor skills to be acquired by the students through the CFK Survivor game jibe with these statements in the literature. All participants also stated that this game would positively affect the teaching of the subject and increase academic success level. The findings of Karamustafaoğlu and Kaya (2013) and Boz

(2018) that learning through educational games increase academic success is in the same direction with these statements.

The fact that the games are interesting is very important in gaining and developing the intended knowledge, skills, behaviors and values. Thus, educational games make it possible to learn the subject in a more interesting and enjoyable way in the learning environments where students can have a good time (Yıldız, Şimşek & Araz, 2016). The student moving more comfortably and independently in the game reflects her/his inner world more realistically while playing. Educational games are important for many acquisitions as strategic thinking, tactical development, planning, discussion, numerical processing, data processing (Kirriemur & McFarlane, 2004). In addition, educational games are effective in providing such skills as comprehension, thinking and acting together, making decisions, respecting the rights of others, being honest and obeying the rules (Hazar & Altun, 2018). The opinions and evaluations of the participants about educational games match up with these statements in the literature.

According to them, thanks to the reinforcement of the rules and gameplay of the CFK Survivor game with figures, the students and teachers might have fewer difficulties. In addition, if the game could be supported with the relevant posters, pictures, videos or simulations, the subject would be more easily concentrated by the students. Giving preparing time to the students by telling the game time in advance would also be crucial for meeting the acquisition. Based on the obtained data, processing the subject of unit conversions for ^{0}C, ^{0}F, ^{0}K via CFK Survivor could

- increase the active participation,
- make the students eager,
- increase their perception levels by concretizing the concepts,
- increase their motivation and attention levels to the lesson,
- increase their excitement and curiosity about the subject/lesson,
- decrease memorization,
- provide the students with the opportunity to show themselves,
- increase team spirit and sense of responsibility,
- facilitate the transfer of knowledge for further subjects.

In this context, it is expected that the prejudices of the students whose willingness and motivation levels might increase by means of concentrating the subject, against physics and its other subjects would be terminated. Because the students can focus their attention on that subject, they become willing to learn by switching from passive to active (Hazar, 1996).

Therefore, both their problem-solving skills could be improved, and their academic success would increase. The students involved in learning and developing positive attitudes, become more inquiring thanks to their more selective receptors and increased motivation (Kıldan, 2001).

In addition, their ability to obey the rules and express themselves would improve thanks to many skills such as commitment, team spirit, respecting others, being open to criticism, and taking responsibility. Specific learning goals can be achieved through educational games dragging students as if they were having a genuine experience (De Freitas, 2006).

They could also gain several positive acquisitions such as hand-eye coordination, speed and quickness, flexibility, rapid decision making and responsiveness, fast processing, fine and coarse muscle development, and coordinated movement skills. In addition to such psychomotor characteristics as strength, endurance, quickness, dynamism, flexibility, several mental skills such as keeping in memory, matching, classification can be acquired through educational games (Aral, Gürsay & Köksal, 2000).

It was stated that the CFK Survivor game would be sufficient for the intended acquisition, and thanks to the acquisition of many cognitive, affective and psychomotor skills, the students could gain enjoyable and permanent learning. Cognitive behaviors as knowledge and skills aimed in the courses taught at schools within the scope of the curriculum psychomotor behaviors as coordination and affective behaviors as attitudes, interests, values can be acquired (Gündüz, 1998). These statements in the literature tally with the evaluations of the participants.

The students involved in learning and developing positive attitudes, become more inquiring thanks to their more selective receptors and increased motivation (Kıldan, 2001). In other words, since they can focus their attention on that subject, they become willing to learn by switching from passive to active (Hazar, 1996). Specific learning goals can be achieved through educational games dragging students as if they were having a genuine experience (De Freitas, 2006). In addition to such psychomotor characteristics as strength, endurance, quickness, dynamism, flexibility, several mental skills such as keeping in memory, matching, classification can be acquired through educational games (Aral, Gürsay & Köksal, 2000). Cognitive behaviors as knowledge and skills aimed in the courses taught at schools within the scope of the curriculum psychomotor behaviors as coordination and affective behaviors as attitudes, interests, values can be acquired (Gündüz, 1998). These statements in the literature tally with the evaluations of the participants on the acquisition of many cognitive, affective and psychomotor skills and such other factors, emphasized above, as academic success.

Suggestions Based on Research Findings

- Educational games should be planned in a detailed way to be suitable for the purpose of teaching and to be flexible enough to the changes according to the necessities.
- In order to avoid confusion, the educational games' layout should be established by providing such factors as the selection of the playground and its arrangement; the preparations of the platforms; the provision and preparation of the materials and tools.
- The rules / gameplay of the educational games should be clear and the roles of the players / leaders should be explained in detail.
- To distinguish the groups, different colored jersey sort t-shirts signs can be used.
- Educational games should be backed up with visual and audio materials for concentrating easily.
- Various measurement tools for evaluating the teaching via educational game applications should be developed.
- School administrators, teachers and students should be in effective cooperation and communication in the educational game process.
- Such activities as interviews, debates, symposiums, and essay writing should be held to increase the impact and permanence of the educational games.
- In terms of such factors such as heat, light, sufficient space, tools and materials, the schools, classes, school gardens and other places should be designed for educational games and other physical activities.

- Physics curriculum should be revised in view of the methods and the duration for the subjects.
- The physics textbooks should be revised and more activities such as educational games should be added.
- The necessary developments and arrangements should be made in the physics curriculum and textbooks prepared under this program, to support the teaching activities via educational games.

Suggestions for Further Researches

- New educational games can be developed on other physics subjects where students have difficulty in participating, motivating, or understanding.
- New educational games can be developed for the relevant 10th, 11th and 12th grade physics subjects.
- A more comprehensive study can be done with experimental and control groups on educational games.
- New longitudinal research can be done for educational games on appropriate topics.

REFERENCES

Aksoy, N. C. & Kaleli Yılmaz, G. (2011). The influence on the attitudes towards Mathematics of the 6th students of game supported instruction in fractions unit. *Bayburt University Journal of Education Faculty, 6*(1/2), 105-117.

Altun, M. (2013). *A study over the problem-solving ability of 11-12 years old children regularly playing educational games.* MA Thesis. Gazi University, Educational Science Institute, Ankara. Retrieved on 24 May 2020 from https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp/ (Dis. No: 349040)

Aral, N., Gürsay, F. & Köksal, A. (2000). *Okul öncesi eğitiminde oyun.* İstanbul: Ya-Pa Publishing.

Ayan, S. & Memiş, U. A. (2012). A research related to the importance of play in early childhood. *Selçuk University Journal of Physical Education and Sport Science, 14*(2), 143–149.

Aydın, G. & Balım, A. G. (2005). An interdisciplinary application based on constructivist approach: Teaching of energy topics. *Ankara University Journal of Faculty of Educational Sciences, 2*, 145-166.

Aymen Peker, E. (2018). *Evaluation of teaching the unit of Let's travel and learn about the living world' for 5th grades with classic educational games and educational games supported with technology.* Ph.D. Thesis. Ondokuz Mayıs University, Graduate School of Educational Sciences, Samsun. Retrieved on 14 May 2020 from https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp/ (Dis. No: 492301)

Ayvacı H.Ş. & Durmuş, A. (2016). Effect of laboratory activities based on "predict-observe-explain (POE)" method on pre-service science teachers' academic achievement on "heat and temperature" subject. *Pamukkale University Journal of Education, 39*, 101-118.

Bayat, S., Kılıçaslan, H. & Şentürk, Ş. (2014). Analysing the effects of educational games in Science and Technology course on seventh grade students' academic achievements. *Abant İzzet Baysal University, Journal of Education Faculty, 14*(2), 204–216.

Bayrak, B. & Erden, A. (2007). The evaluation of science curriculum. *Kastamonu Education Journal, 15*(1), 137-154.

Boz, İ. (2018). The effect of teaching by game to academic success in primary school 4th class Mathematics. *International Journal of Textbooks and Education Materials, 1*(1), 27-45.

Can, S., & Yıldırım, M. (2017). "Deal or no deal": Should science lesson be taught with instructional games? *Atatürk University Journal of Kazım Karabekir Education Faculty, 37*, 12-25.

Canbay, İ. (2012). *Analysing the effects of educational games in mathematics on 7th grade students? Self-regulatory strategies, motivational beliefs and academic achievements.* MA Thesis, Marmara University, Educational Science Institute, İstanbul. Retrieved on 29 March 2020 from https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp (Dis. No: 320420)

Coşkun, H., Akarsu, B. & Kariper, İ. A. (2012). The effectiveness of educational games based on science stories on students' academic achievements in science and technology classroom. *Journal of Kırşehir Education Faculty, 13*(1), 93-109.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*. New York: Sage.

Çoban, B. & Nacar, E. (2006). *Okul öncesi eğitimde eğitsel oyunlar*. Ankara: Nobel Publishing Distribution.

De Freitas, S. (2006). Learning in immersive worlds: A review of game-based learning, *JISC E-Learning Programme*, 3, 73. Retrieved 15 May 2020 from https://researchrepository.murdoch.edu.au/id/eprint/35774/1/gamingreport_v3.pdf

Dönmez N. B. (1999). *Oyun kitabı*. İstanbul: Esin Publishing.

Erçetin, Ş. (2007). *KPSS eğitim bilimleri*. Ankara: Arın Publishing.

Erdemir, N. (2009). Determining students' attitude towards physics through problem-solving strategy. *Asia-Pacific Forum on Science Learning and Teaching, 10*(2), 1-19.

Gee, J. P. (2014), *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan.

Gençer, S., & Karamustafaoğlu, O. (2014). The views of students regarding teaching of "static electricity" with educational games. *Journal of Inquiry Based Activities (JIBA), 4*(2), 72-87

Gülsoy, T. (2013). *The impact of educational games on development of 6th grade students vocabulary.* MS Thesis Niğde University Graduate School of Educational Sciences, Niğde. Retrieved 11 May 2020 from https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp (Dis. No: 345620)

Gündüz, N. (1998). *Beden eğitiminde öğrencilerin değerlendirilmesi. Orta öğretim kurumlarında beden eğitimi ve sorunları*. Ankara: Turkish Education Association Publications.

Gürcan, A., Özhan, S. & Uslu, R. (2008). *Digital games and their effects on children.* Prime Ministry General Directorate of Family and Social Research, 1-50, Ankara.

Hazar, Z. & Altun, M. (2018). Investigation of teacher opinions and competencies for educational games. *Journal Physics Education Sport Science, 13*(1), 52-72.

Hazar, M. (1996). *Beden eğitimi ve sporda oyunla eğitim*. Ankara: Tubitay Limited.

Jara-Guerrero, S. (1993). Misconceptions on heat and temperature. *In Proceedings of the 3rd International Seminar on Misconceptions and Educational Strategies in Science and Mathematics, Misconceptions Trust*, Edited by Novak, J. Ithaca, NY: Cornell University.

Jones, M. G., Carter, G. & Rua, M. J. (2000). Exploring the development of conceptual change ecologies: communities of concepts related to convection and heat. *Journal of Research in Science Teaching*, 37, 139–159.

Karaağaçlı, M. (2011). *Öğretimde kuramlar ve yaklaşımlar*. Ankara: Sage Publishing.

Karamustafaoğlu, O. & Kaya, M. (2013). Teaching the subject of 'Reflection and Mirrors' with educational games: A case of reflective race. *Journal of Inquiry Based Activities (JIBA), 3*(2), 41-49.

Kaytez, N. & Durualp, E. (2014). An overview of postgraduate theses within the field of play at early childhood education in Turkey. *International Journal of Turkish Education Sciences, 2*(2), 110-122.

Kefeli, N., Taş, E., & Yalçın, M. (2018). The effect of teaching science with word games on the attitudes of students towards environment. *International e-Journal of Educational Studies, 2*(3), 44-52.

Kıldan, O. (2001). *The influence of games on children`s growth*. MS Thesis. Selçuk University, Graduate School of Health Sciences, Konya. Retrieved on 19 March 2020 from https://tez.yok.gov.tr/UlusalTezMerkezi/tez SorguSonucYeni.jsp (Dis. No: 110600)

Kirriemuir, J. & McFarlane, A. (2004). Literature review in games and learning (Future lab Series, Report 8). Bristol, UK: Future lab. Retrieved on 8 May 2020 from https://telearn.archives-ouvertes.fr/hal-00190453/

Maskan, A, K. & Maskan, M, H. (2007). The investigation of the 4th grade primary school science and technology textbook by the evaluative criteria. *Dicle University Journal of Ziya Gökalp Education Faculty. 9*, 22–32.

Miles, M, B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded Sourcebook* (2nd ed). Sage Publications, Inc.

Örnek, F., Robinson, W. R., & Haugan, M. P. (2008). What makes physics difficult? *International Journal of Environmental and Science Education, 3*(1), 30-34.

Özer, A., Gürkan, A. C. & Ramazanoğlu, M. O. (2006). Effects of games on development of children. *Eastern Anatolia Region Studies, 4*(3), 54-57.

Özmen, H. & Karamustafaoğlu, O. (Ed.) (2019). *Eğitimde araştırma yöntemleri*. Ankara: PegemA Publications.

Özyürek, A. & Çavuş, Z. S. (2016). Examination of the status of primary school teachers whether or not they use game-based teaching techniques. *Kastamonu Education Journal, 24*(5), 2157-2166.

Patton, M. Q. (2015). *Qualitative evaluation and research methods: Integrating theory and practice.* 4th ed., Sage Publications, Inc.

Pehlivan, H. (2014). *Oyun ve Öğrenme.* 4th ed. Ankara: Anı Publishing.

Rubin, A. & Babbie, E. R. (2016). *Empowerment series: Research methods for social work.* Boston: Cengage Learning.

Saracho, O. N. (2001). Exploring your children's literacy development through play. *Early Child Development and Care, 167*, 103-114.

Sarı, S. (2007). The investigation of intolerance of uncertainty, beliefs about worry and locus of control as predictors of trait anxiety. MA Thesis, Hacettepe University, Educational Science Institute, Ankara. Retrieved on 2 May 2020 from https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp (Dis. No: 221598)

Titchen, A. & Hobson, D. (2005). Phenomenology. (Ed. B. Somekh, C. Lewin). *Research methods in the social sciences*. England: Sage Publications.

Varışoğlu, B., Şeref, İ., Gedik, M. & Yılmaz, İ. (2013). Attitude scale for educational games that played in Turkish lesson: Study of validity and reliability. *Adıyaman University Journal of Social Sciences, 6(*11), 1059–1081.

Yeo, S. & Zadnik, M. (2001). Introductory thermal concept evaluation: assessing students' understanding. *The Physics Teacher*, 39, 495–504.

Yıldırım, A. & Şimşek, H. (2018). *Sosyal bilimlerde nitel araştırma yöntemleri*. 11th ed., Ankara: Seçkin Publishing.

Yıldız, E., Şimşek, Ü., & Araz, H. (2016). The effect of the educational game method on academic achievement and motivation towards science learning in teaching of circulatory system. *Mustafa Kemal University Journal of Graduate School of Social Sciences, 13*(36), 20-32.

Yükseltürk, E. & Altıok, S. (2016). Investigation of pre-service information technology teachers' game projects prepared with Scratch. *SDU International Journal of Educational Studies, 3*(1), 59-66.

ANNEX 1. CFK SURVIVOR

Table A. General information on CFK Survivor educational game

Grade	Unit	Subject	Acquisition	Playing Area	Game Type	Number of Players	Playing Time
9	Heat and Temperature	Celsius, Fahrenheit and Kelvin Conversions	F.9.5.1.3. Makes calculations about temperature units.	Playground (indoor sports hall in overcast days)	Group	20	2 lesson hours (80 mins.)

Table B. Materials required for CFK Survivor educational game.

Piece	Material	Piece	Material
60	Fastener	1	Teacher table
20	Wooden rectangular block	1	Board (60x120 cm in size)
14	Student desk	1	Ruler (100 cm long)
20	Wooden lath (each 60 cm long)	1	Red colored water glass
10	0.5 l water bottle cap (Red)	1	Blue colored water glass
10	0.5 l water bottle cap (Blue)	1	Red colored handkerchief
6	Oversized student eraser	1	Blue colored handkerchief
4	Cardboard paper in different colors	1	Board pen
3	0.5 l filled water bottle with red cap	1	Scissors
3	0.5 l filled water bottle with blue cap	1	Liquid glue
2	Wooden chests with keys	1	Packing tape
2	Referee whistle in different tones	1	Game box (small cardboard box)
2	Piece of nylon rope (each 60 cm long)		

1. PREPARATION OF THE GAME

Packing tape is stuck on the floor to determine the audience area. 9 student desks are placed in the audience area for the players waiting their turn, and the spectators to sit. In addition, the floors of the audience area and playgrounds are made clean and tidy.

1.1. Preparation of Stage 1

- 1 metered packing tape is properly stuck on the ground to mark the starting line. 3 student desks (one meter apart) are lined side by side 1 meter ahead of this line (Figure 1).
- The white cardboard measured with a ruler, is cut into four equal parts with scissors. Celsius, Fahrenheit and Kelvin temperature unit conversion formulas are written on 3 white cardboards as **"^{0}F = 1.8^{0}C + 32", "K = ^{0}C +273" and "^{0}F = 1.8 (K-273) + 32"** and they are taped to the corners of student desks in a way that they do not fall (Figure 2).

- 5x10cm pieces are cut from yellow, green and purple cardboards. 15 questions in the form of ***"X_F=…$_C$", "X_C=….$_F$"*** on yellow cardboards (Celcius-Fahrenheit/Fahrenheit-Celcius)**,** 20 questions as ***"X_K=….$_C$", "X_C=….$_K$"*** on green cardboards (Celcius-Fahrenheit / Fahrenheit-Celcius), and 25 questions as ***"X_F=…$_K$", "X_K=….$_F$"*** on purple cardboards (Celcius-Kelvin / Kelvin-Celcius) are written (X = temperature value). Colored cardboards are turned over and stacked on the tables as in Figure 2. In addition, two pencils and erasers are placed on each table.

1.2. Preparation of Stage 2

- In order to determine the 1-meter throwing line (the area 1 meter next to the table with purple cardboards) 1 meter of tape is stuck on the floor (Figure 1).
- A student bench is placed 3 meters from the throwing line (Figure 3).
- 3 red and 3 blue capped bottles filled with 0.5-liter water are stacked side by side on the table as in Figure 3.

1.3. Preparation of Stage 3

- So as to be placed in the spaces in the temperature unit panel, correspondence values of the units not given in the panel, are written on 20 wooden blocks in terms of Celsius, Fahrenheit and Kelvin with a wooden pen (Figure 6).
- Prepared wooden blocks are scrambled up and placed randomly in 2 wooden chests, 10 in each, and they are locked (Figure 4).
- Wooden chests are placed on a student desk with a 50 cm gap between them, as shown in Figure 4.
- The keys of the wooden chests are taken and hidden randomly, as one under the bottles with a red cap and one under the bottles with blue cap, on the table with 6 bottles in the second stage (Figure 3).

1.4. Preparation of Stage 4

- The temperature units' panel is measured with a ruler and markings are made with a pencil at equal intervals with 20 equal divisions on the long side and 3 equal divisions on the short side. According to the markings, 20 laths are fastened to the short sides of the board and thus 20 equal lines are created on the board. In reference to the markings, 3 equal columns are formed on the panel by stretching and fastening 2 pieces of rope to the long sides. Cardboards on which the formulas Celsius, Fahrenheit and Kelvin are written, are affixed to the heads of the columns. Thus, as in Figure 6, the temperature units panel consisting of 60 equal divisions in which temperature units in Celsius, Fahrenheit and Kelvin will be written on each line is prepared.
- Corresponding units of two of Celsius, Fahrenheit and Kelvin are written on cardboards and pasted in a way that 1 space is left in each line of the temperature board. Therefore, one for the temperature unit not given in each row, a total of 20 answer (wooden block) spaces are created, (Figure 6).
- The temperature units' panel is placed on the teacher's table and two panel alignment lines are drawn on the floor on both sides of the table (Figure 5).
- Next to the table where the board is located, a game box is placed to throw yellow, green and purple colored answered cards (Figure 5).

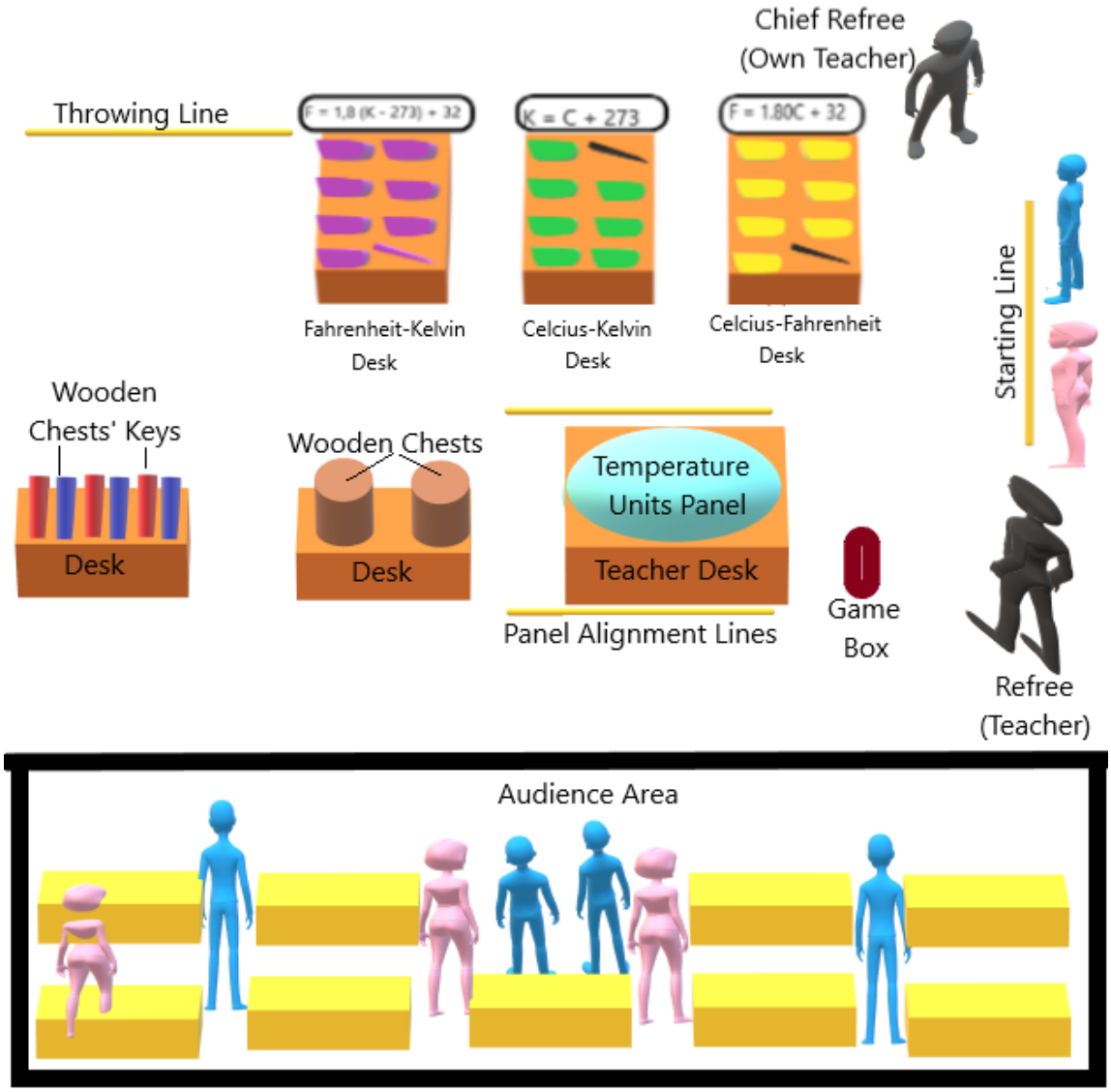


Figure 1. Preparation stages of the CFK Survivor game

2. GAME RULES

1. CFK Survivor game consists of 4 stages. It starts from the 1st stage and all the stages are played, respectively. Next stages cannot be passed before the previous stage is fully completed.

2. Two referees conduct the game. The same referee follows and controls the same player from the start of the 1st stage to the end of the 4th stage. Referee whistles mean as;

• 3 whistles (start / end whistle): it means the game has started in the 1st stage and the round is over in the 4th stage. Only the chief referee may whistle 3 times.

• 2 whistles (rejection whistle): It means that the answers given to the questions on the cards are wrong in the 1st stage and the questions have to be solved again, and also in the 4th stage the gap where the wooden block is placed is wrong and it must be replaced. Both referees can whistle twice.

• 1 whistle (confirmation whistle): It means that the answers given to the questions on the cards in the 1st stage are correct and you can switch to the next table. Both referees can whistle once.

3. Nobody can enter the playground except two referees and two players. The other players must watch the game as an audience in the place reserved for them outside the playing area until their turn. They may cheer and support their group mates in the game, but they cannot interfere with the referee decisions, players or the game in any way.

4. The group leaders play the first game. The players cannot step on the starting line in front of the class door. The game starts with 3 whistles of the referee after the players receive the handkerchiefs in the color of their group (Figure 1).

5. In the first stage, each player has to choose 3 cards and answer the questions in them correctly. The first players can choose 1 yellow, 1 green and 1 purple cardboard. Since the yellow cards will run out, the next players must select 2 green 1 purple cards and the last remaining players 1 green 2 purple cards (Figure 2).

6. In the first stage, the one whistle of the referee indicates that the player's response is correct and could move on to the next table. If the player's answer is wrong, the referee whistles twice and she/he has to solve the question repeatedly until finding the correct answer. The referees take the solved yellow, green and purple question cardboards and throw them into the game box. They also give 3 large erasers to the players finishing the first stage.
7. In the second stage, the throwing line cannot be stepped on. If the bottle full of water under which the chest key is found on the first shot, there is no obligation to shoot again. When the wrong shot is made or the bottle of the other group is dropped, the erasers are picked up the ground again and the game continues. The player finding the key her/his or the other player's dropping the water bottles, moves to stage 3.
8. In stage 3, after opening the correct wooden chest, the player can only take 1 wooden block in it. The randomly selected wooden block cannot be left back or replaced.
9. In stage 4, the player, thinking she/he has placed the wooden block in the correct gap on the board, lifts the group's icon-colored handkerchief in the air. After the check, if the gap where the block is placed is correct, the referee blows his whistle 3 times and the game is over and that player wins that round. If the gap she/he placed is not correct, the referee blows his whistle twice and the player takes his second chance. If he/she still doesn't find the right gap, then she/he takes her/his 3rd and last chance. Still the player placing the block in the wrong space for the third time is eliminated from the game.
10. The player winning the round is given 1 bottle cap in the icon color of his/her group (red or blue). Only the winner in the 10th round will be given 2 bottle caps. Caps collected as winning the tours are put in the glass of the group's icon color. The group with the most caps in their glass at the end of the 10th round wins the game.

3. GAME PLAY:

The CFK Survivor game consists of 4 stages. It starts from the 1st stage and all stages are played respectively. Next stages cannot be passed before the previous stage is completed.

- 1st Stage; answering questions on yellow, blue and purple cartons,
- 2nd Stage; knocking over the right water bottle with oversized erasers and finding the key under it,
- 3rd Stage; opening the correct wooden chest with the key and selecting a wooden block from inside the box,
- 4th Stage; placing the received wooden block in the correct gap in the temperature units' panel.

The chief referee of the game is the teacher of the physics lesson. A second physics teacher working at the school is also asked to act as a referee. The referees (physics teachers) divide the players (students) into two groups of ten people. Once their group is determined, the players choose the group leaders and the color (red or blue) that represents their group. They develop a game strategy led by the group leaders and determine their playing orders accordingly. Determining the playing order of the players is especially important in terms of the 1st and 4th stages (not being able to choose from yellow cards and having less / more gaps in the temperature units panel) and the 10th round (giving 2 bottle caps).

3.1. Gameplay of Stage 1

At the beginning of the game, the players are given handkerchiefs in their group's icon color (red or blue). Both players stand side by side on the starting line (Figure 1). When the chief referee whistles three times, they arrive at the "Celsius-Fahrenheit" table with yellow cartons. They each select one of the question cardboards on the table and read the question below by turning it over. After calculating by looking at the white formula cardboards attached to the head of the table, they show their cardboards to the referee. The player whose answer is correct goes to the "Celsius-Kelvin Table" with green cardboards after the referee whistles once. Likewise, by choosing a green cardboard she/he does the calculations on it. If the answer is correct, the referee whistles once again and she/he arrives at the "Fahrenheit-Kelvin Table" with purple cardboards. So, by choosing a purple cardboard, she/he does the calculations on it. If the answer is correct, the referee whistles one more time and gives the player three oversized erasers. If the answers are wrong, the referee will whistle twice and the player cannot move to the next table until he finds the correct answer. Thus, the 1st stage is completed (Figure 2).

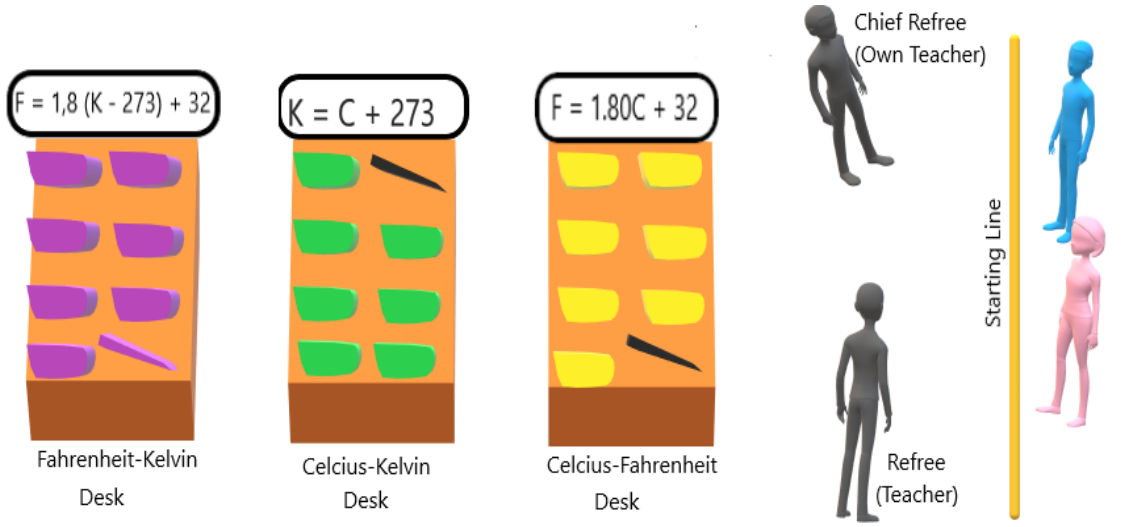


Figure 2. CFK Survivor Stage 1

In the first stage, each player has to choose 3 question cardboards and answer the questions written on them correctly. The first players can choose 1 yellow, 1 green and 1 purple cardboard. Since the yellow cartons will run out, the next players have to choose 2 green 1 purple cartons and the last remaining players have to choose 1 green 2 purple cartons.

Although all 21 questions on yellow, green and purple cards are prepared at "medium difficulty" level, the questions on the yellow card (as the Celsius-Fahrenheit conversion calculations can be made relatively easier and faster) can be an advantage for first players. On the other hand, the next players' being obliged to choose from green and purple cardboards may also be a disadvantage for them. In addition, finishing the first stage fast can give players an advantage before throwing bottles in the second stage.

3.2. Gameplay of Stage 2

After finishing the first stage, the players taking their oversized erasers from the referees, arrive at the throwing point without stepping on the throwing line next to the table with purple cardboards (Figure 1). By throwing 3 erasers, they try to drop the water-filled bottles in group colors standing 3 meters away. When the bottle with the key under it is dropped, there is no need for another shot. So, the player finding the key, no matter if she/he or the other player drops, under the right bottle passes to the third stage. However, if she/he cannot drop the right bottle in all 3 shots, or drops the other group's bottles, the player can take her/his erasers again and shoot until finding the right bottle (Figure 2).

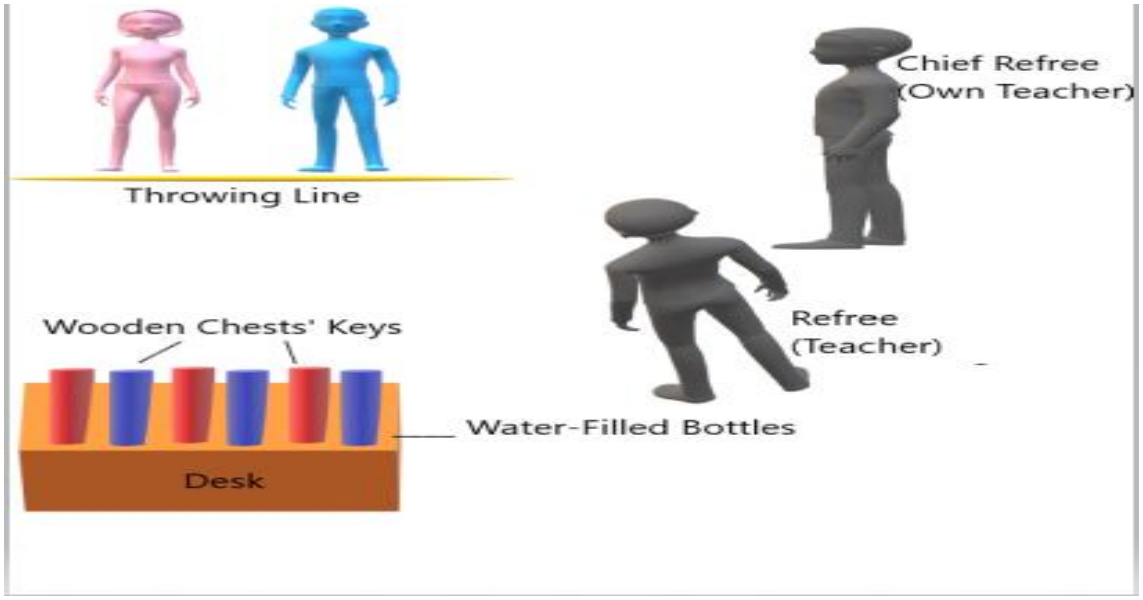


Figure 3. CFK Survivor stage 2

At this stage, the players dropping the bottle with the key under the first shot gives them an advantage in terms of speeding up. On the other hand, it would be a disadvantage for them to find the key in the next shots or to drop the other group's bottles.

3.3. Gameplay of Stage 3

The player receiving the key tries to find the correct one among the 2 wooden chests on the table as in Figure 4. After opening the chest, she/he randomly selects a wooden block with corresponding values in Celsius, Fahrenheit or Kelvin. The player can only select 1 wooden block and cannot leave back or change what he bought. Thus, the third stage is completed.

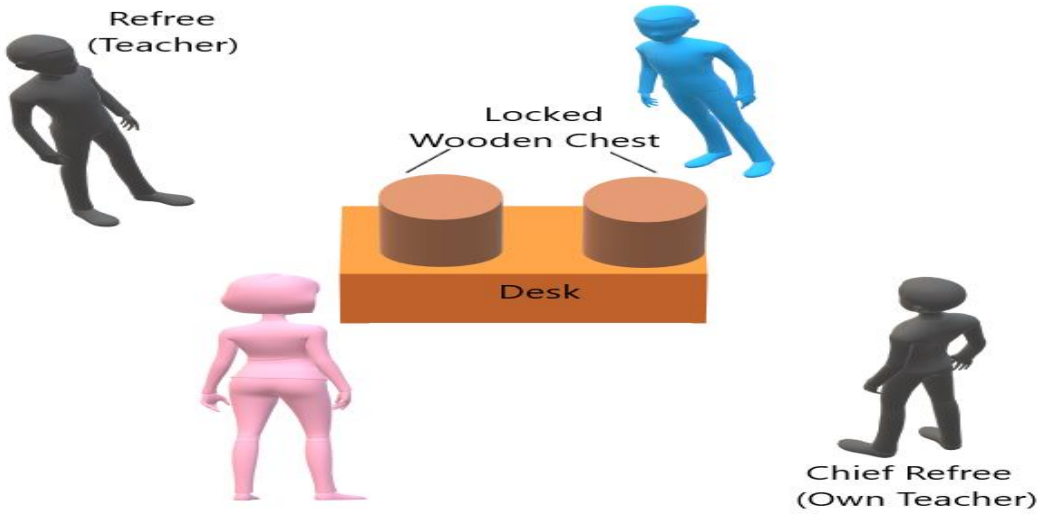


Figure 4. CFK Survivor stage 3

In the 3rd stage, which is shorter than the other stages, panic or excitement to find and unlock the right wooden chest, which is suitable for the key, can cost her/him time. So, this may cause a disadvantage in the fourth stage.

3.4. Gameplay of stage 4

With the wooden blocks, the players come to the temperature units' panel without stepping the alignment band on the floor, touching the board or the table as in Figure 5.

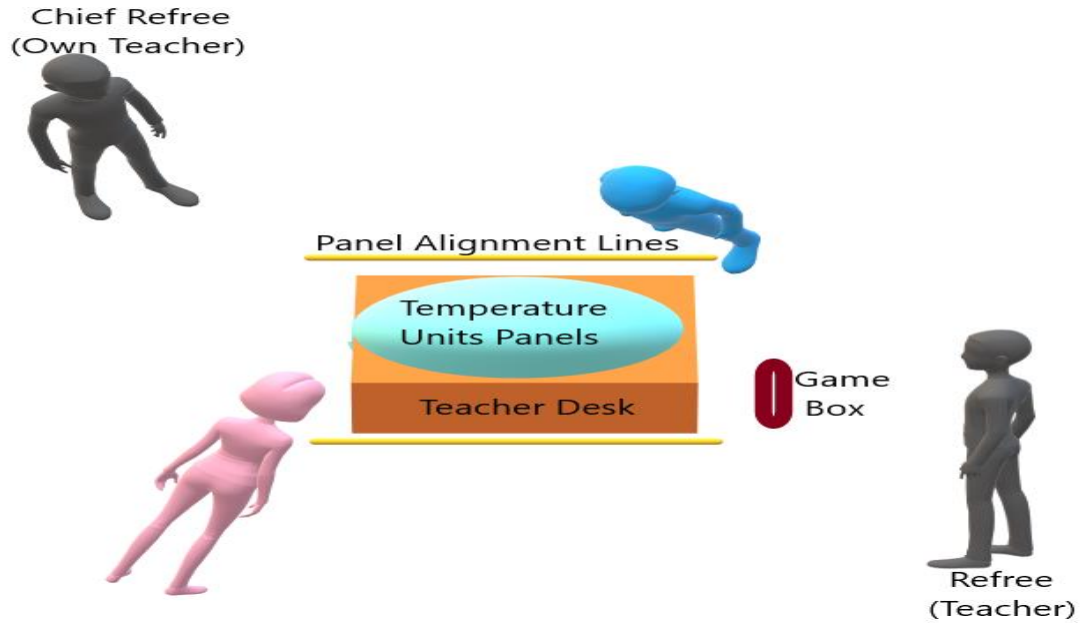
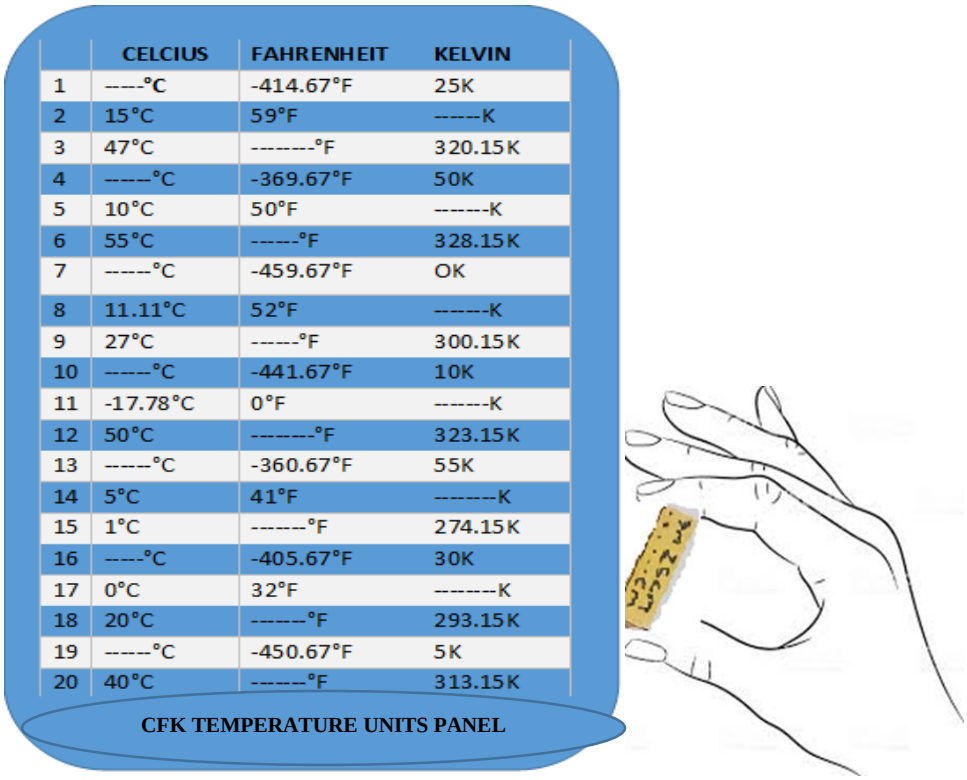


Figure 5. CFK Survivor stage 4

The players place the wooden blocks in the appropriate gap of the 20 spaces in the temperature units' panel as shown in Figure 6. The player thinking, she/he has placed the wooden block in the correct gap on the board, lifts up the group's icon-colored handkerchief. If the gap where the block is placed is correct after the referee check, the referee whistles 3 times and the first round is finished.

If the wooden block is not placed correctly on the board, the referee whistles twice and the player is given a second chance to find the right gap. So, if it is true, the referee whistles 3 times and the player becomes the winner of the round. However, if she/he doesn't place it correctly again, the referee whistles 2 times and the player is given the third and last chance. If the gap in her/his last chance is correct, the referee whistles 3 times and she/he becomes the winner of the round. But if it is not correct, the player failing to use all 3 chances, is eliminated from the game.



	CELCIUS	FAHRENHEIT	KELVIN
1	----°C	-414.67°F	25K
2	15°C	59°F	-----K
3	47°C	-------°F	320.15K
4	-----°C	-369.67°F	50K
5	10°C	50°F	------K
6	55°C	-----°F	328.15K
7	-----°C	-459.67°F	OK
8	11.11°C	52°F	------K
9	27°C	-----°F	300.15K
10	-----°C	-441.67°F	10K
11	-17.78°C	0°F	------K
12	50°C	-------°F	323.15K
13	-----°C	-360.67°F	55K
14	5°C	41°F	-------K
15	1°C	------°F	274.15K
16	----°C	-405.67°F	30K
17	0°C	32°F	-------K
18	20°C	------°F	293.15K
19	-----°C	-450.67°F	5K
20	40°C	------°F	313.15K

CFK TEMPERATURE UNITS PANEL

Figure 6. Placing the wooden block in the temperature units' panel

Therefore, the player finishing the fourth stage first wins that round and is given 1 bottle cap in the icon color of her/his group (no cap is given to the player who finishes the game in second place or fails to finish). The winners of the first 9 rounds are given 1 bottle cap in the group's icon color (red or blue), while only the winner in the 10^{th} round is given 2 bottle caps. Caps collected as winning the rounds are put in the glass of the group's icon color. At the end of the 10^{th} round, the group with the most caps in their glass wins the game.

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Analysis of Information and Communication Technologies and Flipped Classroom Methodology to Motivate Freshmen University Students[1]

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Abstract

In Spain, low motivation is one of the reasons freshman students allege to explain their dropping out from higher education degrees. Hence, this study analyses the impact of different educational resources and tools supported by Information and Communication Technologies (ICT) on the motivation of students in the freshman year of three Bachelor´s Degrees in the University of the Basque Country. With such aim, interactive activities were implemented in two undergraduate courses: Natural Sciences in Primary Education I (NSPEI) of the 'Bachelor´s Degree in Primary Education'; and Chemistry (CH), of both 'Bachelor´s Degree in Marine Studies' and 'Bachelor's Degree in Nautical Studies and Maritime Transport'. Motivation has been modelled according to: the importance a person awards to an activity, the expectations put on it, the belief of the usefulness of the result and the fast reward in the response. The sorting in tool valuations reported in the final questionnaire by NSEPI students generally met the order in the motivation values predicted by the Vroom model. Regarding the final questionnaire, in general, students believe that ICTs are essential, but that they do not replace traditional educational resources. It is remarkable that NSEPI students have a better perception than CH students of ICT tools, probably because they will most certainly implement them in their future professional activity.

INTRODUCTION

Motivation is a key element in learning since when a person is motivated, he or she will be much more involved in academic activities (Ramos, 2014). This implication is important to optimize the performance of the teaching-learning process (Ajello, 2003), particularly in the freshman year of a Bachelor's Degree, in which each student must achieve a minimum percentage of credits to continue with their studies. Such is the case of the Bachelor's Degrees in the University of the Basque Country (UPV/ EHU) (BOPV 2014) to which the undergraduate courses target of this study correspond: Natural Sciences in the Primary Education Classroom I (NSPEI) (Bachelor´s Degree in Primary Education) and Chemistry (CH) (Bachelor´s Degree in Marine Studies and Bachelor´s Degree in Nautical Studies and Maritime Transport). The general characteristics of such undergraduate courses are shown in Table 1.

Table 1. Features of the undergraduate courses studied in the 2019/20 academic year (University of the Basque Country UPV/ EHU, 2019)

Course	ECTS	Bachelors' Degree in	Cut-off mark (over 14)	Number of enrolled students	Male/female/non-binary (%)	Half	Situation
Nature Sciences in Primary Education I	6	Primary Education	9.3	50	33.0/77.0/-	2nd	Alarm status due to COVID 19 pandemic
Chemistry	6	Marine Studies	-	20	100.0/-/-	1st	Usual
		Nautical Studies and Maritime Transport	-	24	88.5/12.5/-		

According to data from the Spanish Ministry of Science, Innovation and Universities (2018), the dropout rate in the freshman year 2014-2015 reached 21.5 %. In other words, almost 1 in 4 freshmen students dropped out. Regarding the Bachelor's Degrees object of this study, the dropout rate for freshmen students in the 2017-2018 academic year widely fluctuated around the aforementioned average value. Namely, it was as much as 33.0 % in the Bachelor's Degree in Nautical Studies and Maritime Transport, and 11.1 % and 8.6 % in the Bachelor's Degree in Marine Studies and the Bachelor's Degree in Primary Education, respectively. According to a report on student dropping out of the University of Jaén (2015), the need to achieve a minimum number of credits was the most frequently stated reason (30%) by those students who dropped out of a Bachelor's Degree of this university during the freshman year, followed by economic reasons (12%). Among the remaining causes addressed in the report, the following most cited was motivation. Hence, upon dropping out of the degree, 11 % of the students interviewed claimed that initial expectations were not met, and 8 % of them reported they had lost interest or motivation.

Bearing in mind the importance of motivation among the students interviewed, this paper will be focused on the way in which 1st grade professors can influence students by increasing their motivation through different educational resources and tools supported by Information and Communication Technologies (ICT).

From a cognitive approach, motivation can be modelled according to Vroom's expectancy-value theory (1964). This theory is based on the assumption that individuals will take action when they believe their efforts will lead to a successful performance, bringing them positive results. This model is represented by the following equation:

$$M = V \cdot E \cdot I \qquad \text{(Equation 1)}$$

Where 'M' stands for motivation, 'V' is the value or level of importance that a person awards to an activity (i.e., the desire or interest they hold when making it), 'E' is the course expectation or probability that effort leads to a result, and 'I' is an instrumentality, that is, the belief of the usefulness of the result to be obtained. On the other hand, from a behavioural perspective, different factors need to be taken into account for reinforcement to be positive, such as the delay

of the reward (DR) (Naranjo, 2004), which is inversely proportional to motivation. By incorporating this variable into equation 1, equation 2 is obtained:

$$M = V \cdot E \cdot I/DR \quad \text{(Equation 2)}$$

The performance of professors might promote student motivation. For example, value (V) can be improved by helping students to find the usefulness of learning in their daily life and/or in designing tools that increase the value of the activity in the total mark of the course. Regarding expectation (E), professors can try to strengthen the confidence of students in their skills to succeed by letting them lead the teaching-learning process (International University of Valencia, 2015), and by providing the means for their self-assessment (Calatayud, 2008).

In such a sense, Flipped Classroom approaches might be helpful for students to play the main role in their learning process since they remove the traditional transmissive lecture and replace it with active in-class tasks and pre-/post-classwork (Abeysekera & Dawson, 2015; Seery, 2015). Besides, a Flipped Classroom course can be taught in various physical facilities, not only in a traditional lecture hall, but also in technology-enhanced classrooms, studios, laboratories, computer labs, meeting rooms, outdoor settings, or online learning spaces (Long et al. 2017). In fact, Nouri (2016) found out that the majority of a BSc degree students who participated in the Flipped Classroom methodology had a positive attitude towards it and, in comparison to those who did not, the students that followed such methodology showed higher motivation and self-sufficiency (Aşıksoy & Özdamlı, 2016). However, as Sáiz Manzanares and Arnaiz-González (2017) report, students considered Flipped Classroom facilitated conceptual construction, butt it could not entirely replace traditional face-to-face lectures. Such statement coheres with the work by van Alen et al. (2019) who found that students in Flipped Classrooms achieved higher learning outcomes when the face-to-face class time was not reduced, or when quizzes were added in the Flipped Classrooms. In fact, quizzes can be a means for students´ self-assessment, which is also an ideal tool to deal with the diversity of first-year students (people with different skills, learning styles, cognitive strategies, previous experiences and knowledge, motivation, attention, emotional and social adjustment, etc.).

Finally, by decreasing the reward delay, such as by publishing the test or activity results once these have ended, the demand for the reward (DR) will decrease and the motivation will thus increase (Eq. 1). In this sense, as pointed out by the International University of Valencia (2015), the use of ICT can be a very useful tool for professors to increase the motivation of students. That might be one of the reasons for which the educational model of the UPV/EHU, approved in 2010 under the IKD name, and followed since 2016 by the IKD i^3 strategy, promotes the use of active and innovative teaching methodologies (UPV/ EHU, 2020). Since 2010, the UPV/ EHU has thus implemented a number of institutional programmes to foster active and innovative methodologies such as Flipped Classroom and ICT, which the authors of this work have joined. Hence, within such a frame, the objective of this work is to evaluate the effectiveness of Flipped Classrooms and ICT to arouse motivation in students.

METHOD

The activities and methodologies were implemented within the framework of the courses NSPEI and CH, which are correspondingly comprehended in the freshman years of the Bachelor's Degree in Primary Education and the Bachelor's Degree in Marine Studies and Nautical Science and Maritime Transport (Table 1). Some of the features of each course and the tools, methodologies and activities implemented are described below. Then, the motivation is quantified on the terms described in equation 2 for each undergraduate course and Bachelor's

Degree. Students at the NSPEI and CH groups underwent two questionnaires about their opinion of the usability of the ICT tools: an initial one before the lessons started and then a final one towards the end of the programme.

Natural Sciences in Primary Education I (NSPEI)

NSPEI is a first-year course of the Primary Education Bachelor's Degree of the Education Faculty of Bilbao. In the 2019-2020 academic year the number of places available was 150 and the cut-off mark was 9.3 from 14.0 for the generic group (Table 1). Such a number of places was divided into three groups of approximately 50 students. One of such groups was assigned to a professor who co-authors this work and thus the students of such groups contributed to this study.

The NSPEI course consists of 6 ECTS credits, 60 hours of face-to-face teaching that comprises the following teaching modalities: masterclasses (40 %), classroom practices (52 %) and seminars (8 %). It takes place during the 2nd second half of the school year (February to May). It should be remarked that face-to-face activity was interrupted in the mentioned period by the establishment of the alarm status due to the COVID-19 pandemic.

The activities conducted through ICT and/or in the form of a Flipped Classroom were implemented in different teaching modalities. As an activity of classroom practice, an individual test about scientific competencies was performed through the Socrative tool after the analysis of a text on the issue using the Aronson puzzle technique (Social Psychology Network, 2020) Socrative (https://socrative.com/) is a gamification application that allows the professor to handle students' participation through mobile devices in real-time, to perform tests, evaluations, activities, etc. and provides the professor with detailed data of the marks obtained by the students in the tests conducted (Bello Pintado & Merino Diaz de Cerio, 2017). Unlike the other activities described in this work in which ICT was implemented and did not reflect in the final result of the course, the mark obtained in such a test weighed 13% of the final grade.

In the context of a seminar on the Sun-Earth system, an Excel spreadsheet (https://products.office.com/es-es/excel), developed by Microsoft, was implemented to display the evolution of the daily sun hours graphically in a location selected by each student. Two self-assessment quizzes were also carried out through the Kahoot game-based learning platform (https://kahoot.com/) on the contents that had previously been assessed in masterclasses. Kahoot, as well as Socrative, allows the professor to create multiple choice quizzes and monitor students' responses through mobile devices in real-time. However, unlike Kahoot, Socrative gathers the results obtained by the students in a more detailed report. The Edpuzzle online tool (https://edpuzzle.com/) enables the professor to modify, create and edit interactive videos by entering questions that professors can collect. This tool was used in the context of master lectures to bring in the consumerist perspective. This task corresponded to interdisciplinary work, in which a probable situation in the context of a real school was posed to the NSPEI students. With such aim, a video on consumerism was chosen and questions that students answered individually were inserted in it using the aforementioned online tool.

After the establishment of the health alarm status, the Flipped Classroom methodology was used throughout the four-month period. This methodology consisted of asking students to read the professor's notes, to solve some problems about the contents, to discuss the aroused doubts online, and finally to argue and solve the problems (Milman, 2012).

All the activities mentioned were implemented through the virtual platform eGela (the Moodle platform of the UPV/EHU). The use of this platform as a support for the designed activities was due to its advantages: 1) accessibility from anywhere with an Internet connection, 2) easy updating and use at the time deemed appropriate, 3) no reproduction costs, and 4) interactivity, autonomous learning, acquisition of different cross-cutting skills, etc. (Silva, 2011). It should be emphasized that the accessibility of eGela and other ICT tools, has been critical since the 80 % of face-to-face lessons were unfeasible after the establishment of the health alarm status on 14 March 2020 (the 18th of the 30 scheduled weeks) due to the COVID-19 pandemic.

Chemistry (CH)

As it is shown in Table 1, the CH course is taught in the freshman year of both the Marine Studies and Nautical Studies and Maritime Transport Bachelor`s Degrees at the Faculty of Engineering in Bilbao. As published by the UPV/ EHU, 60 seats were offered at both the aforementioned Bachelor's Degrees in the 2019-2020 academic year and no cut-off grade was established for the generic group in any case (UPV/ EHU, 2019). It should be noted that the offer of this type of Bachelor's Degrees in Spain is low. For instance, according to educaweb (https://www.educaweb.com/nf/carreras-universitarias-de/grado-ingenieria-marina/) such degrees (or similar) are taught at about 19 universities while the search at the same web for Primary Education Bachelor´s Degree results in about 200 sites. Therefore, the home region of the students at Marine Studies and Nautical Studies and Maritime Transport Bachelor`s Degrees at the Faculty of Engineering in Bilbao is probably further away than in other Bachelor's Degrees at the same university, which might add up stress for these freshmen.

Regarding the teaching modalities, the CH course comprehends 6 ECTS credits, hence, 60 face-to-face hours. They consist of master lectures (50 %), classroom practices (17 %), seminars (17 %) and laboratory practices (17 %). The chemistry course takes place during the first half (from September to December). In the case of the mentioned subject, the innovation, ascribed to Flipped Classroom methodology, was implemented in all the laboratory practices. This study is focused on the results obtained in three laboratory groups: two groups that were taught in Spanish (50 enrolled students) and another group that was taught in Basque (6 enrolled students).

According to this methodology, students were asked to go over the theoretical basis and the content of the practices outside the laboratory a week before they took place. Students were also asked to complete and answer a series of questions before the practices. These tasks were mandatory and, although not evaluated or rewarded, their fulfilment was compulsory in order to carry out the laboratory practice.

Motivation on the Use of the Tools

The values of the parameters V, E, I and DR (see equations 1 and 2) presented in Table 2 have been provided by the professor of each course based on the implementation of ICT tools, and M has been calculated according to equation 2. Parameters V, E, I, and DR are considered to range between 1 and 5 integer values (1 being the least and 5 the most), thus total motivation (M) ranges between 0.2 to 125.

As previously indicated, the activity designed with the tool Socrative had an impact on the final mark of the NSPEI course. Therefore, this tool has been assigned with a higher value (V) than the other tools used (Table 2). As for instrumentality (I), it has been considered that the tools Socrative, Kahoot, and Edpuzzle, and Flipped Classroom methodology have a greater projection in the future professional field of NSPEI students than the Flipped Classroom

methodology for CH students. It should be borne in mind that, differently to CH students, NSPEI students will most probably be teachers themselves and will surely use such tools/methodologies or very similar when teaching, thus, such tools are assigned with a 3 and a 1 for NSPEI and CH respectively. On the other hand, the instrumentality associated with Excel utility is considered intermediate for NSEPI students, for in their future as Primary Education teachers they will surely implement such tool but not in their lessons, as they would more probably do with Socrative, Kahhot, Edpuzzle or Flipped Classroom technique. Regarding delay of response (DR), while the results of Flipped Classroom and Excel are long delayed, results for Socrative, Kahoot and Edpuzzle are immediate, so they have been assigned with 1, the minimum possible value.

The rate of return or the ratio between exceeded and enrolled credits on the target courses NSPEI and CH is correspondingly 94 % and around 65 % (on average for the Bachelor's Degree on Marine Studies and Bachelor's Degree on Nautical Studies and Maritime Transport) (UPV/EHU, 2020). Assuming a linear relationship between such ratio and E, it has been concluded that NSPEI students E is 5 and thus it is 3 for CH students (Table 2).

Table 2. Values of the variables in equation 2 for the tools used in NSEPI and CH undergraduate courses

	Socrative	*Kahoot*	Edpuzzle	*Flipped classroom*		*Excel*
	NSEPI	NSEPI	NSEPI	NSEPI	CH	NSEPI
V	2	1	1	1	1	1
E	5	5	5	5	3	5
I	3	3	3	3	1	2
DR	1	1	1	3	3	3
M	30	15	15	5	1	3.3

It can be observed that M ranges between 1 and 30. The minimum value corresponds to CH students regarding Flipped Classroom technique while the maximum corresponds to NSPEI students and the Socrative tool, which, due to the way in which it has been utilized and its projection in the future for NSPEI students, has been assigned with the largest possible values of V, E and I and the minimum value of DR.

FINDINGS

Initial Questionnaire

Before the lessons started, the students were asked about their interests in learning ICT use and their motivation to do so (Figure 1). The students responded on a Likert scale from 1 to 5, where 1 equaled 'nothing' and 5 to 'very much' (Likert, 1932).

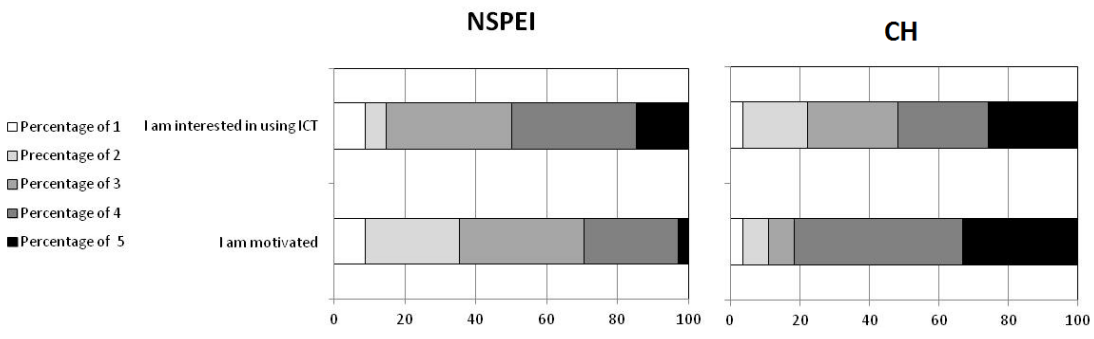

Figure 1. NSPEI and CH students' opinion on interest and motivation in using ICT as addressed in the initial questionnaire

As it is shown in Figure 1, approximately half of both CH and NSPEI students reported that they were interested (4) or very interested (5) in using ICT while clearly more CH than NSPEI students declared they were motivated to learn about it (80 % vs 5 %).

Final Questionnaire

After the implementation of the designed activities, which have been described in the previous section, a questionnaire was carried out in each of the aforementioned courses. Students were surveyed on their satisfaction regarding the teaching methodologies and interactive tools, as well as on their degree of acceptance and usefulness.

The results on satisfaction have been divided into three subsections: (1) general opinion on ICT (Figures 2, 3 and 4); (2) opinion on each specific ICT (Figure 5), and (3) opinion on the innovative role of the tools on the teaching-learning process (Figure 6). The students answered via a Likert scale from 1 to 5, where 1 equaled 'nothing' and 5 to 'very much' (Likert, 1932).

General Opinion on ICT

Concerning the general satisfaction with teaching methodologies, Figure 2 compares the average values obtained in the 10 items included in the final questionnaires for the two courses studied.

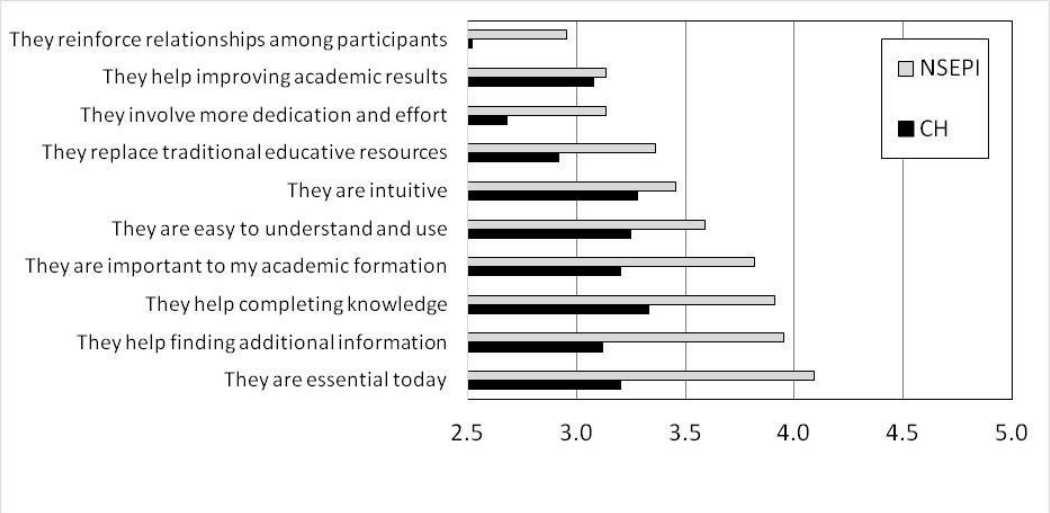

Figure 2. Average values obtained in the final questionnaire on the general opinion of ICT use on NSPEI and CH courses

According to the conclusions derived from Table 2 (the predicted motivation is generally superior for the NSPEI group than for CH), Figure 2 shows that the NSPEI group gave better assessments than the CH group to the utilities of the implemented tools, being in all cases greater than 3.0. Specifically, the score the NSPEI course students gave to the utilities varied between 3.0 and 4.1, while the CH group score ranged between 2.5 and 3.3. CH students allocated less than 3.0 points to the following three items: 'They reinforce relationships among participants'; 'They involve more dedication and effort' and 'They replace traditional educational resources'. These results may be due, among other reasons, to the fact that the CH students might consider Flipped Classroom a too unrewarding effort, which only gives access to the laboratory.

On the other hand, it should be noted that the items that got the most dissimilar marks between CH and the NSPEI students were: 'They are essential today' and 'They help to find additional information', probably because, unlike CH students, the alarm status for the COVID-19 was in force when the NSPEI students responded to the questionnaire. However, both groups agree on attributing an average score of around 3.2 to the item 'They help improve academic results'.

According to the majority of the students surveyed, ICT is essential today in academic training, but according to CH students, who on average attributed less than 3.0 out of 5.0 to it, they do not replace traditional resources, but should be used as a complement to acquire knowledge because they help to seek additional information. CH students also report that ICT tools are easy to understand and use because they are intuitive. The main drawbacks of using ICT pointed out by both groups are that relationships between participants (both students and student-professor) are not fostered, and that students consider that they barely improve their academic results.

For a better understanding of the differences in the results on the two courses, the percentages of the punctuations obtained for each item have been compared for both courses. The percentages of each score (grouping 1 and 2; 3; 4 and 5 values) are shown in Figure 3. This figure also includes the percentage associated with the blank answers (Does not know/Does not answer (DK/DA)).

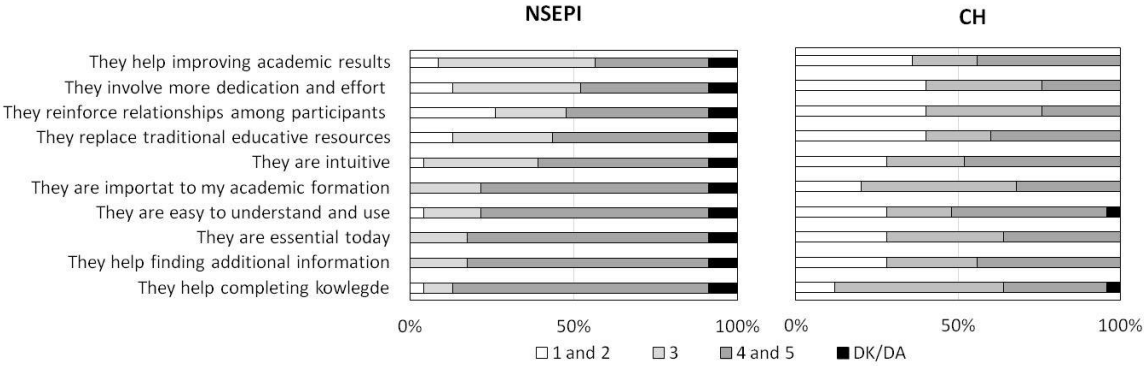

Figure 3. Ranges of valuation percentages obtained in the final questionnaire on the general opinion of ICT use on NSPEI and CH courses

When comparing the distribution of valuation percentages, unlike in CH, higher scores predominate in the NSPEI course (4.0 and 5.0). Namely, the item 'They help complete knowledge' (Figure 3) reaches almost 80 %. The intermediate valuation of 3.0 given in each group varies depending on the item, with no clear trend. In the NSPEI group there is hardly any presence of the lowest valuations (1 and 2), which vary between 0% and 13% %, only attaining the maximum value 26 % at the item "They reinforce relationships among participants". On the contrary, in the CH group such punctuations are quite noticeable. In fact, in some cases the lowest values are given by as much as the 50 % of CH students, i.e. "They help complete knowledge". In the NSPEI group the does not know/does not answer number is constant for all questions.

In general, it can be stated that in the CH group ICT are not as well valued as in the NSPEI group. However, the motivation stated by the CH students in the initial questionnaire was larger than the addressed by the NSEPI students (Figure 1). The good opinion about the use of ICT in of the NSPEI group (Figure 2) could be due to the larger number of interactive activities proposed in the NSPEI course, which were designed to meet the suspension of face-to-face

classes in the UPV/EHU. This fact may have made students aware of the need for this type of tools and, hereafter accustom them to its use considering that, at that particular time, it was the only feasible way of studying and working on the course. Besides, it should be beard in mind that the ICT and methodologies implemented are tools that might be directly implemented in their future professional activity by the NSPEI students, while its applicability might not seem so direct for the CH students.

Comparison of NSPEI Students' Opinion on the Implemented ICT and Vroom´s Model

Concerning the opinion on the implemented ICT, Figure 4 contains the NSPEI students' global valorisation acquired through the final questionnaire. The data shown refer to the obtained average values, within an interval from 0 to 5. Motivation, as calculated from equation 2, is also included in the secondary y-axis, ranging from 0 to 30.

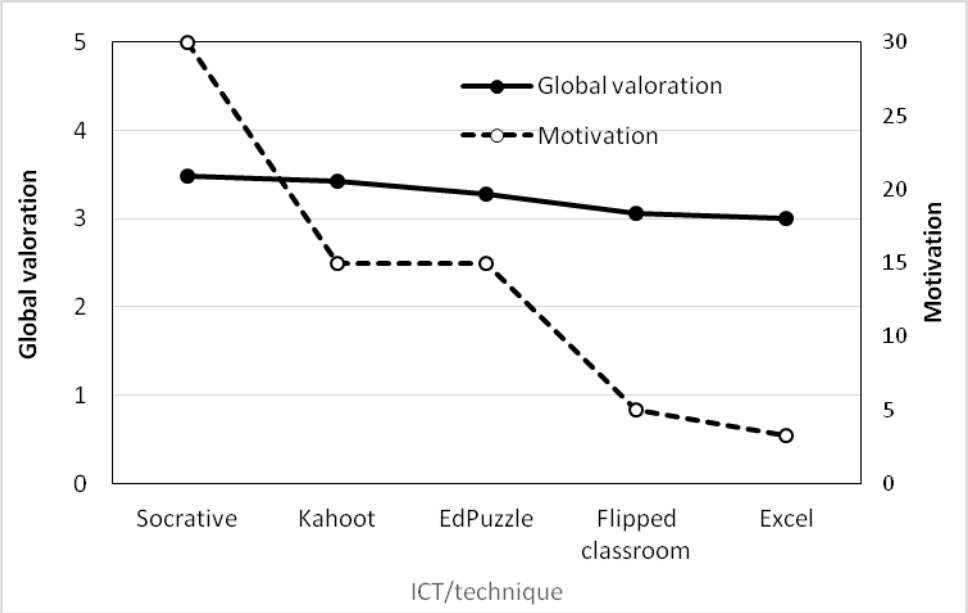

Figure 4. Average values obtained in the final questionnaire on the overall valuation and calculated motivation (Table 2) of the different ICT used in NSPEI

As it can be observed in Figure 4, all implemented ICT tools are valued globally with at least 3.0 points out of 5.0, being Socrative and Excel the most and least valued, respectively (Figure 4). Such might be since the Excel spreadsheet does not provide any gamification, while it is a basic feature of Socrative. The sorting in tool valuations generally meets the order in the motivation values predicted by the Vroom model (Table 2), only Edpuzzle differs from this trend. Namely, this interactive tool is valued worse than Kahoot probably because it is more unknown than Kahoot and therefore the students attribute less utility (I) to it when compared with the value predicted in Table 2. To know the reason for these differences between the overall ICT tools assessments in the NSPEI course, all responses were analyzed taking into account five aspects: motivating capacity, collaborative attitude, understanding, self-assessment and autonomy. The results obtained from this data analysis are shown in Figure 5, which also agrees with the statements in Figure 3. As the results collected in Figure 4 suggest, NSPEI students value the tool Socrative the most in most aspects, except for motivation, in which the tool Kahoot gets the best grade. Of all the items explored, 'Learning Autonomy' for Socrative's activity scored best (4.0 out of 5.0). This may be because, as the NSPEI students reported in their initial questionnaire, Kahoot was the least unknown tool and thus it can raise more interest and motivation for the student.

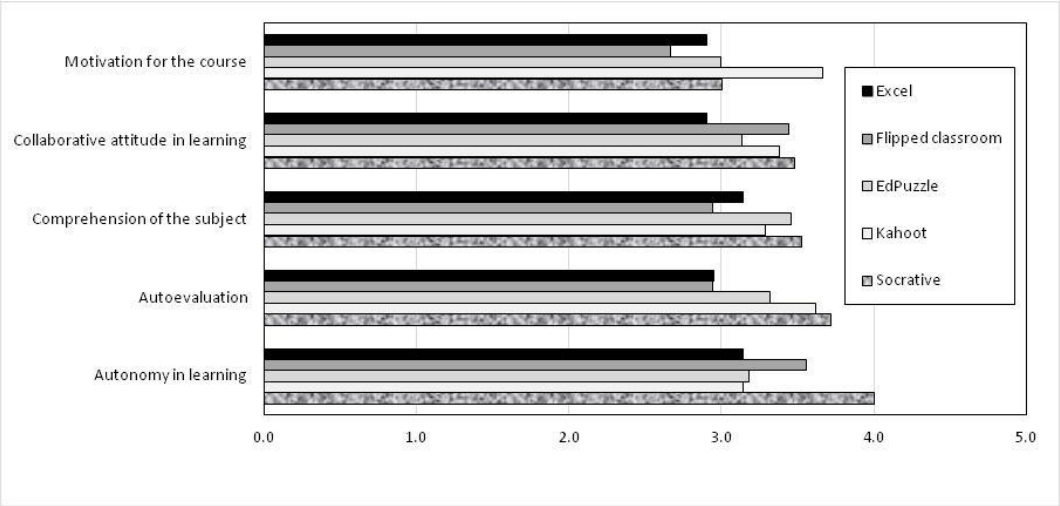

Figure 5. Average values obtained in the final questionnaire on ICTs used in Natural Sciences in Primary Education I (NSEPI)

The ICT that in the overall valuation obtained the best score (Socrative, Kahoot and EdPuzzle) (see Figure 3), have a rating greater than 3.0 at all items (Figure 5). The worst-rated tools in the graph above (Flipped Classroom and Excel) get a lower rating than 3.0 in 3 of the 5 items, agreeing to fail below 3.0 in two of them: 'Motivation for the course' and 'Auto-evaluation'. Seemingly, the perception of these two items is related, since if these tools are not motivating, it should be expected that students will not use them for self-assessment. These low values may also be linked to the fact that Flipped Classroom involves greater personal effort and attention from students, and that Excel is a resource that has a presumably less future projection in the professional practice of Bachelor's Degree in Primary Education students, as mentioned when setting the utility (I) value (Table 2).

Opinion of the Innovative Role of the Tools on the Teaching-Learning Process

Based on their experience, the teaching team classified the ICT tools, formats and methodologies implemented in the courses according to their degree of innovation and allowed each of them a score in the range of 1 to 5, as shown in Figure 6.

Also, NSPEI students have posed the following questions on the implemented ICT tools and methodologies: 'When learning, understanding, setting concepts and knowledge, etc., what has been easier for you?' The score ranged between 1 and 5, and the response for each ICT and/or methodology is shown in Figure 6 together with the values suggested in Table 2.

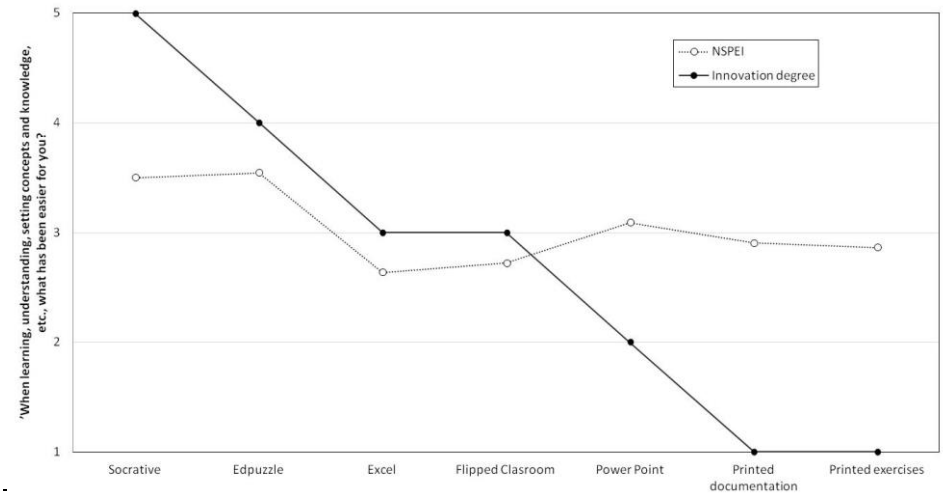

Figure 6. Average values obtained in the survey on ICTs used in NSPEI and the innovation degree of the ICT/Methodology

No relationship between the innovative degree of the ICT tools, the formats and methodologies implemented and its capacity to help NSPEI students to learn, understand and set concepts and knowledge, etc., can be observed in Figure 6.

CONCLUSION, DISCUSSION AND SUGGESTIONS

Different interactive teaching tools supported by Information and Communication Technologies (ICT) have been employed for designing various activities which were implemented in different courses. This implementation aimed to analyze their suitability to increase motivation in freshmen students. To this end, the students of two first-year courses: Nature Sciences in Primary Education I (NSPEI, Bachelor's Degree in Primary Education) and Chemistry (CH, Bachelor's Degree in Marine Studies and Bachelor's Degree in Nautical Studies and Maritime Transport), have been surveyed in relation to their opinions on the above-mentioned tools.

Regarding ICTs in general, students in both courses believe that they are essential, but that they do not replace traditional educational resources. Particularly such is the opinion of the CH students who, unlike NSPEI students, were not confined due to the state of alarm derived from the COVID-19 pandemic. The negative aspects students highlight are the lack of interpersonal relationships that their use entails and the fact that they (by themselves) do not help improve academic results. In short, students consider that digital tools and novel methodologies complement traditional educational resources. Such findings cohere with those reported by Thi Thai et al. (2017), according to which students in a blended learning setting had a higher learning performance as compared to those in an e-learning setting.

Regarding the tools raised in the course NSEPI, students value Socrative, Kahoot and EdPuzzle tools better than Flipped Classroom or Excel, which agrees with the motivation capacity of such tools as calculated through the Vroom model. And yet, as reported by Díaz-Garrido et al. (2017), the capacity of Flipped Classroom for motivating students might be higher than that of traditional resources. In the case of the Flipped Classroom, a methodology used in the two courses, NSEPI students have a better perception of it, seemingly because such students may be more motivated in the use of such methodology, as well as ICT, for they will most likely implement them in their future professional activity. Also, as previously mentioned, NSPEI students were confined to their homes when the course took place, which might have made up their minds about the convenience of ICT. Such classification matches the suggested by Mc

Nelly et al. (2016), who found that Flipped Classroom endorsers had more positive attitudes towards the course activities (both pre-class and in-class) and felt more involved and engaged in the content. In this sense, we agree with Tomás et al. (2019) who suggest a flipped learning continuum that fosters different levels of student-centered learning and autonomy. And, particularly in the context of the first year experience, they recommend some teacher-led instruction to support students' transition to learning in higher education. In future studies, research on the impact on higher degree courses students' motivation of scientific-technological grades of Flipped Classroom in combination with ICT will be carried out.

On the other hand, Flipped Classroom may rely on ICT which, in combination with the former or just by themselves, have proved to be essential in times or situations when presential lessons are not feasible. Moreover, according to the results obtained in this work, it can be concluded that if the ICT formats are properly selected, they can be powerful motivating tools. However, and despite the fact that the students in this study agreed with the need for ICT, they also pointed out that they would not replace traditional educational resources. Hence, the choice of blended learning may be the most appropriate teaching-learning method.

REFERENCES

Abeysekera, L. l., & Dawson, P. (2015), Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research. *Higher education research & development, 34*(1), 1-14. https://doi.org/10.1080/07294360.2014.934336

Aşıksoy, G., & Özdamlı, F. (2016). Flipped classroom adapted to the ARCS model of motivation and applied to a physics course. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(6), 1589-1603. https://doi.org/10.12973/eurasia.2016.1251a

Ajello, A. M. (2003). Manual de psicología de la educación. In: C. Pontecorvo (Ed.). *La motivación para aprender* (pp. 251-271). Popular.

Boletín Oficial del País Vasco (BOPV) del 26 de marzo de 2014. *Normativa de permanencia para estudios de Grado*. Euskadi.eus. https://www.euskadi.eus/y22-bopv/es/p43aBOPVWebWar/VerParalelo.do?cd2014001771

Calatayud, M. A. (2008). La *autoevaluación como estrategia de aprendizaje para atender a la diversidad*. Educaweb. https://www.educaweb.com/noticia/2008/01/28/autoevaluacion-como-estrategia-aprendizaje-atender-diversidad-2752/

Likert, R. (1932). A Technique for the measurement of attitudes. *Archives of Psychology. 140*, 1-55.

Long, T., Cummins, J., & Waugh, M. (2017). Use of the flipped classroom instructional model in higher education: instructors' perspectives. *Journal of Computing in Higher Education 29*, 179-200. https://doi.org/10.1007/s12528-016-9119-8.

McNally B., Chipperfield J., Dorsett P., Del Fabbro L., Frommolt V., Goetz S., Lewohl J., Molineux M., Pearson A., Reddan G., Roiko A., & Rung A. (2017). Flipped classroom experiences: student preferences and flip strategy in a higher education context. *High Education 73*, 281-298. https://doi.org/10.1007/s10734-016-0014-z

Milman, N. B. (2012). The flipped classroom strategy: What is it and how can it best be used? *Distance Learning, 9*(3), 85-87.

Spanish Ministry of Science, Innovation and Universities- Ministerio de Ciencia Innovación y Universidades (MCINU). (2018). *Estadística de indicadores universitarios.* Sistema Integrado de Información Universitaria.https://www.educacionyfp.gob.es/dam/jcr:ca09ad6b-9ae6-484e-968a-9acf1e101a9b/nota-estadistica-de-indicadores-universitarios-2018.pdf

Naranjo, M. L. (2004). *Enfoques conductistas, cognitivos y racional emotivos*. Universidad de Costa Rica.

Ramos, M. 2014. *Estudio sobre la motivación y su relación con el rendimiento académico (Master´s thesis)* . Universidad de Almería. http://repositorio.ual.es/bitstream/handle/10835/3064/Trabajo.pdf?sequence=1 el 1/06/2021

Sáiz Manzanares, M. C., & Arnaiz-González, A. (2017). *Más allá del Flipped Classroom: Una experiencia de Flipped Learning en la Universidad de Burgos*. Experiencias Flipped [30]. . https://www.theflippedclassroom.es/experiencias-flipped-30-mas-alla-del-flipped-classroom-una-experiencia-de-flipped-learning-en-la-universidad-de-burgos-maria-consuelo-saiz-manzanares/

Seery M. K. (2015). Flipped learning in higher education chemistry: emerging trends and potential directions. *Chemical Education Research and Practice*, *16*, 758-768. https://doi.org/10.1039/C5RP00136F

Silva, J. (2011). *Diseño y moderación de Entornos Virtuales de Aprendizaje*. UOC.

Social Psychology Network, (2021). *The Jigsaw Classroom.* Jigsaw Classroom. https://www.jigsaw.org/

Thi Thai N.T., De Wever B., & Valcke, M. (2017). The impact of a flipped classroom design on learning performance in higher education: Looking for the best "blend" of lectures and guiding questions with feedback. *Computers & Education, 107*,113-126. https://doi.org/10.1016/j.compedu.2017.01.003.

Tomas, L., Doyle, T., & Skamp, K. (2019). Are first year students ready for a flipped classroom? A case for a flipped learning continuum. *International Journal of Educational Technology in Higher Education*, *16*(1), 1-22. https://doi.org/10.1186/s41239-019-0135

International University of Valencia-Universidad Internacional de Valencia (UIV). (2015). Como motivar a los alumnos: recursos y estrategias: https://www.universidadviu.es/como-motivar-a-los-alumnos-recursos-y-estrategias/ el 1/06/2021

University of Jaén-Universidad de Jaén. (2015). *Informe de Abandonos de la Universidad de Jaén*. Universidad de Jaén. https://www.ujaen.es/gobierno/vicest/sites/gobierno_vicest/files/uploads/Informacion_general/informe abandonos 2015 definitivo.pdf

University of the Basque Country-Universidad del País Vasco/Euskal Herriko Unibertsitatea (UPV/EHU). (2010). *IKD i3 strategy*. UPV/EHU> Sustainability> EHU Agenda 2030> IKD i^3 strategy. https://www.ehu.eus/en/web/iraunkortasuna/ehuagenda-2030/ikd-i3-estrategia

University of the Basque Country-Universidad del País Vasco/Euskal Herriko Unibertsitatea (UPV/EHU). (2019). *Límite de plazas y nota de corte de admisión para el curso 2019-2021*. https://www.ehu.eus/documents/1940628/12571058/notas+de+corte-cas2019%28sin+Prion%29-DEFINITIVAS-2019-11-4.pdf/29bb6a99-62d0-5d21-1a73-437520a15182.

University of the Basque Country-Universidad del País Vasco/Euskal Herriko Unibertsitatea (UPV/EHU). (2021). *Resultados de enseñanza-aprendizaje*. UPV/EHU> Portal de Transparencia UPV/EHU> Resultados y Rankings> Enseñanza Aprendizaje> Grados. https://www.ehu.eus/es/web/gardentasun-ataria/gradua1.

van Alten D. C.D., Phielix C., Janssen J., & Kester L.(2019). Effects of flipping the classroom on learning outcomes and satisfaction: *A meta-analysis, Educational Research Review, 28,* 100281,https://doi.org/10.1016/j.edurev.2019.05.003.

Vroom, V. H. (1964). *Work and Motivation*. John Wiley and Sons.

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Developing a Literacy Scale for Renewable Energy Resources and Identifying the Literacy Levels of Pre-Service Science Teachers

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Abstract

This study aims to develop a valid and reliable literacy scale for renewable energy resources to identify the literacy levels of pre-service teachers for renewable energy resources and to reveal the literacy levels of pre-service science teachers for renewable energy resources. The survey model was used in the research. With the study, a 20 item 3 points Likert type Literacy Scale for Renewable Energy Resources consisting of two sub-dimensions was developed. The internal consistency coefficient of the first sub-dimension of the scale was .94 and the internal consistency coefficient of the second sub-dimension was .88, and the overall internal consistency coefficient of the scale was .91. After the scale was developed, it was administered to pre-service science teachers. It was found that pre-service science teachers got an average score of 22.82 from the scale, which can score at most 40. The results showed that the literacy level of pre-service science teachers towards renewable energy resources was at a medium level.

INTRODUCTION

In order to survive, a person places their life on very different internal and external balances that depend on each other. Perhaps the most important of such balances is the balance that a human has with their environment, which has been going on since existence. In other words, humans and the environment have been in an ongoing interaction for millions of years, and it is not possible to think of the environment outside of humans and independently of human activities. Therefore, human beings and all of their activities affect the environment and environmental resources and cause their destruction. With the transition from the living conditions that are determined by nature, to activities that are determined by humans, the most rapidly destroyed environmental resources are the non-renewable energy resources.

Today, rapid population growth, industrialization and technological developments cause an increase in the requirement for energy resources. A significant part of the worldwide energy production is provided by non-renewable energy sources consisting of fossil fuels. However, the fact that fossil fuels will be depleted in the near future, causing serious global damages by releasing CO_2 and greenhouse gases to the environment, and the encouragement of environmentally-friendly advanced and innovative technologies in accordance with the Kyoto Protocol drive people to renewable energy resources (Fırat, Sepetçioğlu, & Kiraz, 2012; Boz, 2020). Renewable energy sources are defined as clean and sustainable energy that is equal to the energy consumed from the energy source or can renew itself faster than the depletion rate

of the resource and that does not run out even though they are used (Yakıncı & Kök, 2017; MEB, 2018a). These resources are classified as solar energy, biomass energy, hydrogen energy, hydraulic energy, wave energy, geothermal energy and wind energy (Sülükçüler, 2018). A review of the literature reveals that public acceptance of environmentally-friendly energy sources such as solar, wind, hydroelectric, geothermal and biomass energy is an important factor (Wüstenhagen, Wolsink, & Bürer, 2007). However, incomplete or incorrect information about energy and energy resources in individuals appears as an obstacle in their search for solutions to environmental events such as global warming and in their choice of energy use (Akitsu, Ishihara, Okumura, & Yamasue, 2017; Demirbağ, 2019). According to Bodzin, Fu, Peffer and Kulo (2013), many research results reveal that individuals have an incomplete understanding of energy consumption habits and a lack of conceptual knowledge about non-renewable and renewable energy sources. Accordingly, concepts related to energy and energy resources should be included in the national curricula of countries (Bodzin, 2012). In our country, science (MEB, 2018b), biology (MEB, 2018c), geography (MEB, 2018d) and chemistry (MEB, 2018e) curricula include topics such as renewable energy sources, sustainable development, energy-saving, and the relationship of natural resources with the economy. The inclusion of the determined subjects in the curriculum is of great importance, especially in terms of environmental awareness and energy literacy. Because, in order to use natural resources in a sustainable and economical way, to transfer them to future generations, to raise awareness and consciousness about renewable energy sources, and to create sustainable environmental awareness, individuals who grow up should be environmentally and energy literate individuals.

Partnership for 21st Century Learning (P21) project, which is a strategic education project, explains the skills that individuals are expected to acquire in the 21st century. This project also includes energy literacy among the main topics of 21st century skills, and it is seen that global and environmental literacy skills are also among the skills and competencies that an individual should have. Global environmental literacy includes utilizing 21st century skills to understand and solve global issues. In addition, it is defined as skills and competencies such as knowing the environmental conditions related to air, climate, soil, energy and water; understanding the impact of the resource consumption rate of the society and the population growth on nature; taking individual and social measures for environmental problems (Gelen, 2017; Taşlıbeyaz, 2019; Boz, 2020).

The issue of energy, which is mostly referred to under the category of environmental literacy, is currently used as a separate term in the form of energy literacy with global climate change, increasing energy requirements and energy consumption gaining importance (Merritt, Bowers, & Rimm Kaufman, 2019). Energy literacy is defined as understanding the nature and the role of energy in the universe and our lives, finding answers to questions about energy with this understanding, solving problems, and making conscious emotional and behavioral choices about energy in daily life (DeWaters & Powers, 2011; Öykün & Abbasoğlu, 2017; Boz, 2020). Energy literacy is also described as having knowledge about the production and consumption of energy, developing alternative resources, using energy resources efficiently and being able to recognize the environmental, social and global effects of energy use (Fah, Hoon, Munting, & Chong, 2012). Energy literacy encompasses not only the understanding of the nature and role of energy in the world and our lives, but also the ability to apply this understanding to answer questions and solve problems (U.S. Department of Energy, 2017). Energy literacy emerges in the literature as a broad concept encompassing three dimensions: knowledge, attitude, and behavior (DeWaters, Qaqish, Graham, & Powers, 2013). A review of the relevant literature reveals that international studies have focused on energy literacy in

recent years, and studies have been conducted with different sample groups in many countries (Fah, Hoon, Munting, & Chong, 2012; Bodzin, Fu, Peffer, & Kulo, 2013; Brounen, Kok, & Quigley, 2013; Chen, Chou, Yen, & Chao, 2015; DeWaters, Qaqish, Graham, & Powers, 2013; Cotton, Miller, Winter, Bailey, & Sterling, 2015; Lee, Lee, Altschuld, & Pan, 2015; Sovaccol & Blyth, 2015; Horst, Harrison, Staddon, & Wood, 2016; Akitsu, Ishihara, Okumura, & Yamasue, 2017). However, it is worth noting that the number of studies on energy literacy in our country is quite limited (Görgülü Arı & Arslan, 2019; Güven, Yakar & Sülün, 2019; Oluk, Şengören & Babadağ, 2019; Boz, 2020). Studies on energy in our country primarily investigate the individuals' knowledge and awareness of, and attitudes towards renewable energy sources (Fırat, Sepetçioğlu, Kiraz, & 2012; Güneş, Alat, & Gözüm, 2013; Bozdoğan & Yiğit, 2014; Aygan & Zengin, 2017; Cebesoy & Karışan, 2017; Cırıt, 2017; Yenice & Tunç, 2018; Balbağ & Balbağ, 2019; Mertoğlu, 2019). However, energy literacy includes the cognitive (knowledge, understanding, skills), affective (sensitivity, attitudes) and behavioral (intention, participation, action) acquisitions of individuals in relation to energy, in addition to knowledge and awareness of, and attitudes towards energy resources (DeWaters & Powers, 2013; Lay, Khoo, Treagust, & Chandrasegaran, 2013). The energy literacy scale developed by DeWaters and Powers (2011) was also developed specifically to evaluate energy literacy in three basic dimensions: cognitive (knowledge), affective (attitudes, values) and behavior. The result of the reviews indicates that there is no study or measurement tool aiming to measure the literacy levels of individuals for renewable energy resources. From this point of view, with this research, it is aimed to develop a literacy scale for renewable energy sources, which is not included in the national and international literature. In particular, it is thought that the scale will contribute to this field for which a measurement tool has not been developed before.

The Purpose of Study

In today's world, global environmental problems and energy needs are increasing rapidly. Considering this situation, it is thought that it is of great importance to determine the literacy levels of individuals towards renewable energy resources and the effective use of these resources. Many countries around the world have initiated educational programs on renewable energy technologies and envisioned a review of the methods of teaching for renewable energy (Kandpal & Broman, 2014). This is because the entire population needs to be educated from an early age for a more comprehensive education on sustainable energy and the development of energy literacy (Göcük & Şahin, 2016). It is always the teachers who educate this population. Therefore, it is thought that it is extremely important to identify the literacy levels of teachers and pre-service teachers, who are the teachers of the future, in particular, for renewable energy sources. In this respect, this study aims to develop a valid and reliable literacy scale for renewable energy resources to identify the literacy levels of pre-service teachers for renewable energy resources, and to reveal the literacy levels of pre-service science teachers for renewable energy resources.

METHOD

Study Design

Aiming to develop a literacy scale for renewable energy resources and identify the literacy levels of pre-service science teachers for renewable energy resources, this study was conducted in two stages. The first stage of the study includes the process of developing a scale. The other stage includes the process of identifying the literacy levels of pre-service science teachers for renewable energy resources without any intervention. The second part of the research was therefore conducted with a general survey model, which is a type of

descriptive research. The general survey model aims to reveal the existing situation without any intervention to the past or present situation or events (Karasar, 2014).

Study Group

In the process of developing a literacy scale for renewable energy resources, which is the first stage of the research, a total of 242 pre-service teachers from various branches who were studying at a state university in Ankara in the spring semester of the 2018-2019 academic year were worked with. Such branches were identified as physics education, chemistry education, geography education, elementary education, biology education and science education in accordance with the contents and the target audience of the scale. Considering that the sample size in scale development studies should be at least five times the number of items that are included in the scale (Bryman & Cramer, 2001), it was determined that the size was sufficient. The distribution of the study group based on the department they study in is given in Table 1.

Table 1. Frequency distribution of the study group according to departments

Departments	f	%
Science Education	43	17.77
Biology Education	45	18.59
Chemistry Education	47	19.42
Physics Education	40	16.53
Geography Education	28	11.57
Elementary Education	39	16.12
Total	242	100.00

In the next stage of the research, the scale was applied to a total of 35 junior pre-service science teachers who were studying at the faculty of education of a state university in Ankara in the fall semester of the 2019-2020 academic year to identify their literacy levels of renewable energy resources.

The Process for the Development of the Scale

A review of the literature revealed that there were several valid and reliable scales of attitudes for renewable energy sources (Liarakou, Gavrilakis, & Flouri, 2009; Güneş, Alat, & Gözüm, 2013; Çelikler & Aksan, 2016; Zainudin & Ishak, 2019), a scale of awareness for renewable energy resources (Mutlu, 2016) and a scale of energy literacy (Dewaters, Qaqish, Graham, & Powers, 2013). However, it was identified that there were no scales of literacy for renewable energy resources.

This study was intended to contribute to the literature by developing a literacy scale for renewable energy resources and analyzing the literacy levels of pre-service teachers. In the first stage of the scale development process, various sources were reviewed, renewable energy sources were identified, and items that could identify the literacy levels of pre-service teachers were prepared for each. In this way, a pool of 48 items was created. When preparing the items, care was taken to ensure that all items contain a single case and that they are clear and understandable. The scale was prepared as a 3-point Likert-type scale, including the points of "Yes", "No" and "I don't have an opinion".

Experts were consulted for their opinions to ensure the content validity of the draft scale, which was prepared as a 3-point Likert-type scale with 48 items. The scale was reviewed by two faculty members serving at the science education department and one faculty member

serving at the biology education department for content validity; by one faculty member serving at the assessment and evaluation department for compliance with the assessment and evaluation criteria; and finally, by an expert for compliance with grammar rules and clarity. Language changes were made to the contents of seven items, and three items that did not measure literacy were removed from the draft pool based on the opinions that are received from experts. Thus, a draft scale with 45 items was obtained.

In the next stage, the draft scale was applied to 22 pre-service science teachers who were seniors; the incomprehensible items were revised based on the feedback for the sake of clarity received from the pre-service teachers; and the application time of the scale was determined as 15 minutes.

Data Analysis

The SPSS 21 statistical analysis program was used to analyze the data obtained from the research. Descriptive statistical techniques (mode, median, arithmetic mean, standard deviation) were used to determine the general distribution of the responses of pre-service science teachers for the developed scale and to examine whether the data showed normal distribution. Central tendency (mean, mode and median) and central distribution (standard deviation, skewness and kurtosis) values of the scale scores were reported. In addition, frequency and percentage distributions were used in the analysis of the data.

FINDINGS

Results of the Scale Development

The draft scale, which was prepared in line with the opinions that were obtained from both experts and pre-service teachers, was applied to a total of 242 pre-service teachers who were studying at various departments of the education faculty of a state university in Ankara.

The Kaiser-Meyer-Olkin (KMO) value of the scale was calculated as .88, and it was found through the Bartlett Sphericity test ($p < .05$) that there was a significant difference in the data. Since the fact that the KMO value was greater than .70 and there was a significant difference in the Bartlett Sphericity test was considered as appropriate for factor analysis, it was concluded that factor analysis could be performed on these data (Leech, Barrett, & Morgan, 2005; Tavşancıl, 2010). In the next stage, factor analysis was applied to the scale. With factor analysis, items with a difference of less than 1 among those with a factor load of less than .30, which were simultaneously under multiple factors (M1, M2, M3, M5, M7, M10, M11, M14, M15, M16, M19, M23, M25, M26, M27, M29, M30, M32, M33, M38, M40, M41, M42, M43, M45), were removed from the scale; the analyses were repeated, and the factor load values of 20 items which remained in the final scale, were indicated in Table 2 after the number of factors was identified. Items with factor load values that are below .50 were excluded from the scale. Consequently, it is seen that the factor load values of the items in the literacy scale literacy for renewable energy resources vary between .52 and .90. It is sufficient for the factor load values to be above .30 (Bryman & Cramer, 2001).

Table 2. Distribution of items to factors and their factor loadings

Item Number	Factor 1	Item Number	Factor 2
I21	.89	I31	.90
I22	.88	I35	.85
I20	.87	I36	.80
I17	.86	I39	.78
I6	.84	I4	.69

I9	.84	I24	.62
I8	.81	I18	.60
I13	.80	I12	.57
I44	.70	I28	.52
I34	.62		
I37	.60		

Factors with an eigenvalue that is greater than 1.00 emerged as a result of the analysis of the basic components of the scale and the inclusion of the items with factor loads that are suitable for the desired level in the scale. The eigenvalues of the first two factors are significantly greater than the eigenvalues of the other factors, while the eigenvalues of the factors other than these two factors are close to each other and do not show sharp declines in the scree plot chart. Factors with sharp declines in the chart point to the number of factors (Singh, 2007). With the "scree plot" test of Cattel on such factors (Kline, 1994), the chart in Figure 1 was obtained. For this reason, the scale was accepted to have two factors and the results of these two factors are presented in Table 3.

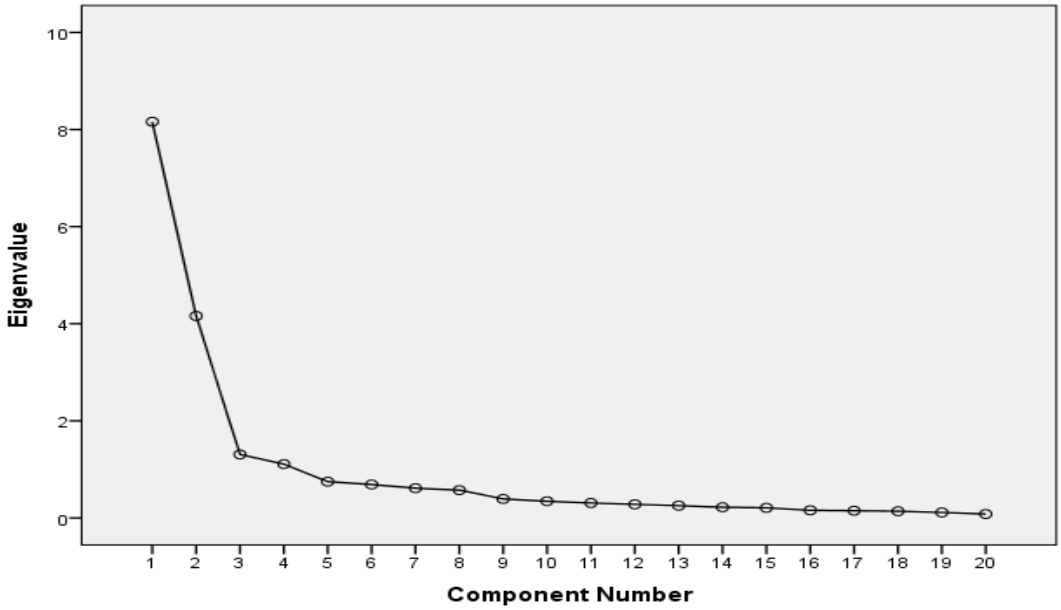

Figure 1. Literacy scale for renewable energy sources scree plot

Table 3. Factor analysis results

Factor	Eigenvalue	% of Variance	Cumulative %
1	8.16	40.80	40.80
2	4.16	20.79	61.59

Following the factor analysis, it was determined that 12 items in the scale were included in the first factor that is referred to as "Literacy in terms of the Types of Energy Resources, while 9 items were included in the second factor that is referred to as "Literacy in terms of Country and Environmental Problems". In addition, the items numbered I8, I13, I18, I21, I31, I34, I37, I39, I44 in the scale were identified as reverse items.

Finally, the internal consistency coefficient (Cronbach alpha) was calculated to determine the reliability of the scale. The internal consistency coefficient of the first and second sub-

dimensions, and the overall internal consistency coefficient of the scale were found to be .94, .88 and .91, respectively.

After the validity and reliability analyses were completed, a scale with two-sub-dimensions, which consists of 20 items, was obtained. The lowest and highest scores that can be received from the scale were identified as 0 and 40, respectively. In determining the cut-off points, the mean value ± 1 Standard deviation statistical approach, which was used by Tabacchi et al. (2020) in the food literacy scale was used to determine the breakpoint for categorizing individuals based on low, medium and high literacy for renewable energy sources. Therefore, one standard deviation below, and 1 standard deviation above the average score, and scores between the two indicate low literacy (scores below 16), high literacy (scores above 33), and medium literacy (scores between 16 and 33, including both), respectively. The scale is presented in the appendix.

After this stage, the scale was applied to junior pre-service science teachers, and their levels of literacy for renewable energy resources were identified.

Descriptive results regarding pre-service science teachers' literacy scale scores

After confirming the validity and reliability of the literacy scale for renewable energy resources (SLRER), the scale was applied to the pre-service science teachers, and the results for the responses of the pre-service teachers to the items in the scale are given in Table 4 and Table 5.

Table 4. Descriptive results regarding pre-service science teachers' literacy scale scores

Scale	N	M	Sd.	Mod	Median	Kurtosis	Skewness
SLRER	35	22.82	2.53	24.00	23.00	-.28	-.28

When the values given in Table 4 are examined, it is observed that the mode median and arithmetic mean have values that are close to each other. In addition, when the kurtosis and skewness values are examined, it is observed that these values are between -2 and +2. In this case, it can be stated that the data show a normal distribution (George & Mallery, 2003). When Table 4 is examined, it is determined that the total average score of the pre-service science teachers for the scale was 22.82. Based on this value, it was concluded that the literacy level of pre-service science teachers for renewable energy resources was medium.

Information on the percentage-frequency distribution of the responses of the pre-service teachers to the items in the scale is provided in Table 5.

Table 5. Percentage and frequency distribution of pre-service teachers' responses to the scale

	Yes		I don't have an opinion		No	
Scale Items	%	f	%	f	%	f
Item 4	51.4	18	25.7	9	22.9	8
Item 6	82.9	29	11.4	4	5.7	2
Item 8	-	-	2.9	1	97.1	34
Item 9	57.1	20	31.4	11	11.4	4
Item 12	68.6	24	14.3	5	17.1	6
Item 13	17.1	6	20.0	7	62.9	22
Item 17	85.7	30	14.3	5	-	-
Item 18	5.7	2	20.0	7	74.3	26
Item 20	91.4	32	5.7	2	2.9	1

Item 21	-	-	22.9	8	77.1	27
Item 22	75.3	26	25.7	9	-	-
Item 24	85.7	30	5.7	2	8.6	3
Item 28	77.1	27	17.1	6	5.7	2
Item 31	8.6	3	8.6	3	82.9	29
Item 34	68.6	24	17.1	6	14.3	5
Item 35	74.3	26	17.1	6	8.6	3
Item 36	85.7	30	8.6	3	5.7	2
Item 37	20.0	7	17.1	6	62.9	22
Item 39	11.4	4	17.1	6	71.4	25
Item 44	14.3	5	20.0	7	65.7	23

When the data obtained from Table 5 are examined, it is seen that the distribution of the responses of the pre-service science teachers to the scale varies according to the items. However, the responses that are given to four items stand out. First of all, almost all the pre-service teachers responded as no to the item, “Fossil fuels are renewable energy sources because they are formed as a result of natural processes”. Likewise, there were no pre-service teachers who responded “No” to the item, “Geothermal energy is formed by the heat accumulated in the depths of the earth’s crust as hot water, steam and gases”. Once again, no response of “No” was received from the pre-service teachers for the item, “Hydroelectric energy is obtained as a result of the difference in potential energy that water has”. Finally, a majority of the pre-service teachers responded “No” to the statement “Coal, oil and natural gas are some of the renewable energy resources”. According to the mentioned situations, it was seen that the pre-service teachers mostly had correct information about the mentioned items.

CONCLUSION, DISCUSSION AND SUGGESTIONS

In this research, a valid and reliable scale that aims to measure the literacy level of pre-service teachers for renewable energy resources was first developed. A review of the studies where a measurement tool on the subject was developed, revealed that there was only one study where an energy literacy scale was developed (Dewaters, Qaqish, Graham, & Powers, 2013). However, as emphasized before, no other measurement tools to measure the level of literacy for renewable energy sources were found in the literature.

The developed literacy scale for renewable energy resources was then applied to pre-service science teachers, whose literacy levels for renewable energy resources were examined. While the responses of the pre-service science teachers to the items in the scale differ based on the items, it was concluded that the literacy levels of the pre-service teachers for renewable energy sources were at a medium level. In most of the undergraduate programs, there is no course in which only renewable energy resources are explained, the importance of these resources is emphasized for a long time and literacy education is given for these resources. However, in the content of environmental courses, the subject of renewable energy sources is mentioned. It is thought that this is the reason why the literacy levels of the candidates for renewable energy sources are at a medium level. Although there are no studies in the literature, which directly measure the literacy levels of pre-service teachers for renewable energy resources, there are study results which show that pre-service teachers have a medium-level, positive attitude towards, and also a medium-level awareness for renewable energy resources. For example, in their study, Emlik (2017) concluded that the attitudes of pre-service teachers towards renewable energy resources were at a medium level. Similarly, in both the studies conducted by Bilen, Özel, and Sürücü (2013) and Akçöltekin and Doğan

(2013), it was observed that the attitudes of the pre-service teachers towards renewable energy were positive. However, both studies concluded that the pre-service teachers did not have sufficient knowledge about renewable energy sources. As a result of the study conducted by Tiftikçi (2014), it was observed that the renewable energy awareness levels of the students of science faculties and education faculties were at a medium level. Similarly, the study conducted by Yenice and Tunç (2018) found that the awareness of pre-service science teachers for environmental problems was at a positive level, while their attitudes towards renewable energy resources were close to a positive level.

The answers given to the items in the scale were examined. It was found that the pre-service teachers generally had high levels of literacy for the items in the "Literacy in terms of the Types of Energy Resources" dimension of the scale. However, it was observed that many pre-service teachers had higher levels of literacy, particularly for solar, wind, geothermal and hydroelectric energy compared to other renewable energy resources. The reason for this situation is that our country is in an extremely favorable position, especially in terms of hydraulic, geothermal, wind and solar energy potentials. Turkey uses energy sources such as hydraulic, wind, solar and geothermal more than other renewable energy sources to meet its electricity needs. In this respect, it is thought that pre-service teachers have a high level of literacy, especially for these resources. This situation is exactly in line with the results of the research conducted by Zyadin et al. (2014). Zyadin et al. (2014) found in their study that teachers have more knowledge about renewable energy resources such as solar, wind and geothermal energy, in particular, compared to other energy resources. Similarly, in the study conducted by Cebesoy and Karışan (2017), it was found that pre-service science teachers had more information about solar, wind, geothermal and hydroelectric energy and biomass than other types of energy, which are hydrogen and wave energy. However, unlike the findings of this study, the studies conducted by Çelik (2017) and Cırıt (2017) found that the pre-service science teachers did not have sufficient knowledge about the concept of renewable energy and energy resources, and the candidates could not distinguish between renewable and non-renewable energy resources. A review of the responses in Table 5 revealed that pre-service teachers were able to distinguish between renewable and non-renewable energy sources, and most of them did not view fossil fuels such as coal, oil and natural gas as renewable energy resources. However, in contrast to this, the study conducted by Saraç and Bedir (2014) concluded that some teachers lacked knowledge of renewable energy and were confused about the concepts in relation to renewable and non-renewable energy resources.

When the responses given by the pre-service teachers to the items related to the "Literacy in terms of Country and Environmental Problems" dimension of the scale were examined, the responses given to a few items, in particular, were noteworthy. Almost all the pre-service teachers viewed renewable energy resources as more environmentally friendly than fossil fuels, and thought that the use of such resources was of great importance in preventing the greenhouse effect and global warming. It is thought that pre-service teachers see renewable energy sources as more environmentally friendly than fossil fuels because of the environmental education they have received. Pre-service teachers take various environmental courses during their undergraduate education. The content of these courses includes topics such as environmental pollution, causes and consequences of environmental problems. Pre-service teachers who take these courses during their undergraduate education learn that one of the biggest causes of environmental problems is the increase in the use of fossil fuels. With the increase in population and industrialization, there is an increase in the use of fossil fuels and therefore carbon emissions. This results in the greenhouse effect and global warming. In line with the education they received, pre-service teachers establish this connection between

fossil fuels and the greenhouse effect/global warming and see renewable energy sources as more environmentally friendly. A review of the literature reveals that the studies on the subject support this result. In their study, Perez-Lombard, Ortiz, and Pout (2008) mentioned issues such as energy use, depletion of energy resources, thinning of the ozone layer, global warming and climate change in a rapidly developing world, and emphasized that studies should be carried out for the effective use of renewable energy. The results of the study conducted by Cebesoy and Karışan (2017) revealed that pre-service teachers view renewable energy as a permanent solution. It was seen that the pre-service teachers explained the reason for this thought as the fact that such resources cannot be depleted and they are harmless to the environment. In another study conducted by Bozdoğan and Yiğit (2014), it was concluded that pre-service teachers who were studying in various branches, support energy generation types, and view renewable energy resources as environmentally-friendly resources that do not harm the environment and human health. Likewise, the study conducted by Çelikler, Aksan, and Yılmaz (2017) found that students were aware that renewable energy resources were environmentally friendly. However, contrary to the results of this study, the study conducted by Halder, Havu-Nuutinen, Pietarinen, Zyadin, and Pelkonen (2014) concluded that science teachers did not have enough information about the effects of renewable energy resources on the environment, even though they had an acceptable level of knowledge about such resources. Again, one of the items in the table, which stand out, is the view of the vast majority of the pre-service teachers, indicating the lack of awareness on renewable energy resources as one of the reasons for their low level of use. Similarly, the study conducted by Kaldellis, Kapsali and Katsanou (2012) in Greece found that the public had a positive attitude on renewable energy, as their knowledge on it increased. In the literature, it is also emphasized that the public acceptance of environmentally-friendly energy resources is an important factor and that incomplete or incorrect information about energy and energy resources in individuals is an obstacle for them to seek solutions to environmental events such as global warming, and prefer to use appropriate energy (Wüstenhagen, Wolsink, & Bürer, 2007; Jennings, 2009; Kilinç, Stanisstreet, & Boyes, 2009; Akitsu, Ishihara, Okumura, & Yamasue, 2017; Demirbağ, 2019).

The environmental problems we face today and the rapid depletion of non-renewable energy resources, particularly fossil fuels, have drawn the attention of all the countries in the world to renewable energy resources. In this context, individuals who make up the societies should gain literacy for renewable energy resources to understand them, gain an awareness of and attitude towards this issue, and make conscious decisions in the selection of energy resources. In this respect, identifying and improving the literacy levels of teachers and pre-service teachers, who are the educators of the future societies, for renewable energy resources is considered to be quite important. In light of this information, studies for identifying the literacy levels of teachers and pre-service teachers who serve/study in various branches, for renewable energy resources can be conducted as future research.

REFERENCES

Akçöltekin, A. & Doğan, S. (2013). Sınıf öğretmenlerinin yenilenebilir enerji hakkındaki tutumlarının belirlenmesi. *International Journal of Social Science, 6*(1), 143-153.

Akitsu, Y., Ishihara, K. N., Okumura, H., & Yamasue, E. (2017). Investigating energy literacy and its structural model for lower secondary students in Japan. *International Journal of Environmental and Science Education, 12*(5), 1067-1095.

Aygan, M.B. & Kırbağ Zengin, F. (2017). Yenilenebilir enerji konusunda geçerliliği ve güvenilirliği sağlanmış bir başarı testi geliştirme çalışması, *International Journal of Eurasia Social Sciences, 8*(28), CXXXIX-CLV.

Balbağ, N. L. & Balbağ, M. Z. (2019). Sınıf ve fen bilgisi öğretmen adaylarının yenilenebilir enerji kaynaklarına yönelik tutumlarının bazı değişkenlere göre incelenmesi. *Eskişehir Osmangazi Üniversitesi Sosyal Bilimler Dergisi, 20*, 1209- 1222.

Bilen, K., Özel, M., & Sürücü, A. (2013). Fen bilgisi öğretmen adaylarının yenilenebilir enerjiye yönelik tutumları. *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi, 36*, 101-112.

Bodzin, A. (2012). Investigating urban eighth-grade students' knowledge of energy resources. *International Journal of Science Education, 34*(8), 1255-1275.

Bodzin, A.M., Fu, Q., Peffer, T.E., & Kulo, V. (2013). Developing energy literacy in US middle-level students using the geospatial curriculum approach. *International Journal of Science Education, 35*(9), 1561-1589.

Boz, V. (2020). *Enerji kaynaklarına ilişkin öğrenci görüşleri ve enerji okuryazarlığı: durum çalışması.* Yüksek Lisans Tezi. Yıldız Teknik Üniversitesi, Fen Bilimleri Enstitüsü.

Bozdoğan, A. E. & Yiğit, D. (2014). Öğretmen adaylarının alternatif enerji kaynaklarına yönelik görüşlerinin farklı değişkenler açısından incelenmesi. *Elektronik Eğitim Bilimleri Dergisi, 2*(3), 113-130.

Brounen, D., Kok, N., & Quigley, J. M. (2013). Energy literacy, awareness, and conservation behavior of residential households. *Energy Economics, 38*, 42-50.

Bryman, A. & Cramer, D. (2001). *Quantitative data analysis with SPSS release 10 for windows*. USA and Canada:.Routledge is an imprint of the Taylor & Francis Group.

Cebesoy, Ü. B. & Karışan, D. (2017). Fen Bilgisi Öğretmen adaylarının yenilenebilir enerji kaynaklarına yönelik bilgilerinin, tutumlarının ve bu kaynakların öğretimi konusundaki öz-yeterlik algılarının incelenmesi. *Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi, 14*(1), 1377-1415.

Chen, S. J., Chou, Y. C., Yen, H.Y., & Chao, Y.L. (2015). Investigating and structural modeling energy literacy of high school students in Taiwan. *Energy Efficiency, 8*(4), 791-808.

Cırıt, D. (2017). Fen bilgisi öğretmen adaylarının yenilenebilir enerji kaynaklarına ilişkin bilgileri. *Turkish Journal of Educational Studies, 4*(3), 21-43.

Cotton, D.R.E., Miller, W., Winter, J., Bailey, I., & Sterling, S. (2015). Developing students' energy literacy in higher education. *International Journal of Sustainability in Higher Education, 16*(4), 456-473.

Çelik, E. (2017). *Yenilenebilir enerji kaynaklarının fen eğitimindeki önemi*. Yüksek Lisans Tezi. Mersin Üniversitesi, Eğitim Bilimleri Enstitüsü.

Çelikler, D. & Aksan, Z. (2016). The development of an attitude scale to assess the attitudes of high school students towards renewable energy sources. *Renewable and Sustainable Energy Reviews*, 54, 1092–1098.

Çelikler, D., Aksan, Z., & Yılmaz, A. (2017). Ortaokul öğrencilerinin yenilenebilir enerji kaynakları konusundaki farkındalıkları. *IV. International Eurasian Educational Research Congress*, Denizli.

Demirbağ, G. (2019). *Ortaokul öğrencilerinin yenilenebilir enerji kullanımına yönelik niyetlerinin planlı davranış teorisi bağlamında incelenmesi: bir yapısal eşitlik modellemesi araştırması.* Yüksek Lisans Tezi. Kırşehir Ahi Evran Üniversitesi, Fen Bilimleri Enstitüsü.

DeWaters, J. & Powers, S. (2013). Establishing measurement criteria for an energy literacy questionnaire. *The Journal of Environmental Education, 44*(1), 38-55.

DeWaters, J. E. & Powers, S. E. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. *Energy Policy, 39*(3), 1699-1710.

DeWaters, J., Qaqish, B., Graham, M., & Powers, S. (2013). Designing an energy literacy questionnaire for middle and high school youth. *Journal of Environment Education, 44*(1), 56–78.

Emlik, H. (2017). *Öğretmen adaylarının yenilenebilir enerji kaynaklarına karşı tutumları ile enerjinin etkin kullanımı ve teknolojik kirlilik farkındalıkları arasındaki ilişkinin incelenmesi*. Yüksek Lisans Tezi. Kahramanmaraş Sütçü İmam Üniversitesi, Fen Bilimleri Enstitüsü.

Fah, L.Y., Hoon, K.C., Munting, E. T., & Chong, C.A. (2012). Secondary school students' energy literacy: Effect of gender and school location. *OIDA International Journal of Sustainable Development, 3*(7), 75- 86.

Fırat, A., Sepetçioğlu, H., & Kiraz, A. (2012). Öğretmen adaylarının yenilenebilir enerjiye ilişkin tutumlarının incelenmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, Özel Sayı 1,* 216-224.

Gelen, İ. (2017). P21- 21st century skill frameworks in curriculum and instruction (USA practices). *Journal of Interdisciplinary Educational Research, 1*(2), 15-29.

George, D. & Mallery, P. (2003). Using SPSS for Windows step by step: a simple guide and reference (4th ed.). London: Pearson Education.

Göcük, A. & Şahin, F. (2016). The effect of problem based learning on 5th grades students' energy literacy. *Journal of Human Sciences, 13*(2), 3446-3468.

Görgülü Arı, A. & Arslan, K. (2019). Çoklu yazma etkinliklerinin kullanılmasının öğrencilerin enerji okuryazarlıkları üzerine etkisi. *International Social Sciences Studies Journal, 5*(47), 5892-5907.

Güneş, T., Alat, K., & Gözüm, A. İ. C. (2013). Fen öğretmeni adaylarına yönelik yenilenebilir enerji kaynakları tutum ölçeği: Geçerlilik ve güvenirlik çalışması. *Eğitim Bilimleri Araştırmaları Dergisi - Journal of Educational Sciences Research, 3*(2), 269-289.

Güven, G., Yakar, A., & Sülün, Y. (2019). Enerji okuryazarlığı ölçeğinin Türkçeye uyarlanması: geçerlilik ve güvenilirlik çalışması. *Çukurova Üniversitesi Eğitim Fakültesi Dergisi, 48*(1), 821-857.

Halder, P., Havu-Nuutinen, S., Pietarinen, J., Zyadin, A., & Pelkonen, P. (2014). Subject knowledge and perceptions of bioenergy among school teachers in India: results from a survey. *Resources, 3*(4), 599-613.

Horst, D., Harrison, C., Staddon, S., & Wood, G. (2016). Improving energy literacy through student-led fieldwork at home. *Journal of Geography in Higher Education, 40*(1), 67-76.

Jennings, P. (2009). New directions in renewable energy education. *Renewable Energy, 34*(2), 435–439.

Kaldellis, J.K., Kapsalı, M., & Katsanou, E. (2012). Renewable energy applications in Greece-What is the public attitude? *Energy Policy, 47*, 37-48.

Kandpal, T. C. & Broman, L. (2014). Renewable energy education: a global status review. *Renewable and Sustainable Energy Reviews, 34*, 300-324.

Karasar, N. (2014). *Bilimsel araştırma yöntemi*. Ankara: Seçkin Yayıncılık.

Kılınç, A., Stanisstreet, M., & Boyes, E. (2009). Incentives and disincentives for using renewable energy: Turkish students' ideas. *Renewable and Sustainable Energy Reviews, 13*, 1089-1095.

Kline, P. (1994). *An easy guide to factor analysis.* London: Routledge.

Lay, Y. F., Khoo, C. H., Treagust, D. F., & Chandrasegaran, A. L. (2013). Assessing secondary school students' understanding of the relevance of energy in their daily lives. *International Journal of Environmental and Science Education, 8*(1), 199-215.

Lee, L. S., Lee, Y.F., Altschuld, J. W., & Pan, Y. J. (2015). Energy literacy: evaluating knowledge, affect, and behavior of students in Taiwan. *Energy Policy, 76*, 98-106.

Leech, N. L., Barrett, K. C., & Morgan, G. A. (2005). *SPSS for Intermediate Statistics: Use and Interpretation.* NJ: Lawrence Erlbaum Associates, Inc.

Liarakou, G., Gavrilakis, C., & Flouri, E. (2009). Secondary school teachers' knowledge and attitudes towards renewable energy sources. *Journal of Science Education and Technology, 18*(2), 120–129.

Merritt, E. G., Bowers, N., & Rimm-Kaufman, S. E. (2019). Making connections: elementary students' ideas about electricity and energy resources. *Renewable Energy, 138*, 1078-1086.

Mertoğlu, Ç. (2019). *Üniversite öğrencilerinin yenilenebilir enerji kaynakları konusundaki farkındalık düzeylerinin belirlenmesi.* Yüksek Lisans Tezi. Ondokuz Mayıs Üniversitesi, Eğitim Bilimleri Enstitüsü.

Milli Eğitim Bakanlığı (MEB), (2018b). *İlköğretim fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı.* Ankara.

Milli Eğitim Bakanlığı (MEB), (2018c). *Ortaöğretim biyoloji dersi (9, 10, 11 ve 12. sınıflar) öğretim programı.* Ankara.

Milli Eğitim Bakanlığı (MEB), (2018d). *Ortaöğretim coğrafya dersi (9, 10, 11 ve 12. sınıflar) öğretim programı.* Ankara.

Milli Eğitim Bakanlığı (MEB), (2018e). *Ortaöğretim kimya dersi (9, 10, 11 ve 12. sınıflar) öğretim programı.* Ankara.

Milli Eğitim Bakanlığı (MEB). (2018a). *Ortaokul fen bilimleri 6. sınıf ders kitabı.* Ankara.

Mutlu, O. (2016). *Fen dersleri (fizik, kimya ve biyoloji) öğretmen adaylarının yenilenebilir enerji farkındalık düzeylerinin incelenmesi*. Yüksek Lisans Tezi. Süleyman Demirel Üniversitesi, Eğitim Bilimleri Enstitüsü.

Oluk S., Kaya Şengören, S., & Babadağ, G. (2019). Öğretmen adaylarının enerji tasarrufuna yönelik tutum ve davranışlarının bazı değişkenler açısından değerlendirilmesi. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi,* (47), 1- 13.

Öykün, T., & Abbasoğlu, S. (2017). Energy literacy survey at high schools in Northern Cyprus. *International Journal of New Trends in Arts, Sports & Science Education, 6*(2), 1-16.

Pérez-Lombard, L., Ortiz, J., & Pout, C. (2008) A review on buildings energy consumption information. *Energy and Buildings, 40*, 394-398.

Saraç, E. & Bedir, H. (2014). Sınıf öğretmenlerinin yenilenebilir enerji kaynakları ile ilgili algılamaları üzerine nitel bir çalışma. *Kara Harp Okulu Bilim Dergisi, 24*(1), 19–45.

Singh, K. (2007). *Quantitative social research methods*. Los Angeles: Sage Publications.

Sovacool, B.K. & Blyth, P.L. (2015). Energy and environmental attitudes in the green state of Denmark: implications for energy democracy, low carbon transitions, and energy literacy. *Environmental Science & Policy, 54*, 304-315.

Sülükçüler, S. (2018). *Yenilenebilir enerji potansiyelinin ortaya çıkmasında kamu teşviklerinin etkisi: OECD ülkeleri ve Türkiye karşılaştırması.* Yüksek Lisans Tezi. Manisa Celal Bayar Üniversitesi, Sosyal Bilimler Enstitüsü.

Tabacchi, G., Battaglia, G., Alesi, M., Paoli, A., Palma, A., & Bellafiore, M. (2020). Food literacy predictors and associations with physical and emergent literacy in pre-schoolers: results from the training-to-health project. *Public Health Nutrition, 23*(2), 356-365.

Taşlıbeyaz, E. (2019). Z kuşağı ile ilgili araştırma eğilimlerinin analizi ve eğitime yönelik katkıları. *Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 21*(3), 715-729.

Tavşancıl, E. (2010). *Tutumların ölçülmesi ve SPSS ile veri analizi*. Ankara: Nobel Yayın Dağıtım.

Tiftikçi, H. İ. (2014). *Farklı bölümlerde öğrenim görmekte olan son sınıf üniversite öğrencilerinin yenilenebilir enerji kaynakları hakkındaki farkındalıkları.* Yüksek Lisans Tezi. Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü.

U.S. Department of Energy, (2017). Energy literacy: essential principles and fundamental concepts for energy education. Retrieved June 1, 2021, from https://www.energy.gov/eere/education/energy-literacy-essential-principles-energy-education

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007) Social acceptance of renewable energy ınnovation: an ıntroduction to the concept. *Energy Policy, 35*, 2683-2691.

Yakıncı, Z. D. & Kök, M. (2017). Yenilenebilir enerji ve toplum sağlığı. *İnönü Üniversitesi Sağlık Hizmetleri Meslek Yüksek Okulu Dergisi, 5*(1), 43-55.

Yenice, N. & Tunç, G. (2018). Fen bilgisi öğretmen adaylarının çevre sorunlarına yönelik farkındalıkları ile yenilenebilir enerji kaynaklarına yönelik tutumlarının incelenmesi. *Uludağ Üniversitesi, Eğitim Fakültesi Dergisi, 31*(1), 207- 222.

Zainudin, W. N. R. A B., & Ishak, W. W. M. (2019). The scale validation of public participation of renewable energy (re) development in Malaysia: an exploratory factor analysis (EFA). *International Journal of Recent Technology and Engineering (IJRTE), 7*(4S2), 44-48.

Zyadin, A., Puhakka, A., Ahponen, P., & Pelkonen, P. (2014). Secondary school teachers' knowledge, perceptions, and attitudes toward renewable energy in Jordan. *Renewable Energy*, 62, 341-348.

APPENDIX

YENİLENEBİLİR ENERJİ KAYNAKLARINA YÖNELİK OKURYAZARLIK ÖLÇEĞİ			
İfadeler	**Evet**	**Fikrim Yok**	**Hayır**
4. Yenilenebilir enerji kaynaklarının kullanımı ülkenin enerjide dışa bağımlılığını azaltır.			
6. Dünyanın temel enerji kaynağını oluşturan güneş, aynı zamanda en önemli yenilenebilir enerji kaynağıdır.			
8. Fosil yakıtlar doğal süreçler sonucu oluştuğu için yenilenebilir enerji kaynaklarıdır.			
9. Biyokütle enerjisi doğada yaşamını sürdüren hayvan ve bitkilerin atıkları ile üretilen enerji çeşididir.			
12. Doğayı korumak için yalnızca yenilenebilir enerji kaynaklarının kullanılması yeterli değildir.			
13. Dalga enerjisi yenilenemez bir enerji çeşididir.			
17. Jeotermal enerji, yer kabuğunun derinliklerinde birikmiş olan ısının yüzeye sıcak su, buhar ve gazlar olarak çıkması ile oluşur.			
18. Yenilenebilir enerji kaynaklarının kullanımı çok büyük maliyetler gerektirdiği için devamlı kullanılması çevre için daha zararlıdır.			

20. Rüzgâr enerjisi elektrik enerjisinin temin edilmesinde kullanılır.			
21. Kömür, petrol, doğalgaz yenilenebilir olan enerji kaynaklarından bazılarıdır.			
22. Hidroelektrik enerji suyun sahip olduğu potansiyel enerji farkı sonucu elde edilir.			
24. Yenilenebilir enerji kaynaklarının kullanımı sera etkisi ve küresel ısınmanın önlenmesinde büyük önem taşır.			
28. Fosil yakıtlar insan, hayvan ve sanayi tesislerinin istismarı sonucu yakın gelecekte tamamen tükenme tehlikesi ile karşı karşıyadır.			
31. Yenilenebilir enerji kaynaklarının kullanılması ülke ekonomisine katkı sağlamaz.			
34. Jeotermal kaynaklardan biyokütle enerjisi elde edilir.			
35. Çevre kirliliğini önlemede yalnızca bir ülkenin yenilenebilir enerji kaynaklarını kullanması yeterli değildir.			
36. Yenilenebilir enerji kaynaklarının az kullanılmasının nedenlerinden biri de bu konudaki bilinçsizliktir.			
37. Artan enerji talebini karşılayabilmek için fosil yakıtların kullanımına ağırlık verilmelidir.			
39. Yenilenebilir enerji kaynaklarının kullanımı doğal kaynakların daha hızlı tükenmesine neden olur.			
44. Nükleer enerji de bir çeşit yenilenebilir enerji kaynağıdır.			

Note: 8, 13, 18, 21, 31, 34, 37, 39, 44 are reverse items.