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Contact Info

Journal of Education in Science, Environment and Health (JESEH)
Email: jesehoffice@gmail.com
Web : www.jeseh.net

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An Analysis of the Concept of Water in Secondary School Biology Textbooks

Musa Dikmenli, Vedat Kadir Ozkan, Selda Kilic, Osman Cardak

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Abstract

As a result of human beings' activities to dominate nature and transform it for their own benefit as they continue to advance in science and technology, environmental problems such as climate change have become the biggest threat faced by the biosphere in the current century. One of the biggest problems of humanity today is the scarcity of water resources. It is important to reveal the meanings attributed to the concept of water in biology textbooks in order to identify and eliminate the deficiencies or gaps between the concepts related to the subject. The main purpose of this study is to analyze how the concept of water is presented in secondary school biology textbooks. In line with this purpose, answers to the following questions were sought: What biological concepts is water associated with in biology textbooks and how often is it used? Under which categories can the concept of water be classified in biology textbooks? In the study, document analysis was conducted on four biology textbooks published by the Ministry of National Education to be taught in high schools in the 2023-2024 academic year. A qualitative methodology based on inductive logic was used to analyze the data. How water is emphasized in biology textbooks was discussed, and categories were developed to conceptualize explanations about water. These categories were: water as a substance in the structure of organisms, water as a habitat for organisms, water as a substance involved in chemical reactions, water as a human health factor, water as an essential requirement for organisms, water as an environmental problem factor and water as a scarcity factor. According to the results of the textbook content analysis, it was seen that the relationships between water and health concepts in the category of water as a human health factor were well structured. In the study, it was seen that the concept of water was presented in accordance with the target achievements in line with the secondary school biology course curriculum and that the key concepts were given literally. However, it was revealed that the concept of water in textbooks should be structured according to the principles of the systems thinking approach.

Introduction

It is estimated that organic life on earth first started in water and then spread throughout the world. Looking at the past, it is seen that human communities settled down, started agriculture and established civilizations on the banks of water. The civilizations established around the Nile River in Egypt, the Euphrates and Tigris in Mesopotamia, the Yellow River in China and the Ganges River in India are examples of these. This shows that human beings were aware of the need to live close to fresh water to survive. Early civilizations knew the importance of water in preventing life-threatening famine. Water was also considered a vital substance by ancient philosophers. For example, Thales (624-548 BC) argued that all substances on earth were composed of water. According to him, the building block of all substances was water. Things that did not look like water were also made of water or were a kind of water that had changed. In short, the main substance of the world was water. Hippocrates (460-370 BC), in his study "On airs, waters and places", questioned the relationship between environmental factors and human health, and the effects of wind, seasons and water on human physical and mental health. Aristotle (384-322 BC), on the other hand, attributed the differences between the peoples of Europe and Asia to climatic differences and stated that countries with favorable climatic conditions would develop faster.

As a result of human beings' activities to dominate nature and transform nature for their own benefit as they continue to advance in science and technology, environmental problems such as climate change have become the biggest threat faced by the biosphere in the current century. The most important substance associated with

climate change is water, because climate change affects the water cycle, and the water cycle affects the climate. As a result of these interactions, problems related to water resources, energy, food, health and biodiversity arise for human beings. Water is a substance consisting of two molecules of hydrogen and one molecule of oxygen, has its own important physical and chemical properties, provides living organisms with the opportunity to live thanks to these properties, fills seas, lakes and rivers and is normally in liquid form.

More than two-thirds of the earth is covered with water. Land covers 29% of the earth's surface. There is approximately 1.3 billion km^3 of water on Earth. This water is found in oceans, rivers, lakes, underground, in clouds, and also in solid form in glaciers and ice sheets. Only 2.5-3% of the water on Earth is fresh water, and most of this water is trapped in glaciers and ice sheets and locked in frozen soil. These water resources are inaccessible, that is, they cannot be used. This reduces the amount of usable freshwater in liquid form on Earth to 1%. For every bathtub full of seawater on Earth, there are only 4 teaspoons of fresh water in all lakes, rivers and the atmosphere. Of this 1%, 74% is used in agriculture, 15% at home and 11% in industry. The availability of usable water is vital for the diversity of living organisms in freshwater ecosystems, food security and sustainable development. Therefore, freshwater resources need to be protected.

One of the biggest problems faced by humanity today is limited water resources. Sustainability of water resources is at the root of many problems such as food security, energy need, population growth, economic growth, climate change and biodiversity loss. Water is vital for the continuation of human existence. Access to usable water and water quality issues are among the biggest challenges of humanity today. Important topics such as weather and climate cannot be adequately understood or explained without a basic scientific understanding of the water cycle and the properties of water. Therefore, understanding the dynamic nature of water systems is becoming increasingly important as water scarcity and other water problems arise in many countries due to factors such as drought and pollution (Sadler, Nguyen, & Lankford, 2017). Although Türkiye seems to be a country that does not face water problems, it is a country on the edge of water scarcity. There was a 40.5% increase in the total amount of water consumed between 1990 and 2010.

Pan and Liu (2018) investigated secondary school students' understanding of groundwater as a system and whether their understanding was related to attitudes towards groundwater use and conservation. Analysis of student drawings showed that students generally had an incomplete and disconnected understanding of the groundwater system. Correlation analysis showed that students' levels of understanding correlated with their perceptions of environmental impacts as well as environmental concerns about groundwater issues. These findings once again emphasized the importance of developing students' systematic thinking abilities and their understanding of environmental systems. The findings also showed that understanding the characteristics of the groundwater system (its internal structure and its relationship with the larger environment) is important for understanding the environmental impacts of groundwater problems and for raising environmental awareness.

Covitt, Gunckel, and Anderson (2009) examined the development of students' understanding of water within environmental systems. The researchers developed a framework of grounded curricular goals for water literacy and documented the challenges students faced in achieving these goals. Water-related environmental literacy requires an understanding of the state changes of water as a substance and of large-scale interconnected natural and human-engineered systems, ranging from atomic-molecular such as solutions to large watersheds, groundwater, and human water treatment and distribution systems. The researchers' assessments of primary and secondary school students showed that nearly all students had some important understandings about water that educators could improve. However, the researchers also found that most students did not consider water and other materials with the systems thinking approach and did not take into account the invisible aspects of water systems at the atomic-molecular level and at landscape scales. The results revealed that a discrepancy existed between students' informal explanations of water in environmental systems and scientific explanations of these systems. This study on students' understandings showed that they were not developing basic water literacy in school and that the current K-12 standardized science curriculum did not support water literacy development. The researchers discussed curriculum practices and recommendations that can help students develop a richer understanding of water systems at various scales. Although many areas must be addressed to prepare students for civic responsibilities, the importance of creating a strong K-12 science curriculum that provides students with the tools to make conscious decisions should not be overlooked.

As with groundwater, the fact that water systems are often hidden and invisible causes students to encounter some conceptual challenges when learning this subject. Although many students can easily appreciate the fact that water can be stored underground, they have limited understanding of the connections between surface water and groundwater and the connections between geologically mediated waters (Sadler et al., 2017). The state change of water as a substance and the water cycle can also be included in these challenges. Groundwater is

often a missing component in students' conceptualization of the water cycle (Shepardson, Wee, Priddy, Schellenberger, & Harbor, 2007). Despite the importance of water and basic water-related concepts in developing scientifically literate individuals, surprisingly few studies have focused on the concept of water in the context of textbooks. In the existing literature, it is seen that researchers have mostly focused on issues such as the water cycle understanding of students and teacher candidates in various age groups (Ben-Zvi Assaraf & Orion, 2005a; Cardak, 2009). There are also past studies revealing that students have misconceptions or alternative concepts about water (Dickerson, Callahan, Van Sickle, & Hay, 2005) and focusing on addressing such misconceptions through strategies such as mental model building (Reinfried, 2006). Regarding water, students have misconceptions or alternative understandings, especially about the water cycle, and these misconceptions have the potential to hinder their understanding of accurate explanations of the movement of water into and out of the atmosphere (Romine, Schaffer, & Barrow, 2015). Since cycle is a process that operates in different times and places, it is a difficult concept for students to understand. Agelidou, Balafoutas, and Gialamas (2001) stated that students generally perceive substance cycles as time-based natural cycles, such as the cycle of life or the cycle of seasons, rather than the transportation and state change of substance, as in the example of the water cycle. In order to learn the water cycle, students need to have knowledge about the properties of water and the heat exchange between the Earth and the Sun. In addition, the concepts of energy transfer during the water cycle are difficult for most students because they relate to a state of substance that is mostly invisible. Discussions about energy levels, such as potential and kinetic energy, tend to be abstract rather than concrete, which increases the likelihood of misunderstanding (Canpolat, 2006; Henriques, 2002). There are also studies that question students' water literacy. For example, Yentür, Sözcü, and Aydınözü (2022) investigated the water literacy levels of high school students. As a result of the analysis, it was concluded that high school students in Türkiye Istanbul sample were moderately water literate. In terms of the sub-dimensions of water literacy, it was observed that they had medium level literacy in water awareness and water sensitivity and high level literacy in water saving. In addition, it was determined that the variables such as gender, school type, grade level, parents' education level, family income level were effective on the water literacy levels of high school students.

Ozalemdar (2019) analyzed the biology textbooks used in secondary education institutions in Türkiye in 2016 and prepared by the Ministry of National Education in order to reveal the importance of water in biology education. The researcher classified the concept of water according to the units in the textbooks and emphasized that the units generally focused on the structure and properties of water. The findings revealed that water has a special place in biology education and that biology education is an important tool in conveying the importance of water for living things. Hussein (2018) conducted a critical study on water scarcity discourses in textbooks and education policy in Jordan. This study analyzed how the discourse of water scarcity is constructed in Jordanian textbooks to understand its role in improving education on environmental sustainability. Teachers and students were also interviewed about water scarcity. The framing of the causes of water scarcity in textbooks tends to move towards a trend towards increasing water resources. However, it is also important to reduce water demand or to save water in better management of water resources. The water scarcity discourse constructed in textbooks presents best practices and aims to shape students' behavior towards the environment. This is especially true in water conservation.The students are advised to use water more efficiently and reduce water waste at the household level, as well as in gardening and farming practices. The textbooks in Jordan emphasize environmental sustainability and encourage individuals to become agents of change by changing their daily behavior towards the use of environmental resources.

According to Tshuma and Sanders (2015), textbooks are widely used by students and teachers and serve as a vital educational tool for them, especially in times of curriculum change. In this process, biology textbooks are considered to be accurate in terms of scientific content. Dikmenli and Çardak (2004), in their study on misconceptions in high school 1st grade biology textbooks, determined the misconceptions in the unit "Cell, the Basic Unit of Life" in the 2003-2004 academic year. They analyzed 4 high school 1st grade biology textbooks and found misconceptions in 3 of them. As a result of the analysis, 14 misconceptions and 10 missing information were identified. Dikmenli (2010) analyzed the analogies used in secondary school biology textbooks in line with certain criteria and found that the use of analogies in biology textbooks is quite common. The researcher reported that many metaphorical expressions and analogies were used in the textbooks. In this study, it was revealed that the analogies used in high school biology textbooks were generally structural, verbal, simple, embedded activating and concrete-abstract type analogies. Despite the advances in instructional technologies and material design, textbooks remain important today. Textbooks are frequently used by both students and teachers, especially in schools where written exams are common and laboratory facilities are limited. Teachers and students see textbooks as reliable sources of information. Therefore, content analysis is very important for textbooks to be efficient. In terms of the function of textbooks, these tools must be qualified because students see textbooks as the source of all information. In order for the textbooks to fully perform their

functions, they must be scientifically adequate and in accordance with the objectives of the secondary education biology curriculum. Analyzing secondary school biology textbooks prepared in line with curriculum objectives, identifying deficiencies, if any, and eliminating them in the next textbooks is important for the quality of biology teaching.

Significance of the Study

Although the above-mentioned studies provide useful information about students' ideas about water, little is known about how biology textbooks conceptualize water and water systems. Effective teaching in biology classes depends on the communication strategies used by textbook writers and teachers. Biology by its very nature involves abstract concepts at the microscopic and sub-microscopic levels. Especially in a situation where the students lack sufficient terminology, how to teach a new and abstract concept is an important problem. In such cases, establishing common bonds necessary for communication between individuals becomes difficult, communication weakens and mental confusion begins. In order to avoid such confusion, the writer, who is the source of communication, often aims to use simple, clear and understandable sentences while trying to explain a concept such as water. There is no detailed research on how often the concept of water is used in secondary school biology textbooks and which biological concepts it is associated with. Therefore, it is necessary to analyze how water, which is of vital importance for the future of the biosphere and all living things in it, is presented in biology textbooks. Constructivist epistemology argues that it is important to reveal what students already know and understand about scientific concepts, because prior knowledge affects subsequent learning. If good learning outcomes are to be achieved, previous ideas should not be ignored, because they can form the basis of conceptual restructuring which in turn can lead to meaningful learning. From this perspective, explanations about water in biology textbooks affect students' conceptual framework and effective learning. For this reason, the concept of water in textbooks needs to be analyzed and filtered. Revealing the meanings attributed to the concept of water in biology textbooks is important in terms of identifying and eliminating the deficiencies or gaps between the concepts related to the subject. In this study, how water, which is of vital importance for the future of humanity, is conceptualized in biology textbooks was examined. It was revealed how the explanations about water in the textbooks were presented to the reader. We believe that by analyzing the concept of water in biology textbooks, ideas and suggestions that can be useful for textbook writers, teachers, students and curriculum developers can be developed.

Purpose of the Study

The main purpose of this study is to analyze how the concept of water is presented in secondary school biology textbooks. In line with this purpose, answers to the following questions were sought: (1) Which biological concepts is water associated with in biology textbooks and how often is it used? (2) Under which categories can the concept of water be classified in biology textbooks?

Method

In this study, using a qualitative research model, document analysis method was used as a data collection technique. The document analysis method is defined as collecting, reviewing, questioning and analyzing documents as the primary data source in research data. Document analysis includes the analysis of written materials containing information about the phenomenon or phenomena targeted to be investigated (Yıldırım and Şimşek, 2016, p. 189). The document source of the study consists of secondary school biology textbooks.

Biology Textbooks Analyzed

Four biology textbooks were published by the Ministry of National Education for high school students for the 2023-2024 academic year. Therefore, in this study, four biology textbooks for 9th, 10th, 11th and 12th grades prepared in line with the secondary biology curriculum were analyzed. These textbooks were used in high schools all over Türkiye with the approval of the Ministry of National Education. No comparison was made between the textbooks in terms of content, as the textbooks were a continuation of each other. The textbooks were coded as Book A (9th grade), Book B (10th grade), Book C (11th grade) and Book D (12th grade).

Book A: Acar, B., Tousun, Z.D., Vurgun, A., Sarız, M. (2022). *Secondary School Biology 9 Textbook*. Ministry of National Education publications, 6965. (Accepted as a textbook by the decision of the Ministry of National Education, Board of Education and Discipline numbered 8 and dated 18.04.2019).

Book B: Bagatır, A., Yüceler, B.B., Atalay, N., Tokgöz, H., Yılmaz, U.G. (2021). *Secondary School Biology 10 Textbook*. Ministry of National Education publications, 6770. (Accepted as a textbook with the decision of the Ministry of National Education, Board of Education and Discipline numbered 78 and dated 28.05.2018).

Book C: Dolaşık, N., Bakioğlu, T., Sahranç, U., Yılmaz, U.G. (2023). *Secondary School Biology 11 Textbook*. Ministry of National Education publications, 8885. (Accepted as a textbook by the decision of the Ministry of National Education, Board of Education and Discipline numbered 02 and dated 04.01.2023).

Book D: Olgun, H., Topu, M., Akad, İ., Doğan Abdioğlu, M. (2022). *Secondary School Biology 12 Textbook.* Ministry of National Education publications, 8877. (Accepted as a textbook by the decision of the Ministry of National Education, Board of Education and Discipline numbered 95 and dated 28.11.2022).

Analysis of Data

A qualitative methodology based on inductive logic was used for the analysis. Each book was carefully read in its entirety by all four researchers, paying attention to the text and visuals. The researchers independently took notes about the water-related explanations they encountered in the textbooks. In the four biology textbooks analyzed, many sentences and images containing explanations about water were identified. However, only 671 of them were evaluated in this study. The reasons why the rest were excluded from the scope of the study are given in detail in "Stage 2" below. The analysis and interpretation of the explanations about "water" were carried out in the following stages: (1) naming stage, (2) eliminating and sorting stage, (3) reviewing and category development stage, (4) ensuring validity and reliability stage, (5) transferring the data to the SPSS package program for digitizing qualitative data.

Stage 1: Naming Stage

At this stage, a provisional list of water-related explanations was made in all four textbooks. In this process, the books were read once more, and the explanations about water were underlined and coded. For example, "water " was marked as an environmental problem factor in the sentence "*When chemicals and pollutants exceed the normal value in ground and surface waters and disrupt the physical, chemical and biological structure of water, this is called water pollution* (Book B, p. 172)". These sentences were transferred to a Microsoft Word file on the computer and then printed out to be analyzed independently of other texts in the book. In each sentence, it was checked whether water was mentioned explicitly and whether it contained any visuals, and those that were not explicit were marked with a colored pencil to be eliminated later.

Stage 2: Eliminating and Sorting Stage

At this stage, "content analysis" technique (Saban, Koçbeker, & Saban, 2006; Yıldırım & Şimşek, 2016) was used to analyze each explanation about water in terms of common characteristics with other explanations about water. In this process, the explanation in each sentence was analyzed in two aspects: (1) the category it represents in terms of meaning and (2) the biological concepts it is related to. In such a sentence, both the category that the explanation about water belongs to in terms of meaning and the biological concepts related to water were determined. For example, a sentence such as "*Water undergoes photolysis in the light-dependent reactions of photosynthesis* (Book D, p.84)" was categorized as "*water as a substance involved in chemical reactions*" and the water-related biological concepts in this sentence were marked as "*photosynthesis, light, reaction, water, photolysis*". Water-related concepts were listed separately for each category. It should be noted that not all sentences containing the term "water" represented the concept of water in terms of meaning. Therefore, such sentences were excluded from the evaluation. For example, the Turkish equivalent of "chickenpox", an infectious disease, is "water flower". The sentences containing such nomenclature were not included in the evaluation. In addition, the terms "water" used in the experimental procedures and multiple-choice question texts at the end of the units were not included in the evaluation.

Stage 3: Reviewing and Category Development Stage

After the sorting process, 671 sentences containing explanations about water were obtained. The distribution of these sentences according to the books is shown in Table 1. At this stage, these sentences were rearranged in alphabetical order with the meaning they expressed and the biological concepts they were related to, and the sentences were reviewed for the third time. A sample sentence was selected for each category. Thus, a list of categories was created by compiling the 671 sentences deemed to best represent the meaning they express. This list was compiled for two main purposes: (1) to use it as a reference source for grouping 671 sentences under certain categories and (2) to validate the data analysis process and interpretations of this study. Finally, 7 conceptual categories were developed by considering the common features related to the meanings of the explanations in the sentences. In this process, firstly, based on the previously created category list, the sentences of each category were analyzed in terms of their meaning and coded with a certain code (e.g. health, scarcity, environmental problem). These codes were then transformed into conceptual categories. For example, the explanations in the sentences under the category "water as a scarcity factor" all associate water with a possible danger of scarcity. For example, "*The global population is predicted to reach 9 billion by 2050, and 65% of the population will face severe water scarcity* (Book B, p.180)". The categorization in the category development process continued until all four researchers reached a consensus. It should be noted that in each sentence of the categories, while listing the biological concepts related to water, synonyms were combined under the name of the most frequently repeated one. For example, living being, organism, plant organism, animal organism, photosynthetic organism, consumer organism, microorganism, transgenic microorganism, prokaryotic organism were all combined under the name "organism". Information on the book and page in which a sentence explanation was found was coded in parentheses at the end of that sentence. In this context, the abbreviation "A/B/C/D" in parentheses symbolized the book type and "s" symbolized the page number.

Table 1. Percentage of sentences containing water-related explanations in secondary school biology textbooks

Textbooks	n	%
Book A	194	28,91
Book B	126	18,78
Book C	127	18,93
Book D	224	33,38
Total	671	100

Stage 4: Ensuring Validity and Reliability

Validity and reliability are the two most important criteria used to ensure or increase the credibility of research results. In this context, "Reporting the collected data in detail and explaining how the researcher reached the results are among the important criteria of validity in a qualitative research (Yıldırım and Şimşek, 2016, p.270). Specific to this research, two important processes were carried out to ensure the validity of the research results: (1) The data analysis process, especially how the 7 concept categories were reached, was explained in detail. (2) The examples that were assumed to best represent the 7 categories created from 671 sentence explanations were compiled and all of these examples were included in the findings section. In other words, in the processing and interpretation of the findings, the sentences containing explanations related to water in the textbooks were used as the main data source, and each conceptual category was supported with examples, i.e. direct quotations.

Three important strategies were followed to ensure the reliability of the study. First, the four researchers, who are the writers of this article, studied in harmony and acted together at every stage of the study from the beginning to the end (e.g., creating the research design, writing the research questions, collecting data, analyzing the data, developing categories, and interpreting the results) and tried to achieve consensus to make decisions in case of any disagreement. Two separate expert opinions were consulted in order to confirm whether the in-sentence explanations given under the 7 conceptual categories developed in the study represented the categories in question. Two lists were given to two faculty members who are experts in the field of biology education: (1) a list of 671 in-sentence explanations arranged in alphabetical order and (2) a list of 7 conceptual category titles arranged randomly. Using both lists, the experts were asked to match the explanations in the first list with the 7 conceptual categories in the second list, leaving none out. Then, the pairings made by these two experts were compared with the researchers' own categories. For example, the statement "*Many diseases such as tooth decay, gum diseases, diarrhea, typhoid, cholera, hepatitis, intestinal parasites are caused by improperly washed food and dirty water* (Book c, p.110)" was placed in the category of "Water as an environmental problem factor" by the researchers, while it was included in the category of "Water as a health factor" by the expert. In this way, the number of agreement and disagreement was determined in all comparisons and the reliability of the study was

calculated using Miles and Huberman's (2016) formula (Reliability = Agreement / Agreement + Disagreement). In the reliability study conducted specifically for this study, an agreement (reliability) of 94% and 96% was achieved, respectively. The first expert disagreed on 37 sentences, and reliability was calculated as = 634 / 634 + 37 = 0.94. The second expert disagreed on 29 sentences, and reliability was calculated as = 642 / 642 + 29 = 0.96. These calculations showed that the desired level of reliability was achieved in the study.

Stage 5: Transferring Data to SPSS Package Program for Digitizing Qualitative Data

After a total of 671 sentences were identified and 7 conceptual categories formed by in-sentence explanations were developed, all data were transferred to the SPSS statistical program and their frequencies (f) and percentages (%) were calculated.

Findings

According to the general findings of this study, a total of 671 sentences containing explanations about water were identified in the 9th, 10th, 11th and 12th grade high school biology textbooks and classified under 7 categories (Table 2). The top ten of these categories were: Water as a substance in the **structure** of organisms (25.19%), Water as a **habitat** for organisms (21.16%), Water as a substance involved in **chemical reactions** (16.9%), Water as a human **health** factor (13.85%), Water as an essential **requirement** for organisms (9.99%), Water as an **environmental problem** factor (9.10%) and Water as a **scarcity** factor (3.72%). In addition, the types and frequencies of water-related concepts in each category are shown in Table 3. It should be noted that at least three or more repeated concepts were included in this table.

Table 2. Categories of sentences with explanations about water in secondary school biology textbooks

Categories		n	%
1	Water as a substance in the **structure** of organisms	169	25,19
2	Water as **a habitat** for organisms	142	21,16
3	Water as a substance involved **in chemical reactions**	114	16,99
4	Water as a human **health** factor	93	13,85
5	Water as an essential **requirement** for organisms	67	9,99
6	Water as **an environmental problem** factor	61	9,10
7	Water as a **scarcity** factor	25	3,72
Total		671	100

Category 1. Water as a Substance in the Structure of Organisms

This dominant category contained 169 sentences (25.19%). This category focused on descriptions of water found in the cells, tissues, and organs or body systems of organisms. In particular, water in the roots, stems and leaves of plants, as well as water carried in plant vascular bundles, was an important component of this category.

Figure 1. Jellyfish

For example: "*Plants living in arid or desert environments have storage parenchyma, called succulent parenchyma, which helps store water* (Book D, p.131)."

Table 3. Water-related concepts in secondary school biology textbooks

Category	Related biological concepts	f	%
1.“ Water as a substance in the structure of organisms”	“Water”132, “Cell”49, “Plant”40, “Leaf”24, “Xylem”23, “Mineral”23, “Water loss”21, “Transport”19, “Transpiration”16, “Tissue”15 , “Root”15, “Stem”14, “Body”14, “Stoma”13, “Substance”12, “Environment”11, “Absorption”11, “Acid”10, “Salt”10, “Vitamin”10 , “Steam”9, “Osmosis”9, “Ion”8, “Molecule”8, “Osmotic pressure”8, “Hormone”8, “Food”8, “Light”7, “Air”7, “Hydatode” 7, “Soil”6, “Organism”6, “Waste”6, “Base”6, “Turgor”6, “Root pressure”5, “Life”5, “Cuticula”5, “Vacuole”5, “Cohesion ”5, “Protein”5, “Water balance”5, “Guttation”5, “Gas”5, “Adhesion”4, “Hypertonic Environment”4, “Cell membrane”4, “Cytoplasm”4, “Synthesis”4 , “ATP”4, “Photosynthesis”4, “Glucose”4, “Lenticel”4, “Liquid”4, “Aminoacid”3, “Active transport”3, “Enzyme”3, “Kidney”3, “Evaporation” 3, “Cactus”3, “Desert”3, “Carbon dioxide”3, “Blood pressure”3, “DNA”3, “RNA”3, “Plasmolysis”3, “Selectively permeable membrane”3, “Sodium”3, “Seed”3, “Organ”3, “Reaction”3, “Fruit”3, “Poison”3, “Density”3, “Trichome”3.	739	24,49
2.“Water as a habitat for organisms”	“Water”120, “Life”41, “Organism”34, “Ecosystem”27, “Environment”24, “Plant”18, “Air”17, “Earth”17, “Fish”17, “Soil”14, “Atmosphere”13, “Light”11, “Species”11, “Body”10, “Freshwater”9, “Temperature”9, “Sea”9, “Adaptation”8, “Algae” 7, “Lake”7, “Animal”7, “Leaf”7, “Mineral”7, “Substance”7, “Carbon Dioxide”7, “Bird”6, “Cell”6, “Seaweed”6 , “Respiration”6, “Ocean”6, “Oxygen”6, “Ant”6, “Frog”5, “Reptile”5, “Coral”5, “Species diversity”5, “Wind”5, “Evaporation”4, “Hunting”4, “Insect”4, “Food”4, “Phytoplankton”4, “Turtle”4, “Transpiration”4, “Total water”4, “Gill”4, “ Climate”4, “Community”4, “Whale”3, “Energy”3, “Photosynthesis”3, “Sun”3, “Dolphin”3, “Türkiye”3, “Water cycle”3, “Cnidaria”3, “Protista”3, “Chloroplast”3, “pH”3, “Sal”3, “Organ”3, “Heat”3, “Root”3, “Amoeba”3, “Muscle”3, “River ”3, “Salt”3, “Condensation”3.	629	20,84
3.“Water as a substance involved in chemical reactions”	“Water”96, “Reaction”43, “Carbon Dioxide”27, “Molecule”25, “Substance”21, “Photosynthesis”20, “Oxygen”18, “Acid”17, “Catabolism”14, “Chemical bond”14 , “Enzyme”14, “Energy”13, “Light”12, “Cell”11, “Aerobic respiration”10, “Hydrogen”11, “ATP”9, “Food”9, “Glucose”9, “Electron” 8, “Fat”8, “Production”8, “Plant”7, “Chlorophyll”7, “Atom”6, “Vitamin”6, “Synthesis”5, “Atmosphere”5, “Bacteria”5, “Compound” 5, “Cell membrane”5, “Density”5, “Phospholipid”5, “Anaerobic respiration”4, “Galactose”4, “Ion”4, “Tissue”4, “Respiration”4, “Metabolism”4, “ Chloroplast”4, “Salt”4, “Organism”3, “Phosphorylation”3, “Hydrogen sulfide”3, “Fermentation”3, “Photolysis”3, “Product”3, “Environment”3, “Scientist”3 , “Proton”3, “Protein”3, “Digestion”3, “Consumption”3, “Fructose”3, “Hydrogen peroxide”3.	562	18,62
4.“Water as a human health factor”	“Water”41, “Ion (electrolyte)”19, “Blood”18, “Disease”18, “Nutrition”16, “Absorption”16, “Body”13, “Drinking water”12, “Enzyme” 12, “Gastric juice”11, “Vitamin”11, “Urine”10, “Hormone”10, “Intestine”10, “Matter”9, “Digestion”9, “Acid”9, “Cell” ”8, “Osmotic pressure”8, “Nutrition”7, “Stomach (Stomach)”7, “Water loss”7, “Cleaning”7, “Water consumption”6, “Thirst”6, “Exercise ”5, “Blood pressure”5, “Mineral”4, “Protein”4, “pH”4, “Eating”4, “Coffee”4, “Need”4, “Texture”4, “Diarrhea”4, “Bacteria”4, “Kidney”4, “Waste”4, “Liquid”4, “Temperature”4, “Drinking water”4, “Fruit”4, “Diabetes”3, “Environment”3, “Skin”3 , “Feces”3, “Pancreas”3, “Hypothalamus”3, “Fat”3, “Salt”3, “Constipation”3, “Chlorine”3, “Health”3, “Sodium”3, “Water balance” 3, “Total water”3, “Fresh water”3, “Water pollution”3.	418	13,85
5.“ Water as an essential requirement for organisms”	“Water”68, “Plant”39, “Soil”23, “Need”22, “Mineral”22, “Root”14, “Leaf”12, “Food”9, “Tree”8, “Life”8, “Organism”7, “Substance”6, “Fungus”6, “Cloud”5, “Air”5, “Cell”5, “Nitrogen”4, “Ion”4, “Salt”4, “Germination”3, “Absorption”3, “Photosynthesis”3, “Animal”3, “Hypha”3, “Hormone”3, “Human”3, “Xylem”3, “Oxygen”3, “Synthesis”3, “Environment”3.	304	10,07
6.“ Water as an environmental problem factor”	“Water”29, “Waste”19, “Soil”16, “Organism”16, “Environment”14, “Water pollution”13, “Earth”11, “Wind”6, “Light”6, “Purification”6 , “Industry”6, “Pollutant”5, “Acid rain”5, “Agriculture”5, “Habitat loss”5, “Erosion”5, “Ecosystem”5, “Environmental problem”5, “Climate change”5, “pH”5, “Poison”5, “Extinction”4, “Heavy metal”4, “Human”4, “Plant”4, “Acid”4, “Recycling”4, “Air pollution”4, “Temperature”4, “Reproduction”4, “Fire”4, “Life”4, “Nitrogen”4, “Environmental pollution”4, “Substance”3, “Enzyme”3, “Atmosphere” 3, “Radioactive pollution”3, “Garbage”3, “Degradation”3, “Fish”3, “Steam”3, “Phosphorus”3, “Rain”3, “Sea”3, “Drinking water” 3, “Carbon footprint”3, “Metal”3, “Hunting”3, “Forest”3.	292	9,68
7.“ Water as a scarcity factor”	“Water”15, “Water footprint”11, “Earth”6, “Türkiye”5, “Fresh water”5, “Human”4, “Glacier”4, “Total water”4, “Consumption”4, “ Production”4, “Water scarcity”3, “Land”3, “Ocean”3, “Sea”3.	74	2,45
Total		3018	100

The fact that approximately two-thirds of the structure of single-celled organisms, fungi, plants and animals consists of water, and the issues such as how water is taken into an organism, where it is located and how it is excreted were evaluated in this category. The examples are as follows:

"98% of the jellyfish body consists of water (Figure 1) (Book A, p.17)*",*

"The most abundant component in all organisms is water (Book A, p.28)*",*

"70%-90% of the cytoplasm is water (Book A, p.96)*",*

"Many land animals have waterproof outer surfaces to reduce the loss of body water (Book B, 145),

"Thus, the water and ion balance of body fluids is maintained, blood pressure and blood volume increase (Book C, p.171)*",*

"Most of the cytoplasm of plant cells consists of water (Book D, p.161)*".*

In the sentences in this dominant category, 75 biological concepts were associated with water. These concepts were repeated 739 times (24.49%). Among these, "Water" (132), "Cell" (49), "Plant" (40), "Leaf" (24), "Xylem" (23), "Mineral" (23), "Water loss" (21), "Transport" (19), "Transpiration" (16), "Tissue" (15) and "Root" (15) were the most frequently associated biological concepts (Table 3). As can be seen in Table 3, the concepts associated with water in this category addressed water as a substance in the structure of organisms.

Category 2. Water as a Habitat for Organisms

This second category contained 142 sentences (21.16%). This category focused on explanations about the water in which organisms live. In particular, water was discussed as the natural habitat of aquatic and amphibian organisms living in saltwater ecosystems such as the sea and freshwater ecosystems such as lakes. For example, "Water is the habitat of many living creatures such as algae, corals, fish, dolphins and whales (Book A, p.28)".

Aristotle's classification of animals in ancient times as animals living in water and on land was the most important explanation representing this category. Explanations about biomes with unique living species and the impact of water on biodiversity in aquatic ecosystems were also discussed in this category. The examples are as follows:

"*In his classification, Aristotle grouped living things into two main groups as plants and animals, and then divided them into subgroups, classifying plants as grasses, shrubs and trees according to their structure and size, and animals as those living in water and on land and those that fly* (Book A, p. 139)",

"*Some of the archaea live in hot spring waters and volcano mouths* (Figure 2) (Book A, p.156)",

Figure 2. Archaea can survive in extreme environmental conditions.

"*Large-scale land or water ecosystems with distinctive climate characteristics and living species are called biomes* (Book B, p.139)",

"*Species diversity and distribution of communities in aquatic ecosystems depends on the depth, cleanliness, light transmittance of water and its distance from the shore* (Book B, p.211)",

"*Aquatic plants do not have stomata in the parts that remain in water* (Book D, p.136)."

In the sentences in this category, 68 biological concepts were associated with water. These concepts were repeated 629 times (20.84%). Among these, "Water" (120), "Life" (41), "Organism" (34), "Ecosystem" (27), "Environment" (24), "Plant" (18), "Air" (17), "Earth" (17), "Fish" (17) and "Soil" (14) were the most frequently associated biological concepts (Table 3). As can be seen in Table 3, in this category, the biological concepts associated with water reflected the idea that water is a habitat for many living organisms.

Category 3. Water as a Substance Involved in Chemical Reactions

This third category contained 114 sentences (16.99%). This category focused on explanations about water that plays a role in chemical reactions that usually occur in vivo and sometimes in vitro. Water molecules that react and emerge as reaction products, especially in digestion, cellular respiration and photosynthesis reactions, were described in this category.

For example, "*The basic elements that play a role in photosynthesis in photosynthetic eukaryotes, other than carbon dioxide and water, are chloroplast, light energy and pigments* (Book D, p.78)."

Water, which plays a role in enzymatic reactions, energy conversion reactions, catabolic and anabolic reactions occurring in water, was the subject of this category. The examples are as follows:

"...*During the reaction, three ester bonds are formed between glycerol and fatty acids and three molecules of water are released* (Book A, p.42)".

"...*The catalase enzyme in these cells breaks down millions of hydrogen peroxide molecules into water and oxygen every second, rendering them harmless* (Figure 3) (Book A, p.52)",

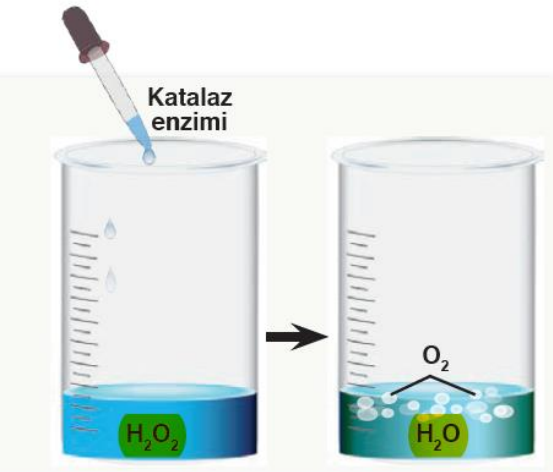

Figure 3. Catalase enzyme breaks down hydrogen peroxide

"The synthesis of organic substance from inorganic substances such as carbon dioxide and water with light energy is called photosynthesis, and the producers of photosynthesis are called photoautotrophs (Book B, p,146)",

"The hydrolysis of ATP with water to release the energy in its structure is called dephosphorylation (Book D, p.72)".

In the sentences in this category, 55 biological concepts were associated with water. These concepts were repeated 562 times (18.62%). Among these, "Water" (106), "Reaction" (43), "Carbon Dioxide" (27),

"Molecule" (25), "Substance" (21), "Photosynthesis" (20), "Oxygen" (18), "Acid"(17), "Catabolism"(14), "Chemical bond"(14) were the most frequently associated biological concepts (Table 3). As can be seen in Table 3, in this category, biological concepts associated with water reflected the role of water in chemical reactions. The concepts such as hydrolysis, dehydration, photolysis and fermentation were also covered in this category.

Category 4. Water as a Human Health Factor

This fourth category contained 93 sentences (13.85%). This category focused on the importance of water in human health and environmental health. In particular, the importance of water in homeostasis and the effects of drinking water on the digestive and circulatory systems were addressed in this category. For example, "*The balance of intake and excretion of water required to maintain homeostasis in the body is carried out by the kidneys* (Book C, p.169)".

Water hygiene means that water is suitable for health. In this category, water hygiene was defined as a health requirement not only for drinking water, but also for water used for exercise, cooking and cleaning. The examples are as follows:

"To protect against viral diseases, hands should be washed thoroughly with soap and plenty of water before and after eating. (Figure 4) (Book A, p.195)",

Figure 4. To protect from diseases, hands should be washed with plenty of water and soap.

"*Cold water therapy, commonly known as ice bath, is one of the most common recovery methods used by athletes after competitions or trainings* (Book C, p.69)",

"Consuming fibrous foods, especially fruit, and taking the daily required amount of water prevents constipation (Book C, p.110)",

"*To maintain a healthy digestive system, it must be ensured that the food consumed and the water drunk are clean* (Book C, p.110)",

"Excessive intake or loss of water can cause death (Book C, p.166)",

In the sentences in this category, 58 biological concepts were associated with water. These concepts were repeated 418 times (13.85%). Among these, "Water" (41), "Ion" (19), "Blood" (18), "Disease" (18), "Food" (16), "Absorption" (16), "Body" (13), "Drinking water" (12), "Enzyme" (12), "Gastric juice" (11) were the most frequently associated biological concepts (Table 3). As can be seen in Table 3, in this category, the biological concepts associated with water reflected the role of water on human health.

Category 5. Water as an Essential Requirement for Organisms

This fifth category contained 67 sentences (9.99%). This category focused on water as an essential requirement for living organisms. In particular, the absolute need for water in order for organisms to maintain their vital activities and to continue their generation was addressed in this category. For example,

"*All living things need water to carry out their metabolic activities* (Book B, p.144).

In this category, it was discussed that water is the most important inorganic substance required for biological structures, that all organisms living both on land and in water depend on water, that water is a necessity in enzymatic reactions, and that water is the best solvent. The examples are as follows:

"*Giraffes use their legs as well as their necks to bend down sufficiently when feeding or drinking from a source close to the ground.*(Figure 5) (Book A, p.187)",

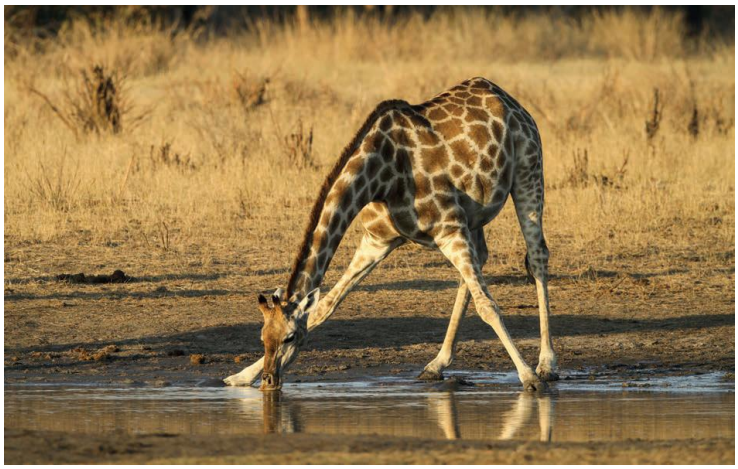

Figure 5. Giraffes spread their front legs sideways when drinking water.

"*Water is the most important inorganic substance necessary for the formation of biological structures and the realization of vital activities* (Book A, p.28)",

"Plants need water for photosynthesis (Book A, p.28)",

"Humans meet their water needs from drinks, food and water produced during metabolic activities (Book A, p.30)",

"*Water is vital for terrestrial organisms* (Book B, p.145)",

"The substances such as nitrogen, carbon, water, oxygen, sulfur and phosphorus are used cyclically for the continuity of life in nature (Book B, p.156)",

"*For living things, water is a good solvent and essential for the continuity of life* (Book B, p.159",

"*The continuity of human life depends on the regulation of the gain or loss of water and dissolved ions* (Book C, p.166)",

"*The environmental factors necessary for germination are suitable temperature, sufficient water and oxygen* (Book D, p.180)".

In the sentences in this category, 30 biological concepts were associated with water. These concepts were repeated 304 times (10.07%). Among these, "Water" (68), "Plant" (39), "Soil" (23), "Need" (22), "Mineral" (22), "Root" (14), "Leaf" (12). , "Food" (9), "Tree" (8), "Life" (8), "Organism" (7) were the most frequently associated biological concepts (Table 3). As can be seen in Table 3, in this category, biological concepts associated with water reflected the idea that water is an essential component for living organisms.

Category 6. Water as an Environmental Problem Factor

This sixth category contained 61 sentences (9.10%). This category focused on the relationship between environmental problems and water. In particular, the effects of water pollution as an environmental problem on

the diversity and population of living organisms, as well as biodiversity and habitat loss due to water pollution were addressed in this category. For example:

"*The most important effect of air pollution, water pollution, soil pollution, radioactive pollution, sound pollution, acid rain, global climate change, erosion, destruction of natural habitats and forest fires as environmental problems is that they cause the extinction of living species that cannot adapt to the changing environment* (Book B, p.178)".

Since water is one of the most important environmental factors in terms of human health, issues such as determining whether the water is hygienic and whether it is suitable for health in terms of the minerals it contains by water analysis, and issues such as acid rain, pesticide contamination of water, heavy metals entering the water and negatively affecting the food chain were also addressed in this category. The examples are as follows:

"*...This system, which is the most advanced treatment method in technology, is used in the water treatment plants of municipalities and large industrial organizations to treat wastewater to meet the standards* (Book B, p.182)",

"*Acid rain lowers the pH of water and soil, which harms organisms, disrupts the cycle of matter in nature and the ecological balance* (Book A, p.31)".

"Some of these toxic substances are broken down by microorganisms in nature to become less harmful, while others accumulate in environments such as soil and water since they cannot be broken down (Book B, p.155)",

"Pesticides are dispersed into the environment by factors such as rainwater and wind, and many of them remain intact in nature for a long time (Book B, p.155)",

"*Heavy metals in soil and water are involved in the food chain and often bioaccumulate to a level that reaches harmful levels in living things in the upper trophic levels* (Book B, p.155)",

"*Acid rain lowers the pH value of water and soil and increases the solubility of toxic substances and heavy metals in the environment* (Figure 6) (Book B, p.175)",

Figure 6. Negative effects caused by acid rain.

"*Heavy metals enter soil and water, creating negative effects on the food chain* (Book B, p.198)".

In the sentences in this category, 50 biological concepts were associated with water. These concepts were repeated 292 times (9.68%). Among these, "Water" (29), "Waste" (19), "Soil" (16), "Organism" (16), "Environment" (14), "Water pollution" (13), "Earth" (11), "Wind" (6), "Light" (6), "Treatment" (6), "Industry" (6), "Pollutant" (5) were the most frequently associated biological concepts (Table 3). As can be seen in Table 3, the explanations in this category reflect the issue of how water pollution, as an environmental problem, threatens the future of humankind.

Category 7. Water as a Scarcity Factor

This last category contained 25 sentences (3.72%). This category focused on the fact that water in nature that is drinkable or usable by living organisms is decreasing. In particular, the issue of how famine and diseases that are likely to occur as a result of the decrease in available water threatens people was discussed in this category. For example,

"*The global population is predicted to reach 9 billion by 2050, and 65% of the population will face severe water shortages* (Book B, p.180)".

The fact that increasing water shortage poses mortal threats to both humanity and all ecosystems in the biosphere, that Türkiye will be greatly affected by this problem in the future, and reducing water footprint and saving water were also addressed in this category. The examples are as follows:

"*The availability of sufficient and high quality water is a fundamental element of humanity's food security and freshwater ecosystems* (Book B, p.180)",

"*Contrary to popular belief, Türkiye is a country on the edge of water scarcity* (Book B, p.180)",

"*Between 1990 and 2010, the total amount of water consumed increased by 40.5%* (Book B, p.180)",

"*Urban use, agricultural irrigation, energy and production activities put great pressure on water resources* (Book B, p.180)",

"*However, in arid conditions, water is the most important stress factor for plants* (Book D, p.125)".

In the sentences in this category, 14 biological concepts were associated with water. These concepts were repeated 74 times (2.45%). Among these, "Water" (15), "Water footprint" (11), "Earth" (6), "Türkiye" (5), "Fresh water" (5), "Human" (4), "Glacier" (4) were the most frequently associated biological concepts (Table 3). As can be seen in Table 3, the explanations in this category reflected the issue of how water-related shortages threaten the future of humankind.

Discussion and Conclusion

Improving the explanations and understanding of water in textbooks in line with the curriculum is a special focus of biology teaching. Therefore, in this article, we discussed how water was emphasized as a curriculum subject in biology textbooks and we introduced a category to conceptualize understandings about water. These categories were: water as a substance in the structure of organisms, water as a habitat for organisms, water as a substance involved in chemical reactions, water as a human health factor, water as an essential requirement for organisms, water as an environmental problem factor and water as a scarcity factor (Table 2). There are a total of 15 water-related learning outcomes in the secondary school biology course curriculum on the subjects of "Basic Compounds in the Structure of Living Things", "Ecosystem Ecology and Current Environmental Problems", "Circulatory Systems", "Community Ecology" and "Photosynthesis". According to the results of the textbook content analysis, it is seen that the relationships between concepts were well structured in the categories of water as a substance in the structure of organisms, water as a habitat for organisms, water as a substance involved in chemical reactions and water as a human health factor (Table 3). Especially in the category of water as a human health factor, the relationships between water and health were explained in detail. It is important that water, which is an essential substance for all organisms to survive and continue their generatios, is of good quality and suitable for health. The quality of water can be determined by different water analysis methods. The properties of water suitable for human health and water-cleanliness-health-disease relationships were detailed in the texts.

Examining the categories put forward in this study, it was seen that the concept of water in biology textbooks was presented in line with the curriculum in accordance with the target achievements, and the key concepts were given literally (Table 3). However, we believe that water and similar topics in textbooks should be addressed in line with the systems thinking approach. Systems thinking offers a framework to reveal the interrelationships between objects rather than objects, and the order of change and processes rather than facts. In this study, while the concept of water was explained in secondary school biology textbooks, there were not enough statements explaining the complex interconnections of all living systems with each other. According to previous studies,

when students do not use systems thinking strategy while describing the water cycle, they often ignore the components of the biosphere such as humans, plants and animals (Ben-Zvi Assaraf & Orion, 2005b). For example, the transfer of water from plants to the atmosphere involves energy that will facilitate the transition of water from a liquid to a gaseous state. Evapotranspiration occurs when the liquid water in plant leaves is heated by the sun and enters the atmosphere as water vapor. A similar process occurs when animals release liquid water through respiration, sweating and waste production. The energy absorbed by water molecules causes a change of state in the atmosphere that transfers radiant energy to kinetic energy (Pitman, 2003).

The textbooks have well-structured explanations of water-related scientific concepts in parts, but the coherence between these parts is weak. A systems thinking approach is crucial for a good understanding of topics such as water and its cycle. Studies conducted with primary and secondary school students show that they generally do not think of water in dynamic, cyclical systems (Ben-Zvi Assaraf & Orion, 2005b). Students often show little awareness of the connections between water in one place and water in another. Students tend to focus on the atmospheric components of the water cycle, ignoring groundwater, surface water, and water-related processes in biotic systems (Ben-Zvi Assaraf & Orion, 2010).

In the biology textbooks examined, surface water rather than groundwater was addressed in many texts in different categories. Mostly, explanations about visible water such as sea, lake and rivers stood out. Previous studies indicated that there were learning difficulties related to invisible, abstract groundwater. Therefore, detailed explanations of the connections between groundwater and surface water and the relationships between concepts related to the water cycle as a system in the biosphere could have been included. This is important considering students' misconceptions about groundwater (Sadler et al., 2017). According to previous research results, students often have difficulty understanding water and the abstract processes of the water cycle. For example, many students think that groundwater is found in underground sewers and have misconceptions about the size of aquifers. They also view groundwater as a dead end in the hydrological cycle (Ben-Zvi Assaraf & Orion, 2005a; 2010; Covitt et al., 2009; Dickerson et al., 2005; Dickerson, Penick, Dawkins, & Van Sickel, 2007).

It is important to consider environmental literacy strategies in general and water literacy strategies in particular when preparing biology textbooks. Although the analysis of water literacy in textbooks is a topic that should be investigated in the future, indicators of water literacy in the books are weak. According to previous research, there are four levels for advancing the learning outcomes of environmental literacy related to water systems.

At the first level (force dynamics), students' explanations of water tend to emphasize the role of humans in transporting and using water. At the second level, students continue to emphasize the role of actors in the movement of water but also begin to incorporate mechanisms and awareness of the physical world. The third level is characterized by partial descriptions of the types of aquatic science ideas that are prominent in school science. Thus, students begin to explain the properties of water and parts of the water cycle, but their explanations are often incomplete and not entirely accurate. The fourth and highest level of progress involves model-based explanations of aquatic science. At this level, students can conceptualize water and related processes at multiple scales (from molecular to global) in multiple locations (earth, surface, atmosphere, and human-made systems). The progress in water systems learning proposes five elements of students' explanations of water that are represented in each of the four successive levels. These elements are (1) structures and systems, (2) scale, (3) scientific principles, (4) representations, and (5) dependency and human action (Sadler et al., 2017).

In this study, it was observed that some of the causes and possible effects of water scarcity were mentioned superficially in biology textbooks. The category "water as a scarcity factor" was represented last (Table 2). The relationship between water scarcity and drip irrigation, which is important in making agricultural irrigation sustainable, and agricultural activities according to crop type were not discussed. The continuation of life on earth depends on the protection of usable water quality and the healthy sustainability of the water cycle. Therefore, explanations about water scarcity can be included more. In order to raise environmentally friendly and water literate individuals, the place, importance and ratio of usable water in the water cycle should be taught well, because Türkiye is a country suffering from water scarcity worldwide.

Explanations about water in textbooks should encourage students to think systemically. Hmelo-Silver and Pfeffer (2004) indicated that complex systems are common in the outside world and that making sense of such systems is challenging. Systems thinking often requires the establishment of relationship networks between concepts related to dynamic phenomena. In this context, it is important that individuals' representations of the water system overlap with the structure and function of the system. Textbooks should contribute to this overlap.

Teachers should not rely solely on textbooks to develop students' understanding of water in relation to natural and engineered systems. Teachers should include out-of-school learning environments in biology. It is known that water-related subjects in the traditional curriculum do not provide innovative teaching that will reduce the water footprint of individuals and raise the standard of water literacy (Irgar, 2020). It would be useful to design activities that students can carry out outside of school in order to associate water-related learning outcomes in the curriculum with their daily lives. Such activities should also be included in biology textbooks.

Understanding of the water system in the biosphere should enable students using textbooks to develop more complex water systems and participate in decision-making about environmental issues. There are some tips that both writers and teachers should pay attention to in their explanations about water in biology courses and textbooks. In line with the systems thinking approach, these explanations should reflect water as a system in the biosphere and refer to the changing processes of this system. Future research can be conducted on students' understanding of water beyond textbooks.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Author(s) Information

Musa Dikmenli
Necmettin Erbakan University
Necmettin Erbakan University Ahmet Kelesoglu Faculty of Education 42090, Meram / Konya, Türkiye
Contact e-mail: *mdikmenli@erbakan.edu.tr*
ORCID iD: 0000-0001-6501-9034

Vedat Kadir Ozkan
Muğla Sıtkı Koçman University
Muğla Sıtkı Koçman University Health Services Vocational School, 48000, Marmaris/ Muğla, Türkiye
ORCID iD: 0000-0002-1049-8282

Selda Kilic
Necmettin Erbakan University
Necmettin Erbakan University Ahmet Kelesoglu Faculty of Education 42090, Meram / Konya, Türkiye
ORCID iD: 0000-0002-5347-9479

Osman Çardak
Necmettin Erbakan University
Necmettin Erbakan University Ahmet Kelesoglu Faculty of Education 42090, Meram / Konya, Türkiye
ORCID iD: 0000-0001-5598-3364

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Reflections of the Stop Climate Change Digital Game on Primary School Students' Learning about Climate Change

Sahin Idil, Orkun Kocak

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Abstract

Climate change and its effects are impacting our world more and more with each passing day. For this reason, we must ensure that our children, as the society of the future, grow up as individuals with high environmental awareness, being aware of climate change and its effects. The aim of this study is to inform students about the subject of climate change and to educate them as individuals with climate change literacy. In this context, a digital game about climate change and its effects was developed for primary school students. A qualitative research method and techniques were adapted in this research. Interview, observation, and document analysis techniques were used to ensure variety in data acquisition in the research. The study was conducted in the 2022 spring semester during the science courses. It was conducted at an urban primary school in Ankara. 22 fourth grade students were participated as control group and 23 fourth grade students were participated as treatment group in the study. It was determined that the students enjoyed this game, called Stop Climate Change; they had fun and simultaneously learned about concepts related to climate change.

Introduction

There are many problems facing the world today, one of which is climate change. The climate is changing due to the increase in temperatures around the world because of the release of harmful gases such as carbon dioxide and carbon monoxide into the atmosphere and the greenhouse effect, caused by greenhouse gases released into the atmosphere (Boon, 2009). Climatologists agree on the dangers of climate change but opposing views may still be found. Climate change causes many negative effects in the world, including air pollution, desertification, and the melting of glaciers. We are experiencing all of these effects today. The most important factor causing climate change is the effect of humans on the environment. Therefore, people should be made aware of climate change and its consequences. It is a particularly important duty to inform children, who constitute the society of the future, and to ensure that they are educated as environmentally conscious individuals. It is crucial for the future of our world to raise the awareness of students on this issue and have them grow up to be environmentally sensitive.

Theoretical Background

Climate Change in Science Education

One of the biggest challenges facing the world is climate change (UNESCO, 2012). Climate change is by far the most important environmental problem facing society and is therefore an important environmental education topic (Jickling, 2001). "The world urgently needs to address the causes of climate change and prepare for the resulting climatic and environmental consequences (IPCC, 2007). The world also needs to take certain steps against the threat of human-induced climate change (Somerville, 2010). Humans have never experienced such a situation of climate change before. The fact that climate change is a broad topic makes it a difficult topic to teach because it has many different aspects. Educators try to convey knowledge through schools, programs, and informal venues. However, there are many misunderstandings about the causes of climate change. Vitale et al. (2016) explained that climate change is important, but it is a challenging topic. In particular, many young people have trouble understanding climate change (Monroe et al., 2017). Therefore, climate change education must be offered, helping young people adapt to risk, uncertainty, and rapid changes (Stevenson, Nicholls, & Whitehouse, 2017). Teaching about climate change is essential in the education of well-rounded students and for overcoming gaps in learning (Shepardson et al., 2009).

It is difficult to understand exactly why the Earth's climate is changing, and not only because the basic scientific principles are complex (Lombardi et al., 2016). Despite the scientific consensus on climate change and the potential risks, the media often portrays climate science as controversial and debatable (Lambert, Lindgren, & Bleicher, 2012). Understanding the science and nature of climate change is also important for future teachers, as global climate change is a complex subject. A primary school student does not have a sufficient level of cognitive development to face the full complexities of the concept of climate. On the other hand, students experience the basics of this subject in science lessons (Fortner, 2001).

Digital Games in Science Education

In light of technological developments in science education in recent years, we can say that various new applications are used in research. Digital games can make unique and powerful contributions to K-12 science education, but much of their potential is still unrecognized (Kinnebrew et al., 2017). Digital games entail reconstructions of reality created by coding a reading system with the help of a sign system along with sounds. Digital games contain various elements, and they include Atari games, computer games, console games, mobile games, and all their different types (Yengin, 2011). Digital games can also be of many different genres (Parekh et al., 2021). They can be used for entertainment as well as for educational purposes (Chen et al., 2020). The educational version of the game Minecraft is an example of this. Students can learn coding, math, chemistry, and other topics with this game and apply the game in their lessons (Sajben, Klimova, & Lovaszova, 2020). In the digital game presented in this paper, we address climate change and global warming, which we think students should be informed about. Computer games, as a type of digital game, are among the most popular leisure activities of children and adolescents (Hussein et al., 2019). Mobile devices and apps, which include digital games, are also very popular among young children. However, the impact of mobile devices on learning and development has not been sufficiently explored. In comparative research conducted within the scope of science lessons, in which 32 students aged 4-5 years participated, significant differences were identified between two groups in terms of game skills and the understanding of throwing motions (Herodotou, 2018). Considering mobile applications, augmented reality and location-based mobile games have become exciting tools for education (Atwood-Blaine & Huffman, 2017). Many researchers have argued that digital games have the potential to help students learn (Martin, Silander, & Rutter, 2019). Game-based learning environments will have an important future in STEM education (Lester, Spiers, Nietfeld, Minogue, Mott, & Lobene, 2014). Predictably, the harmony between science education and games is considered to be good (Samuelson et al., 2010).

Climate Change and Digital Games in Science Education

Great efforts are being made to position information and communication technologies such as digital games as a central issue in educational policies and guidelines (Fernandes et al., 2018). It is very important to proceed based on the story in digital games and to take the story into account. Even if digital games do not contain a fixed story, it is important to consider the plot flow and moods. For this reason, emphasis was placed on the flow of the story in developing the game presented here, called Stop Climate Change (Kim et al., 2018). Teaching science through the making and designing of games in elementary, middle, and high school is a promising approach according to both educators and curriculum developers (Parekh et al., 2021). Galeote and Hamari (2021) stated that video games have emerged as a popular medium with the potential to be powerful tools for social participation regarding climate change. Games about climate change face a challenge, though, being largely at risk of adopting the same dynamics as "serious games" (Abraham & Jayemme, 2017). Climate change games are often considered serious games. Well-designed digital games will provide opportunities for young people to engage with the problems of climate change, encouraging them to think, feel, and act with a focus on problem-solving (Ouariachi et al., 2018). Reckien and Eisenack (2013) stated that there has been a rapid increase in the number of online games or games with online components regarding climate change, especially after the climate negotiations held in Copenhagen in 2009. Climate change and its effects are important for the future of the world, and children, who are the future, should be aware of climate change and its effects and act for a sustainable world. We must talk to children about Earth's problems. In this process, children may learn about these topics by playing in their early years, as information transferred in a fun way will be more effective for them. Therefore, while informing children about climate change, we can choose applications that are fun and educational for them. Today we can find many different applications with themes of fun learning (Chen & Lo, 2011). One type of these applications is digital gaming, which has become popular in recent years. Thinking deeply about climate change can be difficult, but games are natural tools for climate

change education and participation (Wu & Lee, 2015). Digital games can be used while teaching about global climate change in science education.

Purpose and Importance of the Research

One of the emerging challenges in climate change education is the complexity of the science behind climate change (Svihla & Linn, 2012). Numerous studies show that students' knowledge of climate change science is limited and they have many misconceptions (Pruneau, Moncton, Liboiron, & Vrain, 2001; Tolppanen & Maija Aksela, 2018). Previous studies show that knowledge and attitude towards specific environmental concerns can be developed using instructional strategies appropriate for the learner. At primary level, students need to develop an understanding of the basic concepts underlying weather and climate change (Lambert, Lindgren, & Bleicher, 2012). It is important for students to be active during the teaching of the subject of climate change so that they learn the concepts related to this subject correctly. Porter, Weaver, & Raptis, (2012) stated that active teaching strategies also significantly improved students' understanding of climate change.

It is seen that the use of technological applications in science teaching has increased in recent years. The use of smart boards in classrooms and students' use of devices such as tablets and laptops with technological software in science lessons can be given as examples of this. Säljö (2010) stated that educational technology can enrich the way students learn and interpret learning in formal and informal settings.

Learning about the concepts related to climate change can be challenging for students. Concepts such as global warming, greenhouse gases, and the decrease in the thickness of the ozone layer are taught within the scope of climate change. It is stated in the national Turkish science curriculum that it is aimed to provide students with knowledge and skills related to global climate change and its effects within the framework of seasons and climates. It is expected that they will be able to discuss the causes and possible consequences of global climate change and they will know what measures are being taken by different countries of the world to prevent global climate change (MoNE, 2018). However, it has been determined that technological applications are not used to provide more effective content alongside the textbooks used for the science curriculum. To teach students about climate change more efficiently and effectively, a technological platform called Unity was used to design an educational game. When the literature is examined, it is seen that no scientific study has been carried out at the level of primary school education with the Unity platform regarding the issue of climate change. This reveals the originality of the present research. The aim of this work is to develop a game called Stop Climate Change so that students can gain permanent knowledge about climate change. Observations and interviews were conducted with students to determine their thoughts on the subject of climate change, which was covered during the game. Thus, efforts were made to determine how the developed game contributes to the learning processes of students in the scope of climate change.

Method

A qualitative research method and techniques were adapted in this research. In this context, a case study strategy was benefited. Interview, observation, and document analysis techniques can be used to achieve data variety (triangulation) in case studies. Case study is one of the qualitative strategies widely used in qualitative researches (Yıldırım and Şimşek, 2011). In this study, interview, observation, and document analysis techniques were also used to ensure variety in data acquisition in the research.

Participants

The study was conducted in the 2022 spring semester during the science courses. It was conducted at an urban primary school in Ankara. 22 fourth grade students were participated as control group and 23 fourth grade students were participated as treatment group in the study. In one class, stop climate change digital game was used to teach climate change and its concepts to students, while in one class only the regular curriculum was applied.

In order to determine how the developed game was perceived by students and whether it was productive or not, fourth-grade students were invited to play the game. A total of 45 fourth-grade students studying at a public primary school in Ankara participated in the research. Students were selected based on easy accessibility. In this context, the purposive sampling method was applied in this research. The purposeful sampling technique

involves the deliberate selection of participants due to their qualifications. It is a non-random technique that does not require the application of basic theories or a certain number of participants. The researcher decides what needs to be known and sets out to find people who can and are willing to share that knowledge (Bernard, 2002). Generally, this technique is used in qualitative research to identify and select information-rich cases for the most appropriate use of available resources (Patton, 2002).

Data Collection Tool

Both the treatment group and the control group students were asked to draw about climate change before the subject of climate change was taught. In these drawings, students were asked to prepare drawings showing the factors that cause climate change and the consequences that may occur due to the effects of these factors. The drawings requested before the climate change teaching process were evaluated as a pre-test. The same drawings requested after the climate change issue were evaluated as a post-test. It was expected from students that they were able to reveal some concepts in relation with climate change such as global warming, melting of glaciers, greenhouse gas emissions etc. Beside this, students were observed while courses were being applied for the both groups. In this context, the educational environments were observed about four hours for each group. Some criteria were determined to identify whole science course process such as the students' reactions regarding the content of the game were being tried to be fixed. Their feedbacks to the teachers, learning-teaching environments were observed. No camera was used while observation process. The interviews were also carried out with all students while/after games completed. Their views regarding the game processes were tried to be revealed through interviews. Therefore, an interview was prepared that consisted of one question (What have we learned about climate change?). Based on the question, students' views are given exactly. Including this, to be able to gain much more information regarding students' views on climate change a main question was asked to students and probe questions were prepared, as well. In the results, students are coded as "S" and each student is mentioned by using this code such as S1, S2, S3 etc.

Main question:

Why did you draw on climate change like this? Can you please explain it to me?

Probe questions:

1. I see factory chimneys and exhaust gases on the paper. What is the meaning of this drawing?
2. I see polar bears standing on a small land. What is the meaning of this drawing?
3. I see green there is no land on your drawing. Instead, brown land is drawn for descripting the environment. What is the meaning of this drawing?
4. I see the trees have not leaves. What is the meaning of this drawing?
5. I see glaciers and sea ice melting? What is the meaning of this drawing?
6. I see some energy suppliers have been drawn. What is the meaning of this drawing?
7. In your opinion, what would be done to generate energy?
8. I see there are some gases drawn on the paper. What is the meaning of this drawing?

Data Analysis

The data of the study were obtained by using interview, observation and document analysis techniques. To be able to variety of the study, several analysis techniques were used such as interview, observation, and document analysis techniques that are called triangulation (Yıldırım & Şimşek, 2011). Content analysis and descriptive analysis techniques were used to have results of the study. The data acquired from interviews and observations, first sent to field experts. They separated them into concepts. The drawings created by the students were categorized as factors causing climate change and the results of climate change by two educators who are experts in their field, and frequency values were given as percentages. The data obtained were evaluated based on how much change occurred in which category before and after the application as pre-test and post-test.

Validity and Reliability

As in all qualitative research, necessary arrangements were made for the validity of this study, taking into account the concepts of "Internal validity and External validity". In order to ensure validity, it was emphasized

that both validities should be provided. The internal validity of the research was carried out by taking into account the environment in which the data were obtained, making use of the field expert. When the findings are examined carefully, the obtained data are meaningful appears to be a holistic one. Since the purpose of qualitative studies is not to generalize, two expert opinions were taken. As a result of the analysis of the experts, the necessary feedback was received that the sample size was sufficient. This research is not concerned with generalization. Considering the conceptual framework, the generalization effects of the research subject are not felt. In order to generalize, various factors had to be made according to certain criteria. Since such an analysis was not performed in this study, it does not carry any generalization concerns.

In this study, interview, observation and drawings data were examined by two experts. Concepts were created independently by field experts. The data taken by drawings were examined by two experts, characteristics were formed independently from each other. "Compatibility percentage" formula suggested by Miles and Huberman (1994) was benefited from to determine the reliability of the characteristics acquired by the drawings. According to "Compatibility percentage= (Agreement)/ (Agreement + Disagreement) X100", the compatibility percentage in the drawing form for the student was found as 88.38. It is stated that if a compatibility percentage in studies is at .70 and on .70, interview data can be used in a study (Yıldırım, 2008). The observation form was examined by two experts, concepts were formed independently from each other. The same formula was also used to determine reliability of the concepts acquired by the observation form. According to that formula the compatibility percentage in the observation form was found as 91.16.

Ethics

After necessary permission was taken from the school' directorate, the students were informed about the study such as the reason, period of study, content and which apps would be carried out during the study. Students were tried to participate in the study voluntarily. In this context they were given "Volunteer Participation Form".

Stop Climate Change Game

The Houston Center for Advanced Research (2021) found that games about climate change have three main purposes. These are teaching knowledge and familiarizing players with the issue of climate change, making players aware of the challenges associated with global warming, and encouraging players to develop solutions. In this study, an open-source digital game called Stop Climate Change was developed for primary and secondary school students using the Unity platform. With this game, the aim is to inform students about the subject of climate change and educate them as individuals with climate change literacy. During the research process, attention was paid to those three main purposes. The following steps were applied during the game development process:

- Studies on climate change in the field of education were examined.
- The learning outcomes and topics in the science curriculum related to climate change were examined.
- Items related to climate change that would be included in the content of the game were determined by interviewing experts in this field of science.
- Having determined the game content, the game was prepared using Unity.
- The game was designed to be open source for Android and Windows.

Our aim in designing the Stop Climate Change game is to inform children about climate change and increase their awareness. For that purpose, the game essentially answers three questions: What causes climate change? What is happening in the process of climate change? What can we do to avoid global warming? The game also includes a level called "Green World," where a world without climate change is portrayed. Players can learn the answers to the aforementioned questions by choosing a question from the selection screen, entering the relevant level, and playing. In the last part of the game, a world that we can obtain by preventing climate change is described.

Technical Background

The game developed with Unity that is a game engine. The game can be played on Windows, Android, IOS and WebGL platforms. It can be played non-touch devices be available on "https://anonymous010.itch.io/stop-climate-change" and touch devices be available on "https://anonymous010.itch.io/stop-climate-change-touch".

In non-touch devices: In Windows, player will be used the mouse cursor to press buttons in the game. After placing the mouse cursor on the button that press, it will be pressed the left button by player. For example, when the player opened the game, player moved the mouse cursor over the word "Play" on the screen and left clicked, and then the level selection screen will be appeared. We can move our character to the left by pressing the A key, and to the right by pressing the D key. Also, player can make our character jump with the spacebar.

In touch devices: On mobile devices, it is enough to click the buttons to press them. For example, when the player opens the game and click the "Play" button on the screen that appears, the episode selection screen appears. The use of joysticks will help at this point, as mobile devices do not have a keyboard to move the character. When the joystick is moved to the left, we move the character to the left, and when the joystick is moved to the right, the character moves to the right. right. When we pull the joystick up, the character makes a jumping motion.

Login page would see when you open the game. And the main song would start. On the login page, there are three choices (Play, Settings, Quit). You can start the game with play. You can arrange the volume of song from settings. And you can quit from the game. When “Play” is selected, three different levels and an additional final level are displayed. The questions led to the relevant levels. On this screen, there are visuals that will help in understanding what global warming is, including CO2, Earth and a thermometer, the Sun, and a tree.

The player can go to the desired level of the game by clicking on the relevant question on this screen. The order of the questions and the related levels is chronological. The first question is “Why is climate change happening?” In this level, the player is informed about the causes of climate change. The second question is “What happens in the process of climate change?” In this level, the player is informed about what happens during the process of climate change and the results through visuals and gameplay. The third question is “What can we do to prevent global warming?” In this level, there is information about how we can prevent global warming and the wasting of energy sources with visuals and platform elements. In the Green World level, a green and beautiful world, which we could obtain if we prevent global warming, is depicted for the player. The player does not need to pass a previous level to move on to the next one. As levels are finished, the player is directed back to the level selection screen. It will be more beneficial for the player to proceed in chronological order, but the level selection screen nevertheless allows players to choose levels in any preferred order.

Every episode the game has include scoring system, sign system and restart system. Besides there are game objects which portals, character, and trees. Scoring system keeps score a player when the character collides with tree. Sign system inform the player about climate change. Restart system is a death and start again system. Player can explore these systems and game objects. Stop Climate Change allows that an exploring. There can be seen two figures taken from the inside of the game.

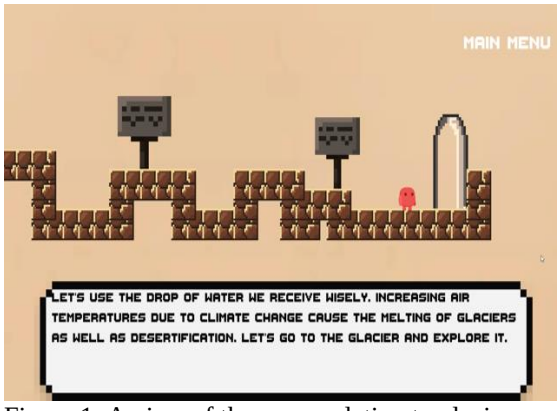

Figure 1. A view of the game relating to glacier

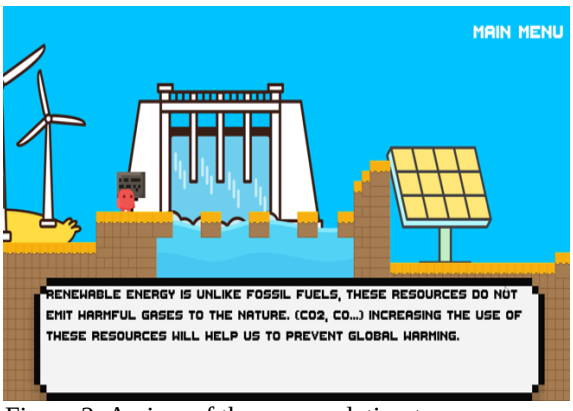

Figure 2. A view of the game relating to energy sources

In figure 1, some reasons of the climate change and the results of those reasons are given. At this stage, students are expected to aware of some indicators of the climate change. In figure 2, the importance of renewable energy and also the advantages of using those resources are being stated. Students are expected to learn renewable energy sources.

In figure 3, it is seen that S3 coded student is playing this digital game. She is playing the game at the phase of renewable energy sources. In figure 4, S7 coded student is playing the game and trying to get marks to pass to another section.

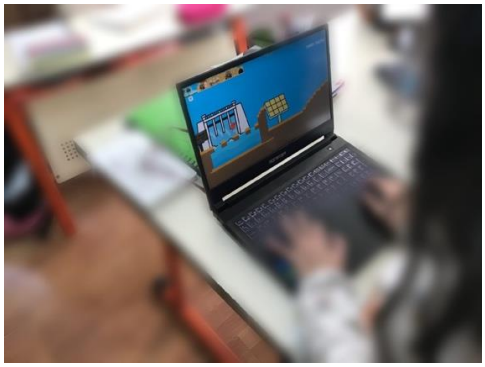

Figure 3. Student 3 is playing the game

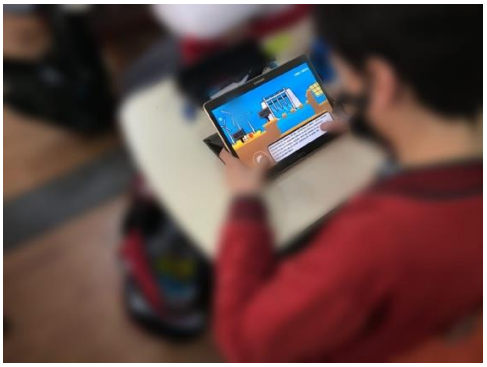

Figure 4. Student 7 is playing the game

Results

In this section, data obtained through observations, interviews and drawings, with the students during the gameplay process, are presented. Before beginning the game, the second author of the study asked the students what they knew about climate change. Some of the participating students gave answers. These included "We should not throw garbage on the ground" and "There are gases coming out of the exhaust of cars." All students were observed to be very excited before the game. In the gameplay process, it was observed that the students read the signs on the screen and read the texts about climate change and its effects with interest. In this process, some students tried to compete with each other and started the game quickly with the desire of beating their friends. After the game was over, all students expressed that they wanted to play it again. Since the class period had ended and there was no time left for continuing the game, the students indicated to the researcher that they would like to play the game at home. They asked questions about the possibility of downloading the game online so that they could play at home. After the game was over, the researcher asked if the students had fun. All of the children stated that they liked the game very much and that they had a lot of fun while playing. The data from the observations made during gameplay confirmed the students' statements. After the game was over, the researcher asked, "What have we learned about climate change?" The concepts contained in the answers given by the students to this question are provided in Table 1.

Table 1. Concepts from replies to the question of "What have we learned about climate change?"

Concept	f	%
Glacier melting	24	37.50
Effects of harmful gases	18	28.12
Renewable energy sources	8	12.50
Solar energy	6	9.37
Wind energy	12	18.75

When the data in Table 1 are examined, it is seen that the most common concept among the answers offered by the students was the glacier melting (37.5%). Both the presence of these objects in the game and the fact that the glaciers on the Antarctic continent were included in the related section of textbooks in the curriculum about climate change may have been effective in the students providing this particular answer. In addition, the effects of gases such as H2O and CO2 on the climate change process were illustrated in the game, and this helped to concretize the students' knowledge of these gases (28.12%). Answers about renewable energy sources (12.5%) and specifically solar energy (9.37%) and wind energy (18.75%) are important in terms of revealing that students learned concepts for reducing climate change.

The data taken by students' drawings are given under this section. It was found that some developed concepts are similar for the both group students. Following concepts were created in pre-test by control group students: "Fume, Exhaust, Greenhouse gases, Garbage, Recycling, Acid rain, Oxygen reduction, Temperature rising, Drought, Glacier melting, Pesticide application and Population growth". Some concepts such as "Fume, Exhaust, Greenhouse gases, Garbage" were created by treatment group students within pre-test. These similar concepts show us both group have similar concepts within the scope of climate change before they exposure to the teaching process. The important point for treatment group students is that they also created different concepts including pre-test results, which are in relation with climate change after digital game-based teaching process ended. Following concepts are given within this result: "Ozone depletion, Sea level rise, Forest fires,

Biodiversity loss, Turmoil and deaths, Food shortage caused by famine, Animal extinction, Resources depletion, shifting seasons and People getting sick". These concepts revealed that treatment group students were able to create almost all necessary concepts in climate change after they finished learning process through Stop Climate Change game. At this time, control group students created their own concepts such as "Recycling, Acid rain, Oxygen reduction, Temperature rising, Drought, Glacier melting, Pesticide application and Population growth". Considering the post-test data obtained from the control group students, it was determined that they did not include concepts such as "shifting seasons temperature rising and drought", which should be considered within the scope of events seen as a result of climate change. The fact that the control group students, who were educated according to the school curriculum, did not include the consequences of climate change in their post-test drawings, reveal that learning is not fully realized. Treatment group students completed their learning process through the digital game called Stop Climate Change. At the end of the learning process, it is seen that the rate of these students to include climate change and related concepts in their drawings has increased. Drawing of student 6 (treatment group) is given as before and after application.

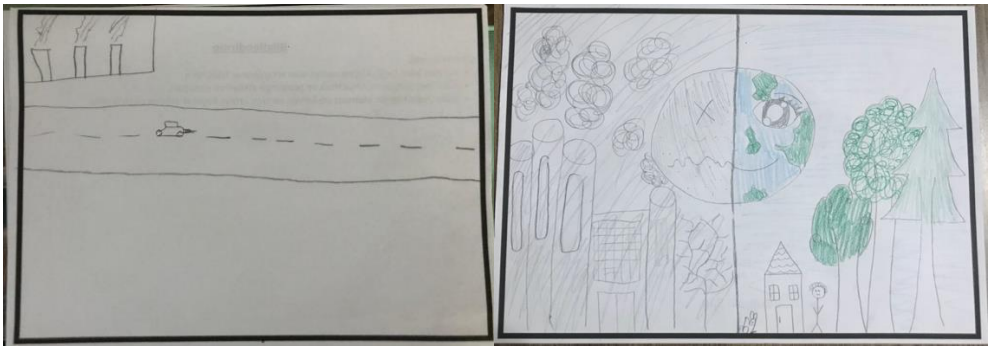

Figure 5. Drawing of student 6 before and after the application

In the figure showing before application gives us some details regarding S6's knowledge about climate change. It is clearly understood that we can only see some factory chimneys and a car being drive on the road. We can think that this student had limited knowledge on climate change because he just mentioned factories. However, in the figure, after application, shows us that this student has learnt necessary knowledge about climate change and its effects, as well. It is because especially the world has been given as livable after application and the world cannot be livable if the climate change fully affects the world. To be able to gain more information about students' knowledge on climate change and its effects a question was asked to another student. Within this context, student 4 (treatment group) views are given below.

> Researcher: Why did you draw on climate change like this? Can you please explain it to me?
> S4: Before application process, I knew that just factory chimneys and exhaust gases were the only reasons within climate change. After this process, by playing this game, I have realized that there are more than two reasons that cause climate change.
>
> Researcher: Can you please give some specific examples of the situation?
> S4: I learnt about greenhouse gases such as CO_2, NO and methane. I have realized that using those gases have negative effects on climate change and global warming. Because, burning coal, oil and gas produces CO_2 and NO. including greenhouse gases, deforestation and increasing livestock farming have negative effects on climate change, as well.
>
> Researcher: I see two different sides are. What is the meaning of this drawing?
> S4: I tried to tell the importance of negative effects of the climate change on environment. The drawing which prepared after application process, seen on the left side, I gave some reasons for climate change and at the same time the results of the climate change. On the right side in the same figure, you are able to see that we have green, trees are green with their leaves and the world itself is happy with green and blue.
>
> Researcher: In your opinion, what would be done to generate energy?
> S4: To be able to decrease negative effects of climate change, more renewable energy sources might be used. Those resources can be given as Sun, hydroelectric, wind, bioenergy and geothermal energy.

With this interview, we understand that this student has obtained some significant knowledge on climate change and its effects such as global warming, the reasons (burning coal, oil, deforestation and increasing livestock

farming) and also be able to illustrate for climate change. We understand from this that student 4 is able to give deep information on climate change and gained required knowledge after completed this game. Drawing of student 22 (treatment group) is given as before and after application.

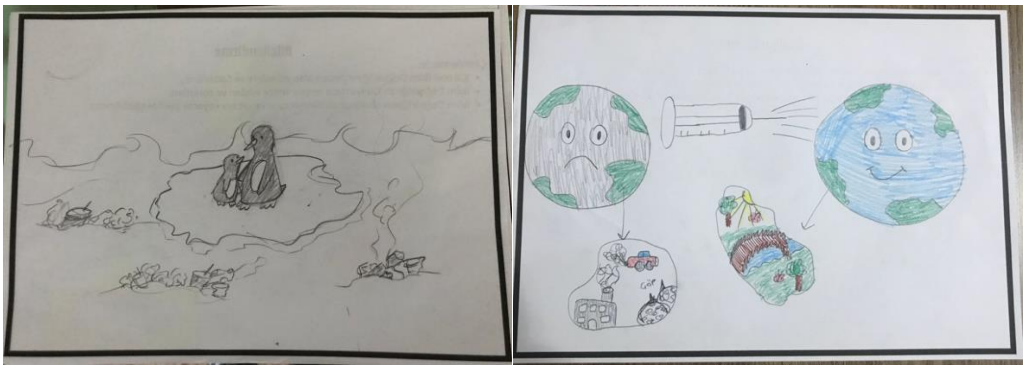

Figure 6. Drawing of student 22 before and after the application

In the first figure, on the left side, there can be seen two penguins that they have a very limited ice mass standing on it. There are several waste materials around the ice mass and the only place for standing is just that mass. Here, S22 tried to tell us the reasons of the climate change. S22 actually wanted to highlight the importance of global warming. When we interviewed with S22, he was not able to state some reasons of the climate change and could not define the climate change term. After application process, there is seen two different worlds. On the left side, a world is pictured and it is unhappy, while the latter, on the right side, is happy. When we asked the reason of this situation, S22 stated that because of temperature, happy world's temperature has normal degrees while the other has not. Including this, unhappy world has factory chimneys, exhaust gases and garbage. Meanwhile, happy world has livable land with green trees, clean water and average temperature degrees. When we focus on another figure drawn by a student 8 (control group), we can also see some changes regarding the knowledge about climate change.

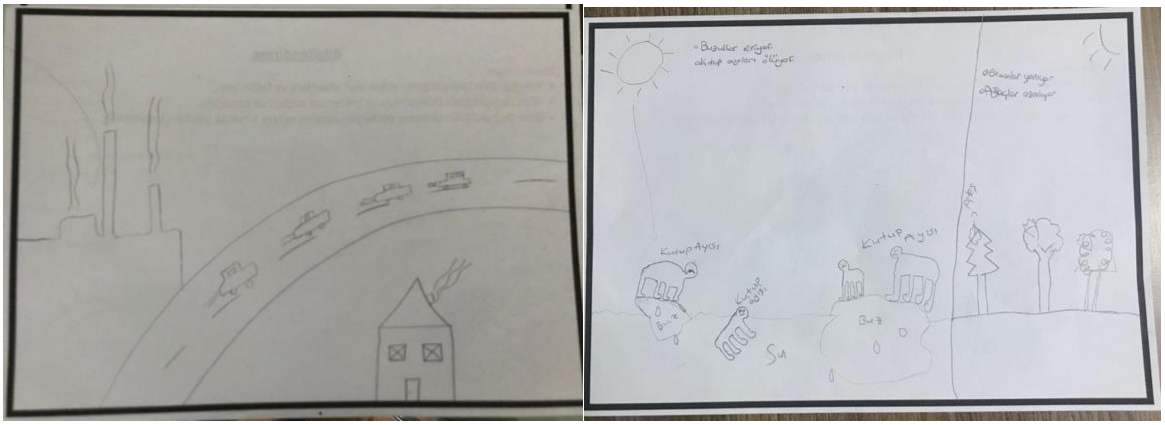

Figure 7. Drawing of student 8 before and after the application

In the figure showing before application gives us some details regarding student 8's pre-knowledge about climate change. It is clearly seen that this student has limited knowledge on climate change because just factory chimneys and exhaust gases have been pictured. However, it is also seen that student S8 has increased her knowledge on climate change and its effects after formal education process. We understand this from her drawing because she mentioned about polar bears. As she stated that ice was being melted and weather temperature increases the number of forest fires originated from climate change. But here, we also know that this knowledge might be gained by science textbook prepared by Ministry of National Education. Because it can be thought that it highlights polar bears when climate change-based subjects are being mentioned. Besides, science teacher gives polar bears as example while teaching climate change and its effects. To be able to gain more information about students' knowledge on climate change and its effects a question was asked to students. In line with this, the view of student 12 (control group) was applied and the answers of S12 is given below.

> Researcher: Why did you draw on climate change like this? Can you please explain it to me?
> S12: I learnt that climate change has negative effects on environment. For example, some animals will be not able to find any places to live in future.

Researcher: I see polar bears standing on a small land. What is the meaning of this drawing?
S12: I think that polar bears will not have any place to live in future. It is because, as the temperature increases the glaciers will melt.

Researcher: I see green land cannot be seen on your drawing. Could you please explain this?
S12: I believe that the number of forest fires will increase in the near future. Because of this reason we will lose more green land.

Researcher: What are you trying to say? Could you please specify this?
S12: As the number of forest fires increase the number of buildings will also increase. This relation is connected to each other, according to me. This process will lead to loses of living things' habitat.

Researcher: In your opinion, what would be done to generate energy?
S12: According to me, instead of coal, natural gas and any other energy sources, some energy sources could be used. For example, energy and hydroelectric power can be used to obtain energy with no harm effects to environment. By doing this, the temperature rises can decline.

By focusing on both drawings, it can be stated that this student's knowledge on climate change originates from her teacher and science textbooks. This information is also understood from the interview carried out by this student. She has limited knowledge on climate change and were not able give detailed information about climate change and its effects.

Observation data and some students' answers are given below, including interview data and drawings. Within this context, students were observed by the researchers and some observation data are given below. The game comprises four levels, and the S16 was observed. S16 was learning about the toxic gases polluting the air that cause global warming and thus climate change. For this knowledge to be permanent in the student's mind, greenhouse gases such as H2O and CO2 are illustrated in the clouds in the background of the game. In another observation, S2 is shown playing the third level of the game. In this level, the student learns about renewable energy sources and how using they will cause greenhouse gas emissions to decrease, slowing the process of climate change. A solar panel is illustrated in this level to help the student realize that solar energy can be used for energy production. In relation to that S9 and S18, both from treatment group, stated their views as given below.

S9: *Thanks to this game, I learned that the climate has changed as a result of the gases from factory fumes and car exhaust. While playing the game, I realized that these gases are water vapor and carbon dioxide.*

S18: *I learned that solar energy and wind energy do not end and they do not harm the environment. Through the game, I learned that the natural gas we use in our house and the gasoline necessary for the operation of the cars cause climate change.*

In another observation, S17 was seen to successfully passed the first three levels to reach this final level. Before this final level, S17 would have seen the factors that cause climate change, the negative effects seen in our world because of climate change, and the effects on life. In the final level, students see the hypothetical green world that they will encounter if they respect the environment and do less harm to nature. In this way, it is aimed that they will understand what they should do and not do for a sustainable green world.

S17: *I learned about the factors affecting climate change until I reached the last stage of the game. I also realized that it is actually people who cause these factors the most. If we use less products such as coal, natural gas and gasoline, we can prevent climate change.*

Situations such as the student being active in the learning process, learning by having fun while playing the game, and being responsible for his or her own learning process are assumed to have positive effects on their permanent knowledge. In line with this, S12 stated his views as given below.

S12: *With this game, I learned the concepts about climate change that I did not know. Through the game I played, I learned that events such as temperature increase, melting of glaciers and drought are dependent on climate change. I loved this game. The game was both educational and entertaining.*

Discussion

In the research, which was carried out with primary school students, the subject of climate change was tried to be taught with the developed digital game. It is understood that some studies within climate change topic have been conducted. Sjöblom et al. (2022) asked them to express climate changes in their study with primary school students. Some students put forward statements such as “it will be warmer”, something is changing, and we will have global warming.

The students revealed that they could not fully explain the formation processes of climate change because they did not see climate change as a natural phenomenon. Boyes & Stanisstreet (1993) determined that 11-year-old students had enough knowledge about the role of CO2 in climate change. Lambert, Lindgren & Bleicher (2012) revealed in their research that many students could not explain greenhouse gases and their effects according to the pre-test results. In addition, according to the post-test findings, they determined that many students expressed carbon dioxide as a greenhouse gas. Bodzin et. Al. (2014) conducted a study with eighth-grade students in order to find out the differences between air and climate, the composition of the Earth's atmosphere and greenhouse gases, how greenhouse gases affect climate change, the characteristics of the climate system, paleoclimatology, anthropogenic resource contributions to climate change, and their lack of knowledge about environmental effects. They emphasized. Similar results were obtained in this study as well. Treatment group students expressed the gases emitted from factories and vehicles as greenhouse gases after the related digital game process. By expressing gases such as CO2 and H2O, they expressed these gases as greenhouse gases that have harmful effects on the climate. Francis et. al. (1993) stated in their research that reducing the use of vehicles by many students would reduce the greenhouse gas effect. Some of the students participating in this research also stated that the number of vehicles is high and that it has a negative effect on climate change in the long term. Siegner & Stapert (2020) stated that Lowell middle school students are more knowledgeable about climate change than American teenagers or adults. According to the research findings of Li & Liu (2022) on the knowledge and views of university students on climate change, they revealed that the level of knowledge about global warming is surprisingly weak. They concluded that even at the end of the teaching process on climate change, there was little improvement in these students' perceptions of knowledge and action on climate change. It is known that students learn faster and more efficiently at earlier ages. Primary school fourth grade students took part in this study. According to the research findings, it can be said that the students are younger and learn climate change and the concepts it covers faster through the practice in the treatment group.

Tolppanen & Aksela (2018) stated that students' knowledge level about climate change is limited, and they have various misconceptions. Some of these are students' belief that ozone layer depletion and air pollution cause climate change (Andersson, & Wallin, 2000; Pruneau, Moncton, Liboiron, & Vrain, 2001; Baker, Loxton & Sherren, 2013). Within the scope of this research, some students in the control group attributed the depletion of the ozone layer to air pollution. Working with children at the primary level is important because they are less likely to require them to "learn" any harmful environmental behaviour acquired later. It was determined that some students in the treatment group had various misconceptions about climate change before the application. These students stated that the weather changes during the day and the occurrence of fog events is due to climate change. Both the drawing data of the experimental group students and the data obtained from the interviews and observations show that the misconceptions they had about climate change disappeared after the application. In addition, the treatment group students stated the concepts related to the causes and consequences of climate change at a high rate after the digital game. It was determined within the scope of the research that the control group students did not reach the same conclusion after the subject was covered. In line with this result, some studies have evidenced the positive effect of digital games in teaching science for climate change subject. Wu and Lee (2015) stated that games on the subject of climate change are well-suited to address some challenges because they can serve as effective tools for education and engagement. Ouariachi et al. (2019) argued that video games have the potential to educate and engage especially young people in climate change and energy issues by facilitating the improvement of helpful thoughts, feelings, and actions.

Conclusion

The Stop Climate Change digital game was developed by the researchers because it is difficult to teach the subject of climate change, one of the most important events affecting our world, and the relevant scientific concepts at primary and secondary school levels. It was understood from interviews, drawings and observation data that the students who played this game liked it, had fun, and were very active in the learning process. It was concluded that the students playing this game learned scientific concepts about climate change.

Recommendations

In future studies on climate change and its effects, it would be helpful to conduct scientific research with larger student groups to further clarify the effectiveness of this game.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Author(s) Information

Sahin Idil
The Scientific and Technological Research Council of Türkiye
Ankara, Türkiye
Contact e-mail: *sahinidin@hotmail.com*
ORCID iD: 0000-0003-2366-913X

Orkun Kocak
TED University,
Ankara, Türkiye
Contact e-mail: *orkunkocak7@gmail.com*
ORCID iD: 0000-0002-0586-6271

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An Investigation of Secondary School Students' Motivation and Addiction towards Digital Gaming by Age, Gender and Number of Siblings

Mehmet Oktay Kablan, Mehmet Imamoglu

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Abstract

The aim of this study was to examine the effects of gender, the number of siblings, and grade level on digital game playing motivation and addiction levels in secondary school students and to reveal the relationship between digital game motivation and addiction. A total of 394 students, 168 boys and 226 girls, participated in the study voluntarily. Personal Information Form, Digital Game Playing Motivation Scale, and Digital Play Addiction Scale for Children were used as data collection tools. Digital game playing situation (yes/no) was associated with gender and number of siblings ($p < .05$) but not with grade level ($p > .05$). The motivation and addiction levels for playing digital games are related to gender and grade level ($p < .05$) but not to the number of siblings ($p > .05$). There is a positive relationship between motivation and addiction to playing digital games ($p < .05$). In light of these findings, more effort should be made to prevent digital addiction in males according to gender and in 8th graders according to grade level.

Introduction

Self-determination theory (Deci & Ryan, 1985) and social cognitive theory (Bandura, 1989) are among the theories examined to understand player motivation and experience. Based on the theory of self-determination, digital gaming is an intrinsically enjoyable experience and is explained by the need for autonomy, competence, and relatedness (Tamborini et al., 2010). Social cognitive theory has also been used while trying to explain play behavior in terms of enjoyment, merge of action and awareness, concentration, self-reactive outcome, habit strength, deficient self-regulation, and optimal balance (Lee & LaRose, 2007). Six key motivational themes for digital gaming can be identified; immersion and flow, gratification and affect, escapism, social interaction, identification, and goal orientation (Cheah et al., 2022). Five main characteristics of each player trait can be expressed; Aesthetic orientation (enjoying aesthetic experiences in games, such as exploring the world, enjoying the scenery, or appreciating the quality of graphics, sound, and art style), narrative orientation (enjoying complex narratives and stories within the game), goal orientation (enjoying completing game goals, exploring all options and completing all collections), social orientation (preferring to play with others), and challenge orientation (usually preferring difficult games and hard challenges) (Tondello et al., 2019).

Gaming disorder is characterized by a pattern of persistent or recurrent gaming behavior, which may be online or offline, manifested by: impaired control over gaming; increasing priority given to gaming to the extent that gaming takes precedence over other life interests and daily activities; and continuation or escalation of gaming despite the occurrence of negative consequences (World Health Organization, 2022). Health responsibility, nutrition, interpersonal relationships, and stress management levels of adolescents addicted to digital games are lower than those not addicted to digital games (Aksoy & Erol, 2021).

Emotional eating refers to overeating due to negative emotions such as depression, fear, anxiety or stress, and digital game addiction is an important determinant of emotional eating (Caner & Evgin, 2021). As a result of increased negative emotions due to addiction, eating patterns are disrupted and excessive consumption of food leads to many health problems. Digital game addiction has a negative relationship with cyberbullying sensibility and a positive relationship with internet addiction, and adolescents with major depressive disorder have a higher digital game addiction than healthy adolescents (Uçar et al., 2020). While digital game addiction increases, cyberbullying sensibility decreases and internet addiction increases. Digital game addiction negatively and significantly predicts social connectedness (Savci & Aysan, 2017) and emotional intelligence (Tetik & Aktan, 2021) levels. Interpersonal disability, the need for online social interaction, and self-regulation (control) are important in predicting game addiction (Bhagat et al., 2020). Long-term phone and computer use for playing games in secondary school children increased their neck pain, and those who scored high on the game addiction

scale had wrist, back, and low back pain (Cankurtaran et al., 2022). Digital game addiction levels of students who do sports are low (Ekinci et al., 2017). Students with low academic achievement have higher gaming addiction levels than students with high academic achievement (Özturk Eyimaya et al., 2020). There is a negative relationship between students' grade point average and the number of hours they spend playing online games per day, so students who play video games have lower academic performance (Naaj & Nachouki, 2021). Students with a low academic average have higher game addiction levels than those with a high average (Ekşi et al., 2020). Among the positive effects and results of the games; knowledge acquisition, perceptual and cognitive, affective, behavior change, physiological, skill, soft and social skills are included (Boyle et al., 2016). Personal computer-based, virtual and augmented reality-based, web application-based, Kinect console-based, Nintendo console-based, mobile application-based, and multi-platform-based games positively affect attention rehabilitation (Shahmoradi et al., 2022).

With the development of technology, the concept of digital games that can be accessed with technological devices such as computers, phones, tablets and game consoles has emerged. The interest in digital games is affected by many factors. The concept of motivation can be expressed as the individual's willingness to be ready for behavior. The uncontrollable increase in the duration of digital game playing reveals the concept of addiction, reaching a level that causes physical, social and psychological problems for individuals. Various demographic factors can influence individuals' digital game use and addiction tendency. In the literature, there are studies in which sociodemographic factors such as gender and age are addressed in terms of Motivation and Addiction Towards Digital Gaming (Aksoy, & Erol, 2021; Ekinci et al., 2017; Kaya, & Pazarcıkcı, 2023; Kesici, 2020).

Understanding the role of factors such as gender, age, and number of siblings in this process provides more in-depth information about individuals' digital game use, emphasizing the importance of individual differences and diversity. Investigating the effect of demographic factors such as gender, age, and number of siblings on digital game addiction and motivation can increase the awareness of both individuals and society about digital game use and contribute to the development of healthier usage habits. In this context, our research problem is as follows: "What is the effect of demographic factors (gender, number of siblings, and class level) on digital game motivation and addiction in secondary school students, and is there a relationship between digital game motivation and addiction?". According to the research question, this study aimed to examine the effects of gender, the number of siblings, and grade level on motivation and addiction towards digital gaming and the relationship between digital gaming motivation and addiction. The following four hypotheses were created and tested for the research, and the results were discussed using the current literature.

H_{01}: Gender has no effect on motivation and addiction to digital gaming.
H_{02}: The number of siblings has no effect on motivation and addiction to digital gaming.
H_{03}: Grade level has no effect on motivation and addiction to digital gaming.
H_{04}: There is no relationship between motivation and addiction to digital gaming.

Method

Participants

The research was carried out with 5th, 6th, 7th, and 8th grade students in three different secondary schools (Kırşehir, Türkiye). Three schools in Kırşehir province were randomly selected, but no sample selection was made among the students in the schools; everyone who volunteered was included in the study. A total of 394 volunteer students, 168 boys and 226 girls, participated in the study. The research was carried out in accordance with the Declaration of Helsinki. Both participants and parents were informed about the study and signed a consent form. The research was approved by the Sinop University Human Research Ethics Committee (Reference no: 09.07.2021/2021-102).

Data Collection Tools

Personal Information Form, Digital Game Playing Motivation Scale (DGPMS), and Digital Play Addiction Scale for Children (DGASFC) are data collection tools. The data collection tool was created in the Google form platform and shared with the student's class groups through the Education Information Network (known as EBA in Turkish). EBA is an online educational platform the Turkish Ministry of National Education uses for all

students. The data collection period is two weeks. The research was carried out on the internet in accordance with the precautions during the epidemic process, so the contact was minimized.

Personal Information Form

The personal information form includes questions about students' age, gender, number of siblings, grade level, electronic devices they own, and digital game playing. The last question of the personal information form is "The games played with electronic devices such as a smartphone, tablet, computer, or game console are called Digital Games. Do you play digital games?" is in the form. First of all, the definition of the digital game was made so that mistakes that may arise from misconceptions were tried to be prevented, then the students who answered yes moved on to the next step, the scale questions. Students who answered "No" to the question "Do you play digital games?" did not proceed to the next stage of the scale questions due to the restriction in the online form. Those who answered no to the question did not fill out the scale questions.

Digital Game Playing Motivation Scale

The Digital Game Playing Motivation Scale (DGPMS) developed by Tekkurşun Demir & Hazar (2018), was used in the research. The scale consisted of 19 questions, and a five-point Likert-type rating was used. The first 14 items of the scale were scored normally, while the 15th, 16th, 17th, 18th, and 19th items were reverse scored. The scale has three sub-dimensions, namely Success and Recovery (5 items), Curiosity and Social Acceptance (9 items), and Uncertainty in Game Request (5 items), and Cronbach's alpha (α) reliability coefficient values are α=.70, α=.87, and α=.72, respectively. The original scale's Cronbach Alpha, internal consistency coefficient, is .82, whereas for this research sample, it is α=.841.

Digital Play Addiction Scale for Children

Digital Play Addiction Scale for Children (DGASFC), developed by Hazar & Hazar (2017), was used in the research. The scale consisted of 24 questions, and a five-point Likert-type rating was used. There is no reverse-scored item on the scale. Rating of the scale according to the score ranges; 24 points: normal, 25-48 points: low risk, 49-72 points: risky, 73-96 points: addicted, 97-120 points: highly addicted. The scale has four sub-dimensions as Excessive Focus and Conflict on Playing Digital Game (7 items), Tolerance Development in Game Play and Value Added to Game (7 items), Postponement of Individual and Social Duties / Assignments (6 items), and Psychological-Physiological Reflection of Dysnity and Diving in Game (4 items) and Cronbach's alpha (α) reliability coefficient values are α=.78, α=.81, α=.76 and α=.67, respectively. The original scale's Cronbach Alpha, internal consistency coefficient, is .90, whereas for this research sample, is α=.946.

Analysis of Data

The software used in the analysis of the data was IBM SPSS 21.0 and the significance level was $p < .05$. It was determined by the Kolmogorov-Smirnov test that the data were not normally distributed. The relationship between the qualitative variables was examined with the Chi-Square Independence test, and the effect size was examined with the Cramér's V value. Cramér's V effect sizes are generally evaluated as negligible association (.00 and under .10), weak association (.10 and under.20), moderate association (.20 and under .40), relatively strong association (.40 and under .60), strong association (.60 and under .80), and very strong association (.80 and under 1.00) (Rea & Parker, 2014). Mann-Whitney U test was used for two groups and Kruskal Wallis test was used for more than two groups in comparisons according to mean rank. Effect size values are interpreted as 0.10 small, 0.30 medium, 0.50 large effects for r, and 0.01 small, 0.06 medium and 0.14 large effects for Eta squared (Cohen, 1988). The Spearman Correlation test examined the relationship between the scale and its sub-dimensions.

Results

The Chi-Square Independence test was used to compare the students' gender, the number of siblings, and grade level variables according to their digital game playing status, and the results are shown in Table 1, along with their age and electronic device information. Among the 394 students participating in the research, the number of

those who play digital games is 254 (64.5%), and the number of those who do not play digital games is 140 (35.5%). It is seen that there is a statistically significant and moderate relationship between gender and playing digital games (p< .05). There is a statistically significant and weak correlation between the number of siblings and the situation of playing digital games (p< .05). The descriptive values of motivation and addiction towards digital gaming in the study are given in Table 2.

Table 1. Descriptive information by age and digital game playing status

Descriptive informations	Age(month)	Do you play digital games?							
		Yes			No			Total	
	M±SD	N	Row N %	Column N %	N	Row N %	Column N %	N	Column N %
Total	153.3±11.5	254	64.5	100.0	140	35.5	100.0	394	100.0
Gender (χ^2=45.510 *p*=.000* V=.340)									
Boys	153.9±11.6	140	83.3[a]	55.1	28	16.7[a]	20.0	168	42.6
Girls	152.8±11.5	114	50.4[b]	44.9	112	49.6[b]	80.0	226	57.4
Number of Siblings (χ^2=4.904 *p*=.027* V=.112)									
≤ 1	150.5±11.7	133	70.0[a]	52.4	57	30.0[a]	40.7	190	48.2
≥ 2	156.1±10.7	121	59.3[b]	47.6	83	40.7[b]	59.3	204	51.8
Grade Level (χ^2=0.921 *p*=.820)									
5th	133.8±3.2	47	67.1	18.5	23	32.9	16.4	70	17.8
6th	146.2±6.4	43	68.3	16.9	20	31.7	14.3	63	16.0
7th	156.9±3.6	94	62.7	37.0	56	37.3	40.0	150	38.1
8th	164.1±5.5	70	63.1	27.6	41	36.9	29.3	111	28.2
Electronic Device (multiple response)									
Smartphone		147	69.3	63.9	65	30.7	58.0	212	62.0
Tablet		121	72.5	52.6	46	27.5	41.1	167	48.8
Computer		113	75.8	49.1	36	24.2	32.1	149	43.6
Game Console		15	100.0	6.5	0	0.0	0.0	15	4.4

Note. V= Cramer's V

a-b Means in columns without a common superscript are statistically different according to z-test analysis (p<.05)

*p< .05

Table 2. Descriptive values of motivation and addiction towards digital gaming

Scales	Minimum	Maximum	M	SD
DGPMS-F1	5	25	14.90	4.07
DGPMS-F2	9	45	28.48	8.90
DGPMS-F3	5	25	16.28	4.64
DGPMS	21	93	59.66	12.13
DGASFC-F1	7	35	13.91	6.04
DGASFC-F2	7	35	17.87	6.46
DGASFC-F3	6	30	11.15	5.22
DGASFC-F4	4	20	7.94	3.62
DGASFC	24	118	50.87	19.09

Note: DGPMS-F1=Success and Recovery, DGPMS-F2=Curiosity and Social Acceptance, DGPMS-F3=Uncertainty in Game Request, DGPMS=Digital Game Playing Motivation Scale, DGASFC-F1=Excessive Focus and Conflict on Playing Digital Game, DGASFC-F2=Tolerance Development in Game Play and Value Added to Game, DGASFC-F3=Postponement of Individual and Social Duties/Assignments, DGASFC-F4=Psychological-Physiological Reflection of Dysnity and Diving in Game, DGASFC=Digital Play Addiction Scale for Children

The Mann-Whitney U test was used to compare motivation and addiction towards digital gaming of the students in the study by gender, and it is shown in Table 3. Success and Recovery, Curiosity and Social Acceptance, Digital Game Playing Motivation, Excessive Focus and Conflict on Playing Digital Game, Tolerance Development in Game Play and Value Added to Game, and Digital Play Addiction levels show a statistically significant difference at the small effect level according to gender (p< .05). There is no significant difference in the levels of Uncertainty in Game Request, Postponement of Individual and Social Duties/Assignments, and Psychological-Physiological Reflection of Dysnity and Diving in Game according to the gender (p> .05).

Table 3. Comparison of motivation and addiction towards digital gaming by gender

Scales	Gender-Mean Rank		U	Z	*p*	r
	Boys(n=140)	Girls(n=114)				
DGPMS-F1	137.93	114.69	6519.500	-2.516	.012*	-0.16
DGPMS-F2	137.95	114.67	6517.500	-2.513	.012*	-0.16
DGPMS-F3	134.17	119.31	7046.500	-1.607	.108	-
DGPMS	142.15	109.51	5929.500	-3.522	.000*	-0.22
DGASFC-F1	137.37	115.38	6598.000	-2.379	.017*	-0.15
DGASFC-F2	137.85	114.79	6530.500	-2.493	.013*	-0.16
DGASFC-F3	133.46	120.18	7146.000	-1.443	.149	-
DGASFC-F4	133.69	119.90	7114.000	-1.499	.134	-
DGASFC	136.77	116.12	6682.500	-2.229	.026*	-0.14

Note: DGPMS-F1=Success and Recovery, DGPMS-F2=Curiosity and Social Acceptance, DGPMS-F3=Uncertainty in Game Request, DGPMS=Digital Game Playing Motivation Scale, DGASFC-F1=Excessive Focus and Conflict on Playing Digital Game, DGASFC-F2=Tolerance Development in Game Play and Value Added to Game, DGASFC-F3=Postponement of Individual and Social Duties/Assignments, DGASFC-F4=Psychological-Physiological Reflection of Dysnity and Diving in Game, DGASFC=Digital Play Addiction Scale for Children

*p< .05

The Mann-Whitney U test was used to compare the students' motivation and addiction towards digital gaming in the study according to the number of siblings, and it is shown in Table 4. Motivation and addiction towards digital gaming do not show a statistically significant difference according to the number of siblings (p>.05).

Table 4. Comparison of motivation and addiction according to the number of siblings

Scales	Number of Siblings-Mean Rank		U	Z	*p*
	≤ 1 (n=133)	≥ 2 (n=121)			
DGPMS-F1	121.78	133.79	7286.000	-1.305	.192
DGPMS-F2	121.79	133.78	7287.000	-1.300	.194
DGPMS-F3	133.77	120.61	7212.500	-1.429	.153
DGPMS	122.94	132.51	7440.500	-1.037	.300
DGASFC-F1	125.12	130.11	7730.500	-.542	.588
DGASFC-F2	121.44	134.16	7240.500	-1.380	.167
DGASFC-F3	121.47	134.13	7244.500	-1.382	.167
DGASFC-F4	123.06	132.38	7455.500	-1.019	.308
DGASFC	122.41	133.09	7370.000	-1.157	.247

Note: DGPMS-F1=Success and Recovery, DGPMS-F2=Curiosity and Social Acceptance, DGPMS-F3=Uncertainty in Game Request, DGPMS=Digital Game Playing Motivation Scale, DGASFC-F1=Excessive Focus and Conflict on Playing Digital Game, DGASFC-F2=Tolerance Development in Game Play and Value Added to Game, DGASFC-F3=Postponement of Individual and Social Duties/Assignments, DGASFC-F4=Psychological-Physiological Reflection of Dysnity and Diving in Game, DGASFC=Digital Play Addiction Scale for Children

Table 5. Comparison of motivation and addiction by grade level

Scales	Grade Level - Mean Rank				χ^2	*p*	η^2
	5th n=47	6th n=43	7th n=94	8th n=70			
DGPMS-F1	105.06	126.06	128.15	142.58	7.406	.060	
DGPMS-F2	102.83	123.14	126.55	148.01	10.938	.012*[a]	.04
DGPMS-F3	132.04	138.44	127.85	117.26	2.506	.474	
DGPMS	101.84	127.06	128.27	143.97	9.271	.026*[a]	.03
DGASFC-F1	100.77	150.23	126.71	132.55	10.739	.013*[b]	.04
DGASFC-F2	105.13	137.64	126.29	137.91	6.630	.085	
DGASFC-F3	103.79	149.67	121.87	137.36	10.784	.013*[b]	.04
DGASFC-F4	113.79	141.23	124.44	132.39	3.674	.299	
DGASFC	101.85	147.31	124.23	136.94	10.203	.017*[a,b]	.04

Note: DGPMS-F1=Success and Recovery, DGPMS-F2=Curiosity and Social Acceptance, DGPMS-F3=Uncertainty in Game Request, DGPMS=Digital Game Playing Motivation Scale, DGASFC-F1=Excessive Focus and Conflict on Playing Digital Game, DGASFC-F2=Tolerance Development in Game Play and Value Added to Game, DGASFC-F3=Postponement of Individual and Social Duties/Assignments, DGASFC-F4=Psychological-Physiological Reflection of Dysnity and Diving in Game, DGASFC=Digital Play Addiction Scale for Children.
Mann Whitney U test was used and results with a $p < .0125$ difference after Bonferroni correction.
[a]5th-8th, [b]5th-6th
*$p < .05$

The Kruskal-Wallis test was used to compare the students' motivation and addiction towards digital gaming in the study according to the grade level, and the Mann-Whitney U test was used for the source of the difference and is shown in Table 5. Curiosity and Social Acceptance, Digital Game Playing Motivation, Excessive Focus and Conflict on Playing Digital Game, Postponement of Individual and Social Duties / Assignments and Digital Play Addiction levels show a statistically significant difference at the large effect level according to grade level ($p < .05$). There is no significant difference in the levels of Success and Recovery, Uncertainty in Game Request, Tolerance Development in Game Play and Value Added to Game, and Psychological-Physiological Reflection of Dysnity and Diving in Game according to the grade level ($p > .05$).

The Spearman Correlation test was used, and the relationship between motivation and addiction towards digital gaming sub-dimension and total scale scores of the students participating in the study is shown in Table 6. There is no statistically significant relationship between the level of Uncertainty in Game Desire and the level of Digital Game Playing Motivation ($p > .05$). However, the relationship between all other sub-dimensions and the total scores of the scales is statistically significant ($p < .05$).

Table 6: Relationship between motivation and addiction towards digital gaming

Scales	1	2	3	4	5	6	7	8	9
1.DGPMS-F1	1.000	.717**	-.211**	.784**	.421**	.621**	.323**	.475**	.556**
2.DGPMS-F2		1.000	-.182**	.918**	.437**	.655**	.335**	.382**	.562**
3.DGPMS-F3			1.000	.121	-.188**	-.138*	-.191**	-.189**	-.205**
4.DGPMS				1.000	.403**	.649**	.290**	.387**	.537**
5.DGASFC-F1					1.000	.675**	.752**	.701**	.898**
6.DGASFC-F2						1.000	.561**	.614**	.872**
7.DGASFC-F3							1.000	.606**	.821**
8.DGASFC-F4								1.000	.800**
9.DGASFC									1.000

Note: DGPMS-F1=Success and Recovery, DGPMS-F2=Curiosity and Social Acceptance, DGPMS-F3=Uncertainty in Game Request, DGPMS=Digital Game Playing Motivation Scale, DGASFC-F1=Excessive Focus and Conflict on Playing Digital Game, DGASFC-F2=Tolerance Development in Game Play and Value Added to Game, DGASFC-F3=Postponement of Individual and Social Duties/Assignments, DGASFC-F4=Psychological-Physiological Reflection of Dysnity and Diving in Game, DGASFC=Digital Play Addiction Scale for Children
*$p < .05$ **$p < .01$

Discussion

According to this study, in which secondary school students participated, the number of digital game players is higher. Although the number of students who state that they play digital games is higher than those who do not, the rate of students who state that they do not play digital games at 35.5% is at a level that cannot be ignored. Among those who play digital games, the proportion of boys is higher than girls, and the proportion of those who have 0-1 siblings is higher than those who have two or more siblings. As the number of siblings decreases, individuals may feel lonely, and therefore, they may turn to digital games. As the number of siblings increases, the rate of playing digital games may decrease as there is an opportunity to spend more time with siblings. There is an inverse relationship between the number of siblings and smartphone addiction, as the number of siblings decreases, smartphone addiction increases (Yıldız Durak, 2019). The grade level does not differ proportionally between those who play digital games and those who do not. The fact that students are at different grade levels also indicates that they are in different age groups. We can say that grade level and accordingly age do not have any decisive influence on the decisions about whether to play digital games or not. The order of electronic

devices owned by the students participating in the research from most to least is a smartphone, tablet, computer, and game console. All of the students who have a game console play digital games but the number of students with a game console is low. The insufficient economic level is one reason of this. Öztürk Eyimaya et al. (2020), listed the electronic devices that primary school fourth-grade students own from most to least as tablets, computers, mobile phones, and game consoles. The fact that the types and numbers of electronic devices students own contain similar results may be due to the similarity of socio-economic structures.

The digital gaming motivation (M=59.66 SD=12.13) scores of the students in our study are slightly above the scale average. Yılmaz (2021), in his study with high school students, determined the sub-dimension and scale mean scores to be Success and Recovery (M=16.60 SD=3.94), Curiosity and Social Acceptance (M=32.33 SD=8.18), Uncertainty in Game Request (M=16.60 SD=3.94) and Digital Game Playing Motivation (M=64.83 SD=13.57) were similar to our study. When the total score averages of the participants' digital gaming addiction are evaluated, the level of addiction is generally between low-risk and risky degrees. Güvendi et al. (2019), in their research with 279 secondary school students, found that the participants were in the risky group according to the average values of the digital game addiction scale, similar to our study.

The hypothesis "H_{01}: Gender has no effect on motivation and addiction to digital gaming" was rejected. According to gender, Success and Recovery, Curiosity and Social Acceptance, Digital Game Playing Motivation, Excessive Focus and Conflict on Playing Digital Game, Tolerance Development in Game Play and Value Added to Game, and Digital Play Addiction levels are higher in boys than girls. There is no difference between boys and girls in the levels of Uncertainty in Game Request, Postponement of Individual and Social Duties/Assignments, and Psychological-Physiological Reflection of Dysnity and Diving in Game. In the studies conducted with secondary school (Bozkurt & Tamer, 2020) and high school (Tekkurşun Demir & Cicioğlu, 2019) students, there was a significant difference in favor of boys in the levels of Success and Recovery, Curiosity and Social Acceptance ($p<,05$) and there was no significant difference in terms of gender at the level of Uncertainty in Game Request ($p> .05$) was determined in a similar way to the results in our study. Significant differences in favor of boys in the digital gaming motivation by gender are similar during the academic year and the summer vacation (Yılmaz, 2021). These essential findings are consistent with research showing that the digital game addiction level scores according to gender were statistically significantly different in favor of males (Gülbetekin et al., 2021; Güvendi et al., 2019; Özturk Eyimaya et al., 2020). During computer games, the mesocorticolimbic reward system shows more activation and functional connectivity in men than in women, resulting in significant gender differences in reward and addiction (Hoeft et al., 2008). The game behavior predictors of male adolescents (violence, self-efficacy, and psychosocial problems) are significantly different from those of females (Irmak & Erdoğan, 2019). In addition to the sources of differences between males and females mentioned in the literature, environmental factors may be among the reasons why the level of motivation to play digital games is higher in males. One reason for the high motivation may be that boys talk more about digital games with their friends than girls.

The hypothesis "H_{02}: The number of siblings has no effect on motivation and addiction to digital gaming" was accepted. The students' motivation and addiction towards digital gaming in this study are not affected by the number of siblings. The number of siblings is not a statistically significant predictor of smartphone addiction (Yıldız Durak, 2019). There is no statistically significant relationship between the number of siblings and the level of internet addiction in high school students (Üneri & Tanıdır, 2011). Similar research results on smartphone and internet addiction support our findings. The fact that the number of siblings is less or more will not change the level of influence on each other, so it can be expected that there will be no differentiation in both motivation and addiction levels.

The hypothesis "H_{03}: Grade level has no effect on motivation and addiction to digital gaming" was rejected. According to grade level: Curiosity and Social Acceptance and Digital Game Playing Motivation levels are higher in 8th grades than in 5th grades, Excessive Focus and Conflict on Playing Digital Game and Postponement of Individual and Social Duties/Assignments levels are higher in 6th grades than in 5th grades, and Digital Play Addiction level is higher in 8th and 6th grades than in 5th grades. There is no significant difference between grade levels in the levels of Success and Recovery, Uncertainty in Game Request, Tolerance Development in Game Play and Value Added to Game, and Psychological-Physiological Reflection of Dysnity and Diving in Game. Bozkurt and Tamer (Bozkurt & Tamer, 2020) found that the Curiosity and Social Acceptance level was higher in 8th grades compared to 5th grades ($p< .05$), and there was no difference in Success and Recovery and Uncertainty in Game Request levels according to grade level. Tekkurşun Demir & Cicioğlu (2019), found that there was a significant difference in favor of the 11th grade at the Curiosity and Social Acceptance level and favor of the 10th grade at the Uncertainty in Game Request level in high school ($p< .05$). 8th grade students play more video games than 5th grade students (Greenberg et al., 2010). It is an

acceptable result that 8th and 6th grade students have higher motivation and addiction levels since they have been playing digital games longer than 5th grade students.

The hypothesis "H_{04}: There is no relationship between motivation and addiction to digital gaming" was rejected. Uncertainty in Game Desire and Digital Game Playing Motivation levels are not related, but all other sub-dimensions and the total scores of the scales are correlated with each other. Hazar (2019), stated in his study that all sub-dimensions of motivation for digital gameplay were statistically significantly correlated and that the Uncertainty in Game Request sub-dimension had a negative and significant relationship with other sub-dimensions ($p< .05$). Gülbetekin et al. (2021), in their study, found a positive and significant relationship between all of the Digital Play Addiction sub-dimensions and total scores, which supports our study. As the level of motivation to play digital games increases, students play more games and this increasing their level of addiction.

As a result, the situation of playing digital games (yes/no) is significantly related to gender (in favor of boys) and the number of siblings (in favor of those with ≤ 1 sibling), but not with the grade level in secondary school. Motivation and addiction towards digital gaming are significantly affected by gender (in favor of boys) and grade level (in favor of 8th graders), but not by the number of siblings. There is a positive and significant relationship between motivation and addiction levels towards digital games. In light of these results, practical implications for preventing digital game addiction were proposed. Educational institutions, families, and communities can organize awareness campaigns to explain digital game addiction's potential risks and effects. Digital game playing times may be restricted. Increasing family interaction and spending more time together can balance children's digital game playing time. Children can be encouraged to do sports, spend time outdoors and be more active. Although the suggestions may be seen as general, based on the results of the research, more effort should be made for males according to gender and for 8th graders according to grade level.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Author(s) Information

Mehmet Oktay Kablan
Coaching Education, Sinop University,
Sinop, Türkiye
ORCID iD: 0000-0002-3544-9292

Mehmet Imamoglu
Department of Sport Management, Sinop University,
Sinop, Türkiye
Contact e-mail: mehmet.imamoglu@outlook.com
ORCID iD: 0000-0001-9820-106X

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The Effects of Digital Game-Based Learning in Technology-Oriented Course: A Case Study in the Biochemistry Department

Cengiz Gunduzalp

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Abstract

This study was done to find out what students thought about the variables of perceived control, perceived learning, perceived benefit, interest, motivation, affective components, attitude, behavioral components, and learning experience when using digital games in information and communication technologies courses. As a case study, the study was created. 30 students from the biochemistry department made up the study's research group. The tool for gathering data was a semi-structured interview form. Data analysis was done using the content analysis method. When the study's results were discussed, students claimed that playing digital games improved their perceptions of their level of control, interest in the subject, motivation, perceived value of the course, learning experiences, and learning facilitation. Students also mentioned that they felt a variety of positive emotions while using digital games, that they wanted to play them constantly and willingly, and that their attitudes had improved. To increase and enhance students' interest in the course, motivation, positive attitudes and emotions, desire, and learning experiences, digital games can be used in technology-focused courses.

Introduction

The importance of the digital gaming sector has increased recently on a global scale. The number of gamers worldwide provides insight into the significance placed on the digital gaming industry. The number of current game users worldwide increased by 5.3% in 2020 compared to the previous year, reaching 2.7 billion. This information comes from the Newzoo 2020G Global Games Market Report. According to the same report, gaming streaming usage increased 69% in the first quarter of 2022 compared to the same period in 2020, and Twitch, a platform for streaming live sports and video games, recorded 229 million hours of streaming in that same period (Digital Games Report, 2020). On a particular day, data from Steam (https://store.steampowered.com), one of the digital gaming websites, revealed that there were 22,395,491 concurrent active users. According to Counter-Strike: Global Offensive's 30-day statistics (found at https://store.steampowered.com/app/730 CounterStrike Global Offensive/), 541 million hours were spent playing the game by 995 thousand players (Savaş, Güler, Kemal, Çoban & Güzel, 2021). This information on digital games shows that they have a significant global impact and tremendous potential. The audience that digital games have an impact on and their potential have been discovered to be quite remarkable in the fields of education and other fields. The use of games for learning has become increasingly popular among academics and practitioners in the field of education, particularly those working in the area of educational technologies (Tüzün, Akıncı, Yıldırım, & Sırakaya, 2016).

Academics are very interested in the widespread and quick development of digital games in the field of education (Mayer, 2019). The possibility of using digital games as a tool for learning and teaching or as a method of learning in the field of education has raised interest in research in this area (Whitton, 2010). Due to this interest, there have been an increasing number of studies in the literature on digital game-based learning that are based on games with various features. In fact, digital game-based learning has received a lot of attention in recent years and has established itself as a significant topic of study in the literature (Chen, Zou, Cheng & Xie, 2020; Koparan, 2021).

Information and communication technologies (ICT) are seen as both a cause and an effect for innovations and changes in the field of education, even though they are one of the most striking symbols of globalization and the innovation movement in education (Clegg, Hudson & Steel, 2003; Power, 2007; Peeraer & Van Petegem, 2015). In actuality, the use of ICT in the field of education is very effective in a variety of areas, including producing, changing, and sharing knowledge, facilitating quick and simple access to information, and creating content that is appropriate for needs and individual differences (Erdoğmuş, 2020). ICT in education has many advantages,

according to studies in the literature (Fullan & Langworthy, 2013). ICT can be used for creative learning outside of the classroom and in the context of a skills-based approach (Peeraer & Van Petegem, 2011a).

The use of mobile technologies, virtual worlds, and cloud computing in education, which support a progression beyond the use of personal computers, can help students develop their knowledge and skills to become independent learners (Peeraer & Van Petegem, 2012). ICT used in education can assist students in taking ownership, allowing them to make mistakes, questioning authority, and making data-driven decisions (Tubin, 2006). It is critical in this setting for students to acquire a solid understanding of contemporary information and communication technologies as well as the knowledge and skills necessary to use them. To ensure that students learn effectively and acquire a variety of knowledge and skills, many different techniques are employed. In fact, methods that encourage students to pursue individual education for an active learning process and distance methods from traditionalism are expected to be included in today's educational systems (Cunska & Savicka, 2012). Learning through digital games has a significant place among them.

Digital game-based learning can be used to facilitate interaction, overcome lack of engagement, deep thinking, positive behavioral changes, and content-based learning in addition to amusing students (Phaire, 2007; Perrotta, et al., 2013; Lester, et al., 2014). Learning materials are combined with competition, feedback, and rewards in digital game-based learning to create a fun and educational environment (Chen & Chang, 2020; Tan, Chen & Lee, 2020; Liu, Wang & Lee, 2021). According to various studies' findings, incorporating competition, feedback, and rewards into digital game-based learning can significantly improve learning (Yang, Chung, & Chen, 2022).

Digital game competition has been used to get students to concentrate more on the game, just-in-time feedback has been used to increase learning gains and retention, and incentives have been used to get students to put in extra effort to learn (Wei, Kao, Lu, & Liu, 2018; Park, Kim, Kim, & Mun, 2019; Reynolds & Kao, 2021). By allowing the games to be played repeatedly, the integrity of these components with the learning material ensures that learners actively participate in the games, making their knowledge more permanent, and creates a fun environment, increasing both participation and motivation (Hung, Yang, Hwang, Chu & Wang, 2018; Lee, 2019). Additionally, by engaging in learning-by-doing activities, students are able to structure their new knowledge with their prior knowledge and experiences and perform more successfully for learning thanks to this integrity (Pitarch, 2018). The types of digital games with the features of knowledge transfer (cognitive learning outcomes), skill acquisition (skill-based learning outcomes), and behavior/attitude change (affective learning outcomes) are used to achieve the stated situations with game-based learning (Stewart et al., 2013). Effectively utilizing various digital game types makes it quick and simple to accomplish a variety of goals and objectives. According to research published in the literature, effective planning and design of games used in digital game-based learning can improve student performance in terms of engagement, motivation, attitude, and concentration (Sung & Hwang, 2018; Tapingkae, Panjaburee, Hwang & Srisawasdi, 2020; Taub, Sawyer, Smith, Rowe, Azevedo & Lester, 2020; Cai, Mao, Wang, He, Chen & Fan, 2022); this can (Hsiao, Chang, Lin, Chang & Chen, 2014; Dindar, 2018; Pratama & Setyaningrum, 2018).

Research on digital game-based learning has shown that it can be more effective than conventional methods in a variety of subject areas, including the teaching of mathematics, the acquisition of foreign languages, the study of science, and the provision of healthcare (Wouters & van Oostendorp, 2013; Clark, Tanner-smith & Killingsworth, 2016; Tokac, Novak & Thompson, 2019; Gentry et al., 2019; Ghoman et al., 2019). Considering the results of the studies on the games used in digital game-based learning, the effects of digital games in shaping the emotions and behaviors of students in the educational environment and processes can be evaluated in the context of different variables. These may include perceived control, perceived usefulness, affective and behavioral components. Perceived control refers to the emotional and reactive behaviors that students develop while playing digital games. Self-learning skills related to tasks in games and having control abilities while playing games can be evaluated in this context. Perceived benefit refers to behaviors that result from students' beliefs about the benefits of games.

The affective components are the feelings of fear, hesitation and irritability before and during the play. Students' willingness or unwillingness to play games are also behavioral components (Sarıgöz, Bolat & Alkan, 2018). Making positive contributions to students' perceived control and benefit, affective and behavioral components with the help of digital games can help shape students' emotions and behaviors. In fact, it is aimed to provide emotional and behavioral participation in the games and to satisfy the students by entertaining them (Sarıgöz, Bolat & Alkan, 2018). The positive development of students' emotions and behaviors with digital games makes significant contributions to many different variables for lessons. These include attracting students' interest in lessons, changing their behaviors, influencing their motivation (Foster & Shah, 2016) and enabling them to

develop positive attitudes towards lessons (Prensky, 2003; Papastergiou, 2009). These findings are supported by meta-analyses of the literature on digital game-based learning (Clark et al., 2016; Tsai & Tsai, 2020). However, it has been noted that there are only a few qualitative studies that reveal the effects of using digital games on various variables while taking student opinions into consideration. Qualitative research is required in this area. With qualitative research, detailed information about the topic and situation being studied can be obtained from a small number of participants, and this information can be thoroughly explained through content analysis (Hsieh & Shannon, 2005; Elo & Kyngäs, 2008). Examining how the use of digital games affects various student-related variables from the viewpoint of the students is deemed important in this context.

The literature on digital game-based learning reveals the positive effects of this method on various variables and fields. However, it is understood from the literature that the underlying reasons that cause and underlie the positive effects of digital games used in digital game-based learning are not well known and researched. Considering this situation, this study was conducted to determine how these positive effects emerge in students and students' experiences of using digital games. In this respect, the study will make important contributions to the literature. This study was conducted to reveal the role of digital game-based learning in the information and communication technologies course within the scope of a qualitative research in line with student views. The research questions to be analyzed in line with the purpose of the study are as follows.

- What are students' views on digital games in terms of perceived control?
- What are students' views on the effects of digital games in terms of perceived learning?
- What are students' views on digital games in terms of perceived benefit?
- What are students' views on the effects of digital games in terms of their interest in the course?
- What are the opinions of students about the effects of digital games in terms of their motivation towards the course?
- What are students' views on digital games in terms of affective components?
- What are the opinions of students about the effects of digital games in terms of their attitudes towards the course?
- What are students' views on digital games in terms of behavioral components?
- What are students' views on the effects of digital games in terms of learning experiences?

Method

Research Model

The study was designed with a case study, one of the designs based on qualitative research approaches. Case studies are research studies in which the causes, processes or results that are thought to be the source of a particular situation are examined and described in detail in line with the research purpose (Creswell & Creswell, 2018). In the study, the research approach was determined first. Then, the process was organized in accordance with the qualitative research approach and the design of the case study was planned. In the next stage, the research group and data collection tools were organized and the research group was determined (Arıcı, Yılmaz & Yılmaz, 2021). The research group was determined by convenience sampling method. A semi-structured interview form was prepared as a data collection tool and its validity and reliability were tested. For this purpose, opinions were taken from experts in the field for the interview form and pilot interviews were conducted with the students with the interview form. In the last stage, the research was carried out. In the study, biochemistry department students were enabled to use digital games in information and communication technologies courses and extracurricular activities. Then, the opinions of the students about digital games were revealed. The students' views were analyzed from their perspectives in terms of perceived learning, interest, attitude, motivation, learning experience, affective components, perceived benefit, perceived control and behavioral components.

Study Group

The participants in the research group of the study were randomly selected from the biochemistry department students among the departments in which the researcher taught the information and communication technologies course with the convenience sampling method. Convenience sampling method was preferred in this study because it allows data collection easily, quickly and without much cost (Karasar, 2014). A total of 30 first-year students, 23 female and 7 male, participated in the study voluntarily. Participants were given detailed

information about the study process. Students participated in the study on a voluntary basis. Permissions were obtained from the institution and ethics committee where the study was conducted. All of the students who actively attended the classes participated in the study.

Data Collection Tools

In the study, a semi-structured interview form was developed to obtain the opinions of the students. The questions in the interview form were adapted from the studies of Sarıgöz, Bolat, and Alkan (2018) and Arıcı, Yılmaz, and Yılmaz (2021) and prepared by the researcher. For the questions in the interview form, the opinions of experts in the field were taken and arrangements were made in line with these opinions. Two of these experts were experts in computer and instructional technologies, and the other two were experts in educational sciences and measurement and evaluation. Pilot interviews were conducted with the interview form. The data obtained from these interviews were taken into consideration and the form was finalized. The questions in the interview form prepared for the students are given below.

- How do you evaluate digital games in terms of perceived control?
- How do you evaluate the effects of digital games on your perceived learning?
- Do you think digital games are useful?
- How do you evaluate the effects of digital games on your interest in the course?
- How do you evaluate the effects of digital games on your motivation towards the course?
- What are your affective feelings towards digital games?
- How do you evaluate the effects of digital games on your attitude towards the course?
- How do you evaluate your behavioral tendencies towards digital games?
- How do you evaluate your learning experiences with digital games?

Data Analysis

The study's data analysis process used the content analysis methodology. The connections and relationships between the themes and codes related to the subject are revealed in the content analysis method, allowing for a detailed and in-depth analysis of the subject (Creswell, 2013). After the course process was completed, individual interviews were held with the students. Interviews were held once with each student participating in the study. The interviews, which were made with the permission of the students, were recorded with a voice recorder. The data recorded with the interviews were converted into text with software. In order to avoid data loss regarding the answers given by the students to the questions, the students were provided to check their answers. Students had the opportunity to review their answers and correct omitted or incorrectly worded sections. In this way, reliability is ensured. The interviews had no set time limit. Short breaks were taken when students became uninterested or uncooperative. The interviews with the students were carefully conducted in a setting conducive to casual conversation. This worked well to build trust.

A comprehensive approach was used to identify the subject-related themes and codes in the content analysis method used to examine the study data (Strauss & Corbin, 1990). The researcher went over each interview form where student opinions were collected multiple times at various times. In this process, opinions of different experts were taken. Repeated phrases in the interview forms, ideas with overlapping characteristics and connections to one another directly or indirectly, and content analysis units were identified (Arc, Yılmaz, & Yılmaz, 2021). Themes and codes make up these units. Tables are used to display the themes and codes that were developed for each research question.

Process

The study used 10 weeks of digital games designed for "Information and Communication Technology Concepts," "Using Computer and Managing Files," "Word Processing Software," "Spreadsheet Software," "Presentation Preparation Software," and "Internet and Web Usage" on the "learningapps.org" and "wordwall.net" websites. Five different templates were used in the design of digital games. 10 different games were designed using these templates. The templates are arranged according to the content of the course topics. Word puzzle, word stack, word hunt, matching and labeled diagram are the templates used. Some images of the games used in the implementation process of the study are shown in Figure 1.

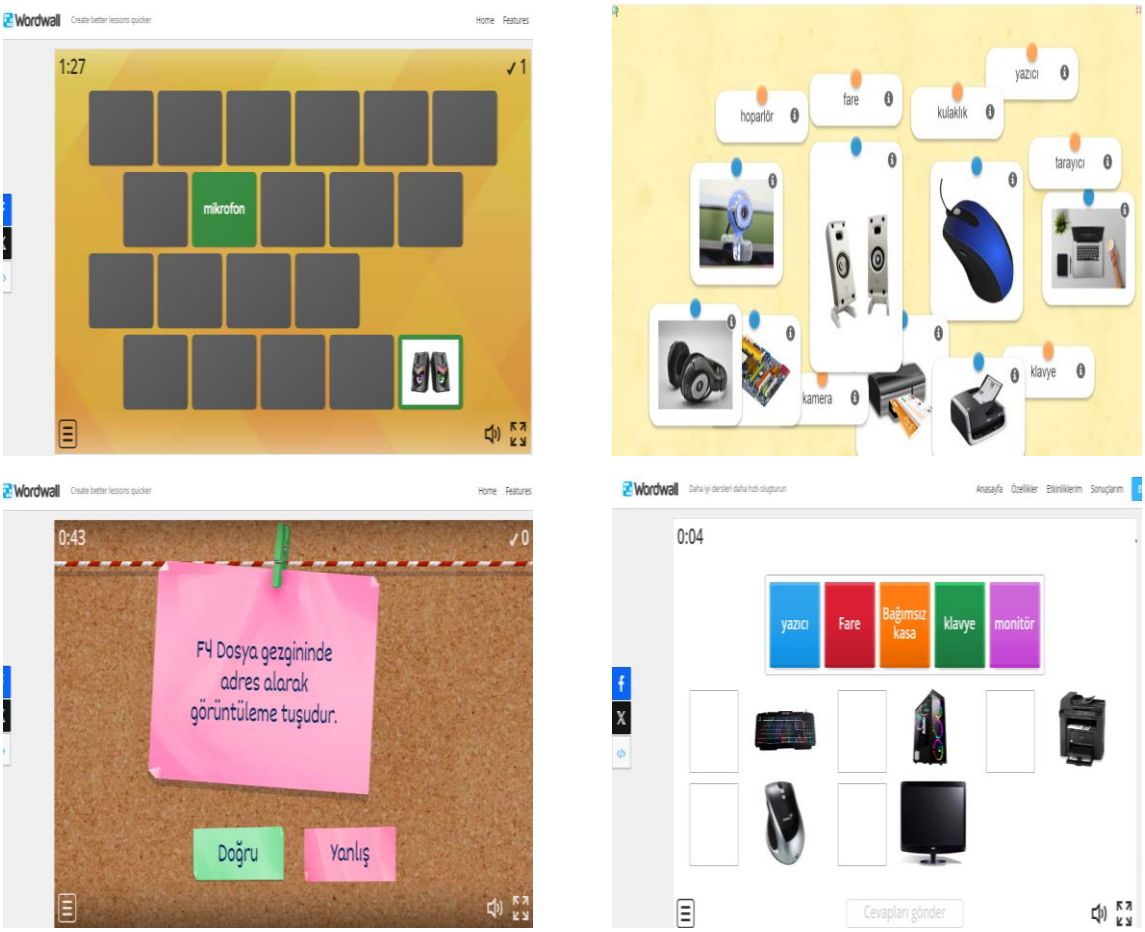

Figure 1. Some images of the games used in the implementation process of the study

Students played digital games in different parts of the lessons under the control of the researcher. Some visuals of the implementation process are presented in Figure 2. Students were permitted to use the digital games for both in-class and extracurricular purposes while the study was being implemented. In order to check whether the students play digital games in extracurricular activities, information about the games was obtained from the students at the beginning of the lessons. At the same time, the students were given the opportunity to replay the games they gave information under the control of the researcher. The students were interviewed at the conclusion of the procedure. The researcher conducted each and every interview.

Role of the Researcher

The researcher's course on information and communication technologies was taught in the biochemistry department, where the study was done. The researcher meticulously carried out and kept track of all of the digital game-based activities during the development and implementation phases of the course. At every stage of the study, the researcher played a part. The use of digital games in the classroom was viewed favorably by the researcher.

Validity and Reliability

In order to guarantee the study's internal validity, external validity, and reliability, Merriam's (2010) suggestions were taken into account. Internal validity was ensured through long-term observation, peer review, participant data verification, researcher expression of views and opinions at the start of the study, and participant involvement throughout the entire process. At the beginning of the implementation process, the researcher shared his thoughts and views with the students and encouraged all students to actively participate in the process. The researcher made his observations impartially in the long term throughout the implementation process. At the end of the application process, the data on the views on digital games were checked by the

researcher and students. Rich descriptions were made and the special characteristics of the circumstance were stated for external validity. For credibility, the researcher clearly described his or her position and role in the study and provided thorough explanations of each stage of its development in accordance with a predetermined system (Yin, 2013). In the study, the consistency was ensured by taking the opinions of different experts in determining the themes and codes.

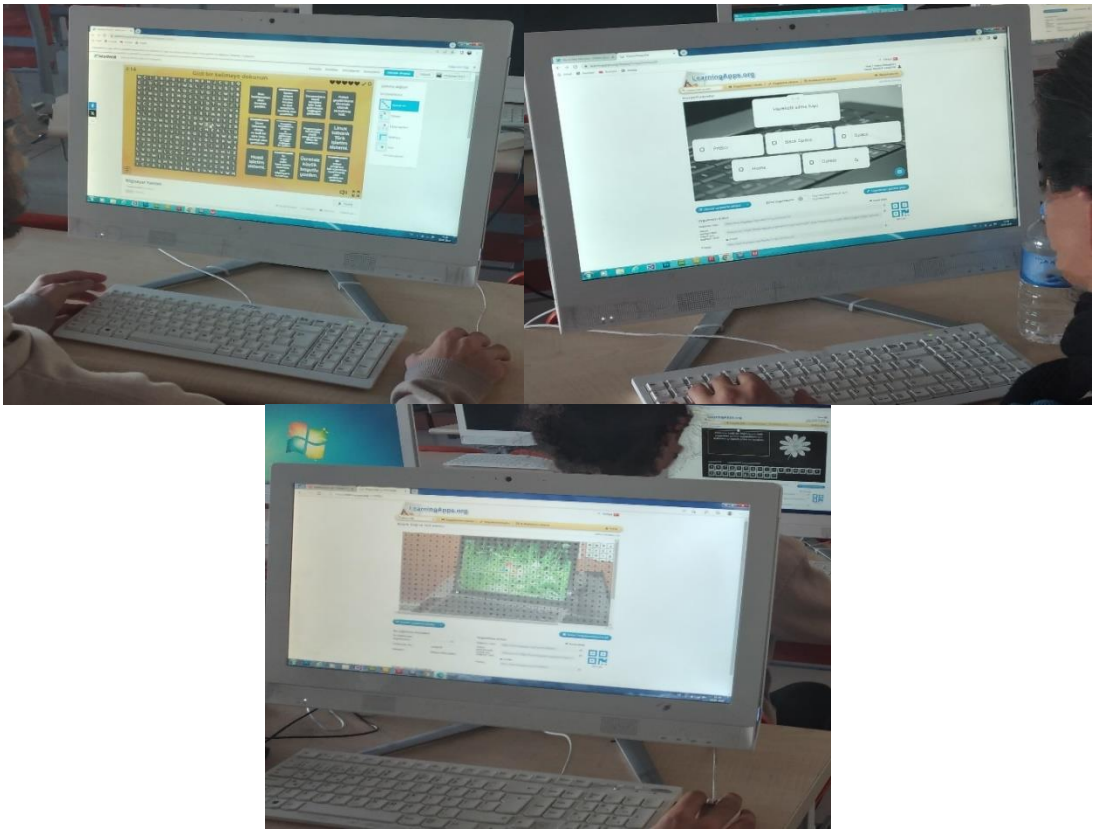

Figure 2. Some visuals of the implementation process

Findings

The findings obtained from student opinions are presented by classifying them in terms of perceived control, perceived learning, perceived benefit, interest, motivation, affective components, attitude, behavioral components and learning experience.

Perceived Control

Student responses to the question "How do you evaluate digital games in terms of perceived control?" were analyzed. Themes and codes were created within the scope of the related data. These are given in Table 1.

Table 1. Digital games in terms of perceived control

Theme	Codes	f
Percevied control	I was able to use the games easily	27
	I was able to use the games the way I wanted	27
	I learned many things about games on my own	26
	I had difficulties using the games	3
	Some games seemed complicated to me	2

According to Table 1, students stated that they could use digital games easily (f = 27) and as they wanted (f = 27) and that they could learn many things about the games by themselves (f = 26). On the other hand, some students stated that they had difficulties in using the games (f = 3) and that some games were complex (f = 2). Student opinions on this issue are given below:

"*I had no difficulty in using the games, I used them the way I wanted. When I examined the structure of the games, I was able to learn many things on my own.*" (S:5)

"*Some games were very easy to use, but some games had a very complex structure and I had a hard time using them*." (S:11)

Perceived Learning

The answers given by the students to the question "How do you evaluate the effects of digital games on your perceived learning?" were analyzed. Themes and codes were created according to the data obtained and presented in Table 2.

Table 2. Effects of digital games on perceived learning

Theme	Codes	f
Perceived learning	Making learning fun	28
	Facilitating learning	28
	Accelerating learning	28
	Making learning more effective	27
	Making learning more permanent	27

According to Table 2, students stated that digital games make learning more fun (f = 28), easier (f = 28) and faster (f = 28). In addition, students stated that games make learning more effective (f = 27) and permanent (f = 27). Examples of student opinions revealing this situation are given below:

"*Digital games made computer-related subjects understandable for me. I can play games in a fun way and learn something easily and quickly*." (S:25)

"*I have never learned computer-related subjects in such a fun way. I learned many subjects that seemed very complicated and difficult to me easily and quickly*." (S:15)

Perceived Benefit

The answers given to the question "Do you think digital games are useful?" were analyzed and Themes and Codes were created according to the answers given. These are given in Table 3.

Table 3**.** Digital games in terms of perceived usefulness

Theme	Codes	f
Benefit	Offer different ways to learn	28
	Enriching learning experiences	26
	Improving performance for learning	27

When Table 3 is examined, students stated that digital games helped them in providing different ways for learning (f = 28) and enriching learning experiences (f = 26). In addition, students stated that the games increased their performance towards learning (f = 27). Student opinions regarding this are presented below:

"*I learned many things in different ways in digital games. It enriched my learning experiences and thus made it easier for me to learn*" (S:30)

"*I think that the games we play are very useful for learning. I think that this is how my performance in the lessons increases*." (S:27)

Interest

The answers to the question "How do you evaluate the effects of digital games on your interest in the course?" were analyzed. Theme and Codes created with the data obtained from the answers given by the students are presented in Table 4.

Table 4. Effects of digital games on interest in the course

Theme	Codes	f
Interest	Having fun in lessons	28
	Enjoying lessons	28
	Increasing curiosity towards lessons	27
	Ensuring that lessons are followed carefully	27

When Table 4 is analyzed, students stated that they had fun in the lessons thanks to digital games (f = 28). While this situation made the lessons enjoyable (f = 28), it increased students' curiosity about the lessons (f = 27) and enabled them to follow their lessons carefully (f = 27). Some of the student opinions on this issue are given below:

"*Digital games make the lessons very fun. I look forward to the next lesson. These lessons are very enjoyable*." (S:5)

"*Computer lessons are very enjoyable and these lessons make me very curious. I follow the lessons very carefully and I want to learn everything about computers*."(S:1)

Motivation

The answers given to the question "How do you evaluate the effects of digital games on your motivation towards the course?" were analyzed and Themes and Codes were created and presented in Table 5. Table 5 shows that students claimed that using digital games increased their positive attitudes (f = 28), self-confidence (f = 28), and self-efficacy (f = 27) toward the course. By giving them control over the lesson, students claimed they improved their performance (f = 26; f = 27). Below are some student opinions in this regard:

"*Before this course began, I found computer-related subjects to be very challenging and complex, but thanks to these games, my positive thoughts about this course have significantly increased, my self-confidence has increased, and I started to see myself as competent in this course*," the student said. (S:26)

"*I learned many subjects quickly, and my performance significantly improved compared to the first time. I feel competent in subjects that I know little to nothing about the computer*. *I learn the course subjects effectively by playing the games whenever and wherever I want, so I am in control*." (S:17)

Table 5. effects of digital games on motivation towards the course

Theme	Codes	f
Motivation	Increasing positive thoughts towards the lesson	28
	Boosting self-confidence	28
	Supporting self-efficacy	27
	Ensuring control of the course	27
	Improving performance	26

Affective Components

The answers to the question "What are your affective feelings towards digital games?" were analyzed. Themes and Codes were created in the context of the data obtained through the analysis and presented in Table 6.

Table 6. Affective feelings towards digital games

Theme	Codes	f
Affective components	I did like games	27
	I enjoyed playing the games	27
	I was happy playing the games	26
	I was wondering while playing games	26
	I got excited playing the games	25
	I didn't like games	3
	I did't enjoy the games	3
	I got angry while playing games	2

According to Table 6, students stated that they had positive emotions towards digital game use such as liking (f = 27), enjoying (f = 27), being happy (f = 26), being curious (f = 26), and being excited (f = 25). On the other hand, some students stated that they had negative emotions towards digital games such as disliking (f = 3), disliking (f = 3) and getting angry (f = 2). Student opinions in this context are given below:

"*I liked the games very much, I had a lot of fun while playing them. They helped me learn while repeating the lesson, which made me very happy.*" (S:22)

"*I was very curious about the new games. Each game excited me a little more. But the fact that I was not successful in some games made me angry and I did not like those games*." (S:26)

"*I don't like computer games very much and I don't like them, they seem very complicated to me and this complexity makes me angry*." (S:27).

Attitude

The answers to the question "How do you evaluate the effects of digital games on your attitude towards the course?" were analyzed. Themes and Codes were created according to the answers given. These are given in Table 7.

Table 7. Effects of digital games on attitude towards the course

Theme	Codes	f
Attitude	Attending classes willingly	28
	Getting rid of prejudices about lessons	27
	Liking the lessons	27
	Be happy in the lessons	26

According to Table 7, students stated that thanks to digital games, they participated in the lessons willingly (f = 28) and got rid of their prejudices about the lessons (f = 27). This situation enabled students to love their lessons (f = 27) and feel happy in these lessons (f = 26). Student opinions on this issue are presented below:

"*I attend computer lessons very willingly. I had a lot of prejudices against this course, but I got rid of them all."* (S:6)

"*At first, I thought that the computer course was very difficult, but I realized that it was not. Now I like the computer course very much and I see it as a very happy course*." (S:7).

Behavioral Components

The answers to the question "How do you evaluate your behavioral tendencies towards digital games?" were analyzed and Themes and Codes were created. These are given in Table 8. When Table 8 is analyzed, students stated that they play digital games continuously (f = 28) and that they are willing to play digital games (f = 28) and that they can learn different subjects through digital games (f = 27). On the other hand, some students stated that they were not willing to play digital games (f = 2) and that they could play digital games when told (f = 2). Student opinions in this context are presented below:

"*I am very eager to play digital games and I play these games constantly. Thanks to these games, I can learn many different subjects*." (S:3)

"*I am not very eager to play games on the computer. I play the games because the lecturer tells me to.*" (S:4).

Table 8. Behavioral tendencies towards digital games

Theme	Codes	f
Behavioral Components	I play digital games all the time	28
	I am very eager to play digital games	28
	I can learn different subjects with digital games	27
	I am not very keen to play digital games	2
	I play digital games when told to	2

Learning Experience

The answers to the question "How do you evaluate your learning experiences with digital games?" were analyzed. Themes and Codes were created within the scope of the data and presented in Table 9.

Table 9. Learning experiences towards digital games

Theme	Codes	f
Experiences of using digital games	Fun	28
	Remarkable	28
	Easy to use	27
	Having content compatible with the course subjects	27
	Supporting individual learning	26

When Table 9 is analyzed, students stated that digital games are fun (f = 28), attention-grabbing (f = 28), easy to use (f = 27) and their content is compatible with the course subjects (f = 27). In addition, students stated that these games support individual learning (f = 26). Student opinions on this subject are given below:

"*Digital games were quite remarkable and fun for me. The games were very easy to use. The subjects that were explained to us in the lesson were all in these games*." (S:19)

"*By using these games, I was able to learn the subjects I did not understand in the lesson by studying them individually. This happened very quickly and effectively*." (S:20).

Discussion & Conclusion

Within the framework of a qualitative study, the opinions of students who use digital games in ICT classes were revealed. These opinions covered perceived control, perceived learning, perceived benefit, interest, motivation, affective components, attitude, behavioral components, and learning experience variables. The opinions of the biochemistry department students were discussed in this context

Perceived Control

The students said they could use the games easily and however they wanted when the study's findings were analyzed. Students acknowledged that they had picked up a lot of knowledge about the games on their own as well. This might be as a result of the simple and clear structures of digital games. The fact that students can play the games repeatedly whenever they want to overcome learning challenges and that they can repeatedly practice the subjects may also have had an impact on this situation. Additionally, this might also be because of how interactive digital games are. In fact, interactive technologies significantly raise users' perceived levels of control (Hu & Wise, 2020). There are similar study results even though there aren't many in the literature (Hu & Wise, 2020; Gu, Chen, Lin, Lin, Wu, Jiang, Chun, & Wei, 2022). Control is entirely given to the students when using digital games. Students had an optimistic view of their own potential and capabilities. Students felt they had more control over video games. The students' high level of perceived control over the digital games they were playing allowed them to have a high level of control over those games (Overmars & Poels, 2015). Better teaching outcomes were influenced by raising the sense of control over the teaching process (Gu et al., 2022). Some students, however, claimed that they found some of the games to be too complex for them and that they had trouble using them. Students may have perceived digital games to be challenging and complex due to the fact that cognitive load on users' working memory increases in digital game-based learning environments (Norman, 2011). In fact, learning becomes challenging when working memory is strained (Hariharasudan, Rahiman, Nawaz & Panakaje, 2021). As a result, it can be concluded that digital games make significant contributions to the enhancement of students' perceptions of their level of control.

Perceived Learning

The use of digital games in the ICT course, according to students' perceptions of their learning, made learning enjoyable. Digital games that have enjoyable environments, high-quality graphics, sound effects, and other aesthetic features can make learning enjoyable (Prensky, 2003). Students claimed that playing digital games made learning simple, quick, effective, and more lasting. Digital games with clearly defined objectives and tasks

to complete (Koparan, 2021) can guarantee the realization of the aforementioned learning-related situations. This situation may have been improved by incorporating learning materials with various components such as competition, feedback, and reward in digital game-based learning (Chen & Chang, 2020; Tan, Chen & Lee, 2020; Liu, Wang & Lee, 2021). Additionally, by encouraging active participation in the games, the competition, feedback, and rewards offered in accordance with the lesson plan may have ensured that the information is more permanent (Hung, Yang, Hwang, Chu, and Wang, 2018; Lee, 2019). Digital games have been shown in the literature to positively impact learning and a number of learning-related variables (Perrotta et al., 2013; Lester et al., 2014; Pitarch, 2018; Azevedo & Lester, 2020; Koparan, 2021; Cai et al., 2022). The positive effects that students reported for their learning may have been brought on by the use of a remarkable technology that had never been used before in their lessons. The novelty effect could also be to blame for this (Jeno, Vandvik, Eliassen & Grytnes, 2019). In light of these findings, it is clear that the use of digital games in game-based learning in ICT courses helps students perceive learning by positively influencing their learning.

Perceived Benefit

According to the study's findings, students said that playing digital games gave them access to new learning opportunities, enhanced their educational experiences, and improved their performance in academic settings. These findings appear to be directly related to how useful people believe digital games to be. Students successfully overcame their challenges by utilizing the variety of learning opportunities provided by digital games. In fact, students who play digital games have a variety of learning options by doing research (Hsiao, 2007). By utilizing the various features and functions of digital games, students showed significant improvements in their learning. This can be explained by the fact that online games can cater to the various expectations and needs of students while also varying their educational opportunities. Digital games' suitability for individualized instruction and a range of learning preferences might have had an impact. This might also be because digital games are simple to use and offer immediate feedback. According to the National Council for Teachers of Mathematics (NCTM), 2000, games can assist students in continuing their learning processes independently, coming up with alternate solutions for various problem situations, and receiving immediate feedback. By fulfilling the fundamental needs of a learning environment, games can give students interesting learning opportunities (Kiili, 2005). Additionally, games can improve and enrich students' educational experiences, making them more enjoyable and captivating (Anastasiadis, Lampropoulos & Siakas, 2018). In light of the study's findings, digital games were able to improve students' learning outcomes and performance by offering a variety of learning opportunities.

Interest

Students claimed that they had fun and enjoyed the lessons as a result of the use of digital games, according to the study's findings. The characteristics of digital games that make lessons less monotonous and boring can be used to explain this outcome. Additionally, it can be asserted that the inclusion of enjoyable elements in digital games and the provision of enjoyable experiences (Abdul Jabbar & Felicia, 2015; Kim & Lee, 2015) contribute significantly to students' enjoyment of the lessons. Digital games, according to the students, piqued their interest in the lessons and made them easier to carefully follow. Students' curiosity was piqued by the games that were created with unique features for each lesson. Students were able to better concentrate on the lessons because of the much more engaging learning environment created by digital games (Cai et al., 2022). The students' interest in video games and ability to closely follow instructions were both greatly influenced by their curiosity about these mediums. Similar study findings have been reported elsewhere (Sáez-López, Miller, Vázquez-Cano, and Domnguez-Garrido, 2015; Akn and Atc, 2015; Chang, Liang, Chou, and Lin, 2017; Anastasiadis, Lampropoulos, and Siakas, 2018), and they may be found in this context. It is safe to conclude that the games used in digital game-based learning increase students' interest in the subject.

Motivation

Students claimed that playing digital games increased their positive attitudes and sense of confidence toward the lessons, taking into account their opinions on motivation. This situation might have been impacted by the fact that students view digital games as a fun and enjoyable environment. This situation may also be impacted by the fact that students had quick and efficient learning experiences with digital games. Students' confidence may rise as a result of playing successful video games. Additionally, students reported that playing video games improved their performance, self-efficacy, and control over their education. This situation may have been

influenced by students' use of digital games to meet their own standards and objectives. Students were able to perceive themselves as competent in this regard and as possessing the necessary skills. Students took individual responsibility for the lessons in this way, assisted by the use of digital games, and improved their performance in terms of learning. All of the aforementioned circumstances can be said to be motivated by motivation. According to recent research, game-based learning significantly boosts motivation (Koparan, 2021). The findings of studies demonstrating the beneficial effects of digital games on motivation and variables related to motivation can be found in the literature (Bhandari, Hallowell & Correll, 2019; Grivokostopoulou, Kovas, & Perikos, 2019; Yang et al., 2020; Hwang & Chang, 2020; Chang, Kao, Hwang & Lin, 2020; Tapingkae et al., 2020). As a result, in learning environments supported by game-based learning, students' motivation and performance toward learning rise (Hsu, Chen, & Cao, 2017).

Affective Components

The study's findings indicated that liking, enjoying, being happy, curious, and excited were among the positive emotions experienced by students when using digital games. The development of these feelings may have been influenced by the fact that students find digital games entertaining and interesting, and that they enjoy playing them. Due to the fact that students use digital games as a new technology in their lessons, an innovation effect can be mentioned. According to Bendicho, Mora, Aorbe-Daz, and Rivero-Rodrguez (2017) and Jeno et al. (2019), the novelty effect may be to blame for this. Additionally, this situation may have been influenced by the fact that digital games assist students in learning new information, skills, and technological concepts and applications. Students' positive attitudes toward digital games grew as they enjoyed the feeling of success while playing these games. The students' curiosity and excitement were significantly piqued by the content, organization, and variety of the games created separately for each course subject. Similar study findings have been published in the past (Cheng & Su, 2012; Akın & Atıcı, 2015; Koparan, 2021; Cai et al., 2022). On the other hand, some students expressed that they experienced negative emotions while playing games, such as dislike for digital games and dislike for games in general. Use of digital games over an extended period of time might have had an impact. After extended use, favorable effects associated with newly adopted technologies may disappear (Arc, Ylmaz, & Yılmaz, 2021). This might also be a result of students' resistance to playing video games. In actuality, digital games might not be particularly engaging for all students and might divert their attention (Ke, 2008). It could be argued that this makes students feel unfavorably about playing video games.

Attitude

The study's findings demonstrated that students willingly engaged in the lessons using digital games and overcame their prejudices. This suggests that the games used in digital game-based learning help students have positive experiences and fulfill their expectations. According to opinions in this context, students adopt a positive attitude toward educational settings where video games are used. This situation may have been impacted by the fact that digital games efficiently allow interaction between the participant and the content (Anderson et al., 2010). A positive attitude toward the lessons was greatly influenced by the students' involvement in the game action, interactions, and challenges (Calleja, 2011; Barzilai & Blau, 2014). By encouraging enthusiastic participation in the lessons and facilitating the quick and easy acquisition of new knowledge and skills, the use of digital games helped students overcome their negative perceptions of the lessons. The use of digital games in the classroom, according to the students, made their lessons enjoyable. The students may have enjoyed themselves by having a good time in class, developed a positive attitude toward the lessons, and let go of their prejudices as a result. Students' active participation has been facilitated by the fact that digital games significantly increase interaction by appealing to multiple sensory organs, making them love their lessons and feel content in the classroom. The use of digital games by students to improve their academic performance also contributed to the appearance of these results. Literature (Sáez-López et al., 2015; Akın & Atıcı, 2015; Kruger, 2016; Sung & Hwang, 2018; Tapingkae et al., 2020; Taub et al., 2020; Yang, Chang, Hwang & Zou, 2020) contains studies with similar findings. As a result, a sizable majority of students adopted a favorable perspective on video games.

Behavioral Components

The study's findings revealed that a sizable majority of students played digital games regularly and were willing to do so. Students claimed that playing digital games allowed them to learn various subjects. The students'

enthusiastic attitude toward playing video games can be used to explain this. By taking part in and interacting with the game action, students were able to cultivate a positive attitude toward video games (Calleja, 2011; Barzilai & Blau, 2014). This situation might be impacted by the behavioral effects that online games have on students (Plass, Homer, & Kinzer, 2015). This situation may also be affected by the fact that students use digital games for enjoyment while also learning and developing new knowledge, skills, and behaviors. Digital games can foster a positive learning environment by incorporating a variety of educational resources (Chen & Chang, 2020; Tan, Chen & Lee, 2020; Liu, Wang & Lee, 2021). Digital games can also amuse students while bringing about positive behavioral changes in them (Phaire, 2007). On the other hand, some of the students claimed that they only participated in the games because someone else told them to. Students who held this opinion may have developed negative attitudes toward video games, which is what led to the situation. In fact, when it comes to occupying some students, some may find that playing digital games is boring (Koparan, 2021). According to the study's findings, students grew to enjoy playing video games and did so voluntarily and continuously. Additionally, this circumstance improved students' perceptions of using video games to teach them various subjects.

Learning Experience

According to the study's findings, students reported having played digital games that were entertaining, captivating, and simple to use. Due to their aesthetic appeal, entertaining features, and enjoyable settings, digital games may be very engaging for students (Prensky, 2003). The students' active and high level of participation in the lessons was significantly impacted by this. Students found the lessons more engaging thanks to digital games. Students were able to understand and learn concepts that were thought to be complex and difficult through the use of digital games. Additionally, playing online games helped students learn new information and skills more quickly. When used in this setting, digital games may have helped students learn while having fun, interacting with one another during class, overcoming a lack of commitment, and changing their behavior for the better (Phaire, 2007). Studies with comparable results have been published (Ebner & Holzinger, 2007; Akın & Atıcı, 2015; Abdul Jabbar & Felicia, 2015; Kim & Lee, 2015; Marsh, 2022) in the literature. Students claimed that digital games support individual learning and have content that is related to the course topics. The findings of studies demonstrating how games benefit individualized learning are in this direction (Hsu, Chu & Wang; 2013; Young & Wang, 2014; Lan, 2015; Hwang & et al., 2017). Digital games that are compatible with the course material can be played repeatedly, which helps students learn the material in the courses effectively. Digital games that were created with students' learning needs in mind were able to significantly support individual learning at the same time. This might have been because digital games allowed students to move at their own pace and repeat lessons they needed to learn in a way and quantity that suited them. In fact, when prepared by taking into account the unique needs and interests of students, digital games can be very effective in fostering the most suitable learning environment (Magerko, Heeter, Fitzgerald & Medler, 2008). Given this situation and the study's findings, it is clear that digital games used in game-based learning significantly enhance the learning experiences of students.

Recommendations

Considering the results of the study, the following suggestions can be made.

- The limited number of studies in the literature that examine the effects of digital games used in digital game-based learning on different variables based on qualitative research approaches can be increased.
- The study was conducted with associate degree students in the biochemistry department. Future studies can be conducted with different study groups.
- Games used in digital game-based learning support active participation by creating fun, enjoyable and highly interactive learning environments. Digital games used in digital game-based learning can be used in technology-oriented courses to improve students' learning experiences.
- Since digital games used in digital game-based learning have significant positive contributions to different variables related to students, more effective learning environments can be created using this method.
- It was understood that digital games used in digital game-based learning are interesting and motivating. In this respect, digital games can be utilized in different courses.

- It was revealed that students got rid of their prejudices about the course with digital games. In this context, digital games can be used in technology-oriented and different courses to eliminate student prejudices.
- It was understood that students developed positive attitudes towards lessons thanks to digital games. Considering this situation, digital games can be used to change students' attitudes towards different courses.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the author.

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Author(s) Information

Cengiz Gunduzalp
Kafkas University
Kafkas University Kazım Karabekir Vocational School of Technical Sciences Kars / Turkiye
Contact e-mail: cengizgunduzalp@kafkas.edu.tr.
ORCID iD: 0000-0001-5108-437X

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Examination of the Mediating Role of Attachment Dimensions in the Link between Suicide Probability and Cognitive Distortions about Relationships in University Students

Gulin Yazici-Celebi , Muge Yilmaz , Muhammed Enes Karacoskun , Aybuke Irem Sahin

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Abstract

Suicide, which is defined as an individual's intentionally attempting to end his or her life, is considered an important public health problem. In this study, it was aimed to examine the relationship between cognitive distortions and suicide probability in university students who are in age groups at risk for suicide, and to examine the mediating roles of the attachment dimensions of anxiety and avoidance, in this relationship. The study group consisted of 441 university students. In the study, Suicide Probability Scale, Experiences in Close Relationships Inventory, Cognitive Distortions in Relationships Scale and a personal information form were used as data collection tools. In accordance with the purpose of the study, a correlation analysis between variables and regression analyses were applied to examine the mediating roles of avoidance and anxiety in the relationship between cognitive distortions and suicide probability. The findings showed that there was a moderate positive correlational relationship between suicide probability scores and avoidance scores and there was a moderate positive correlational relationship between suicide probability scores and cognitive distortion scores. It was shown that there were low and moderate positive correlations between cognitive distortion scores, and avoidance and anxiety scores. The results of the mediation analyses showed that anxiety and avoidance had a partial mediating role in the relationship between cognitive distortion and suicide probability. The results were discussed in light of the literature.

Introduction

Suicide as a global phenomenon is one of the most important public health problems. It is simply defined as ending one's own life in an intentional way. Suicide is a tragedy seen all over the world, regardless of language, religion, race, status, culture, etc. The World Health Organization describes suicidal behavior as self-harm that is occurred with varying degrees of intent (WHO, 2000). It is handled in two groups as completed suicide and suicide attempt. Scientific research has shown that suicide rates have been continually increasing. WHO reports that approximately 800,000 people die each year as a result of suicide, and many more of them attempt it (WHO, 2019). Although it is seen in every age group, some age groups seem to be more at risk. Young people are at the forefronts of at risk groups.

Suicide is the second leading cause of deaths all over the world in the age group 19-29 years (WHO, 2019). Although death rates in Turkey are below the world average, it is stated that there has been an increase in suicide rates (TUİK, 2020). Because young people are in the at risk group, this research sample consists of young people studying at a university. Although university life can be considered as advantageous in terms of offering various opportunities to individuals, it also poses a risk in terms of the diversity of problems faced by young people and in terms of mental health. Therefore, it can be thought to be a vulnerable period. As it is a transitional period, many problems can be encountered. Some examples of them are: problems in social relations, economic and academic problems, problems in the process of identity formation, etc. All these may predispose the individual to some psychological problems. Studies often report these problems as anxiety, stress, depression, personality disorders, and suicide (Zivin, Eisenberg, Gollust & Golberstein, 2009). Among them, suicide can be expressed as one of the prominent problems because it causes devastating consequences for both the individual and society. Due to the fact that it is preventable, it is important to determine the risk factors and warning signs by doing research on suicide. This may be a significant contribution to the literature. Suicide is structurally complex and it can be said that it is affected by many factors such as individual, biological, psychological, social and cultural factors (WHO, 2016). Scientific research conducted to determine

psychologically related factors revealed that suicide was closely related to psychiatric disorders (Ak et al., 2013; Tezcan et al., 1995).

Beck (2008), one of the important representatives of cognitive theory, asserts that inappropriate affect in psychiatric patients results from their cognitive processes. He states that these processes consist of cognitive schemas, cognitive distortions, automatic thoughts, and cognitive triad. In the literature, there are some research findings revealing a relationship between cognitive processes and suicide (Kevlekçi, 2013; Metha, 1998). It was thought that cognitive processes, which have a significant effect on emotions, may be related to suicide. Therefore, cognitive distortions were included in the research as a variable.

Cognitive Distortions

According to the cognitive approach, thoughts are the real causes underlying emotions (Beck, 2008) and the drivers, creators and maintainers of behaviors (Rait, Monsen, & Squires, 2010). In simple terms, what leads to behavior and feelings are thoughts about events rather than events themselves. An error in this thought system may cause incompatibility between cognitively perceived events and the magnitude and quality of emotional and behavioral reactions to those events. In Beck's (2008) theory, this incompatibility results from schemas, cognitive distortions and automatic thoughts arising from schemas. Schemas are characterized as resistant structures shaped by the individual's past experiences, mostly influenced by his or her early childhood experiences (Atkinson et al., 2010). Schemas form the basis of rules in the process of the individual's interpreting events and they are unique to the individual (Wright, Basco, & Thanse, 2006). Negative schemas of the individual are the sources of automatic thoughts and cognitive distortions. Automatic thoughts lead to certain emotions and have a nature to pass quickly through the mind (Türkçapar, 2011).

Cognitive distortions occur when automatic thoughts can be categorized against certain criteria. Beck (2008) defines cognitive distortions as the tendency to interpret, perceive and evaluate external stimuli negatively. In general, ten different cognitive distortions are reported in the literature. These are "mind reading" "all or nothing thinking", "personalization", "emotional reasoning", "selective abstraction", "catastrophizing", "magnification and minimization", "overgeneralization", "labeling", and "'should' statements" (Beck, 2008). It has been revealed that there is a relationship between suicide and cognitive distortions (Hewitt, Flett, Sherry, & Caelian, 2006; Wenzel, Brown & Beck, 2008; Eskin & Köskün, 2019). It is also reported that the highest suicide rate in psychiatric cases is seen in major depressive disorders. In depression, negative bias in thought content is intense (Beck, 2001), cognitive distortions are often present (Bulut, Mercan & Yüksel, 2020), and the probability of suicide increases (Özer, Yıldırım & Erkoç, 2015); therefore, it is thought that cognitive distortions are associated with suicide.

The foundations of cognitive schemas are shaped by childhood experiences. From this point of view, it can be said that early childhood experiences are important. Considering that these experiences are also related to individuals' attachment patterns, it is suggested that the formation of schemas and thus cognitive distortions are related to individuals' attachment styles. Studies have also shown that there is a relationship between attachment styles and cognitive distortions (Çam & Çelik, 2018; Şahin & Yaka, 2010). In addition, some research reveals that attachment offers an important perspective in understanding psychological problems (Manes et al., 2016) and that insecure attachment styles create a predisposition to psychological problems in adulthood (Boysan & Çam, 2016). From this point of view, it was considered that attachment styles might have an effect on the probability of suicide and attachment styles were included in the study as a mediating variable.

Attachment Styles

The concept of 'attachment' in developmental psychology refers to the bond that is established between a caregiver and an infant in the first months of infant's life and is the source of the feeling of security in stressful situations. Attachment is shaped by the relationship established with the first caregiver during infancy (Bowlby, 2013). It continues throughout life and adult relationships. Attachment figures in infancy are mostly parents or caregivers. In later life, these figures correspond to peer groups and people in romantic relationships (Ainsworth, 1989). Bartholomew and Horowitz (1991), who conducted the most important studies on the concept of attachment in adults, developed the quadruple attachment model, based on the individual's cognitions of himself or herself and others. Among these four styles, in the secure attachment one, opinions about both the self and others are positive, and in preoccupied attachment - one of the insecure attachment styles, opinions about the self are negative and about others are positive. In dismissive attachment, the self model is positive, the

model of others is negative and in fearful attachment, both models are negative (Bartholomew & Horowitz, 1991). It is stated that insecure attachment styles make individuals more prone to various psychological problems (Bowlby, 2013 Boysan & Çam, 2016). It is thought that attachment patterns, which are shaped according to the assumptions developed by the individual about himself or herself and others, will affect schemas about relationships (Şahin ve Yaka, 2010) and cognitive distortions resulting from those schemas. There are many research findings in the literature revealing that some attachment styles are associated with various cognitive distortions (Çam & Şahin-Çelik, 2018; Gamble & Roberts, 2005; Sarsici, 2019). The number of studies examining the relationship between attachment styles and suicide is limited, and results of these studies generally indicate that insecure attachment styles are more associated with suicide (Özer, Yıldırım, & Erkoç, 2015).

Method

Research Model

The relational survey model, which is one of the general survey models, was used in the research. Relational survey models are models that aim to determine the existence of change in two or more variables combined (Karasar, 2005).

Research Group

After obtaining permission to use the measurement tools in the research and also the approval of the ethics committee, the data of the research were obtained through online forms in the 2020-‘21 academic year. All procedures in the research were completed within the framework of approval of the University Scientific Research and Publication Ethics Committee. The descriptive information about participants is presented in Table 1.

Table 1. Descriptive information about research group

Gender	n	%
Female	289	
Male	152	
Low (SES)	68	15.4
Middle (SES)	294	66.7
High (SES)	79	17.9
Total	*441*	*100*

Data Collection Tools

Suicide Probability Scale

The scale developed by Cull and Gill (1990) to evaluate the possible risk of suicide in adolescents and adults, was adapted into Turkish by Şahin and Batıgün (2000). The 36 items were answered on a 4-point Likert-type scale including answers such as "never or rarely", "sometimes", "often" and "often or always". High scores on the scale mean a higher probability of suicide.

Experiences in Close Relationships Inventory

The scale developed by Brennan, Clarck and Shaver (1998) aims to measure anxiety and avoidance, which are the two main dimensions of attachment. The scale was adapted into Turkish by Sümer (2006). The scale consists of 36 Likert type items with 7 grades. The 18 items in the scale are used to evaluate the anxiety dimension and the remaining 18 items are used to evaluate the avoidance dimension. In the study conducted by Sümer (2006) to evaluate the psychometric suitability of Experiences in Close Relationships Inventory; anxiety and avoidance dimensions explained 38% of the total variance (22% Avoidance, 16% Anxiety) and both dimensions had high reliability coefficients (αanxiety= .86, αavoidance = .90).

Cognitive Distortions in Relationships Scale

The scale developed by Hamamcı (2003) to evaluate the cognitive distortions that individuals have in their interpersonal relationships consists of 19 items. The highest score that can be obtained from the 5-point Likert type measurement tool is 95, and the lowest score is 19. A high score means that individuals have cognitive distortions about close relationships (Hamamcı, 2003; Hamamcı & Büyüköztürk, 2003). The scale includes three independent factors: 'Avoiding Intimacy', 'Unrealistic Relationship Expectation' and 'Mind Reading'. Internal consistency and test-retest methods were used to determine the reliability of the scale. The internal consistency coefficient for the whole scale was found to be .67. When the sub-dimensions are examined, the internal consistency coefficient is .73 for the first sub-dimension; .66 for the second sub-dimension; and it was calculated as .49 for the third sub-dimension (Hamamcı & Büyüköztürk, 2003).

Personal Information Form

In the form prepared by researchers, there were questions about age, gender, and perceived economic status of participants.

Results

Analysis of Data

Skewness and kurtosis coefficients were used to examine the distribution of suicide probability, avoidance, anxiety and cognitive distortion scores. The skewness and kurtosis coefficients in the range of ±1 indicated that scores had a normal distribution (Tabachnick & Fidell, 2013). The calculated skewness and kurtosis coefficients were shown in Table 2. This result indicated that scores obtained through measurement tools had a univariate normal distribution.

Table 2. Skewness and kurtosis coefficients of suicide probability, avoidance, anxiety, and cognitive distortion scores

Variables	Skewness		Kurtosis	
	z	SE	z	SE
Suicide probability	0.26	0.12	-0.22	0.23
Avoidance	-0.04	0.12	-0.16	0.23
Anxiety	-0.09	0.12	-0.48	0.23
Cognitive distortion	0.18	0.12	0.25	0.23

In accordance with the purpose of the study, regression analyses were used to examine the mediating role of avoidance and anxiety in the relationship between cognitive distortions and suicide probability. SPSS Process Hayes Macro (version 3.0) was used for regression analyses. Hayes Macro performs analyses based on the bootstrap method. In this method, direct and indirect significant effects are determined based on confidence interval (Shrout & Bolger, 2002). Before the regression analysis, Cook distance values were calculated to determine multivariate outliers. The obtained values (Cook distance <1) showed that there were no multivariate outliers in data set.

The existence of a multicollinearity problem between independent variables was investigated by calculating variance increase factor (VIF) values. VIF <10 indicated that there was no multicollinearity problem (Çokluk, Şekercioğlu, & Büyüköztürk, 2010). The calculated values ($1.07 \leq VIF \leq 1.54$) showed that there was no multicollinearity problem between variables. The Durbin-Watson coefficient was calculated to examine the assumption of independence of errors. The fact that this coefficient is in the range of (>1.5 and <2.5) indicates that assumption of independence of errors is met (Kalaycı, 2017).

The Durbin-Watson coefficient was calculated as 2.02 and the assumption was met. Graphs of standardized residuals were examined to determine whether homoscedasticity assumption was met. In the histogram graph, it was observed that residuals were distributed very close to the normal. In normal P-P plot, a large proportion of the residuals was distributed close to or parallel to the normal distribution line. The results indicated that homoscedasticity assumption was met. Confidence interval for analyses was determined as 95%, $p<0.05$ values were considered as significant. Analyzes were performed by using IBM SPSS 25.0 program.

Results

Table 3. Pearson correlation coefficients of relationships between suicide probability, avoidance, anxiety, and cognitive distortion scores

Variables	M	SD	1.	2.	3.	4.
1. Suicide probability	88.20	10.51	1			
2. Avoidance	71.03	14.82	0.29**	1		
3. Anxiety	67.81	20.13	0.38**	-0.09	1	
4. Cognitive distortion	56.24	9.19	0.51**	0.14**	0.56**	1

** $p<0.01$; N=441

When statistically significant relationships in the table were examined, it was understood that there were moderate positive correlations between suicide probability and avoidance scores (r=0.29; $p<0.01$), anxiety scores (r=0.38; $p<0.01$), cognitive distortion scores (r=0.51; $p<0.01$). Considering relationships between variables, it could be said that probability of suicide increased as avoidance, anxiety, and cognitive distortions increased. It was understood that there are low and moderate positive correlations between cognitive distortion scores and avoidance (r=0.14; $p<0.01$) and anxiety (r=0.56; $p<0.01$) scores. This meant that as cognitive distortion increased, avoidance and anxiety also increased.

Regression analysis was performed to examine mediating role of avoidance and anxiety in the relationship between cognitive distortions and suicide probability. In the regression analysis, cognitive distortion was independent variable, suicide probability was dependent variable, and anxiety and avoidance were mediator variables. The path coefficients obtained are shown in Table 4.

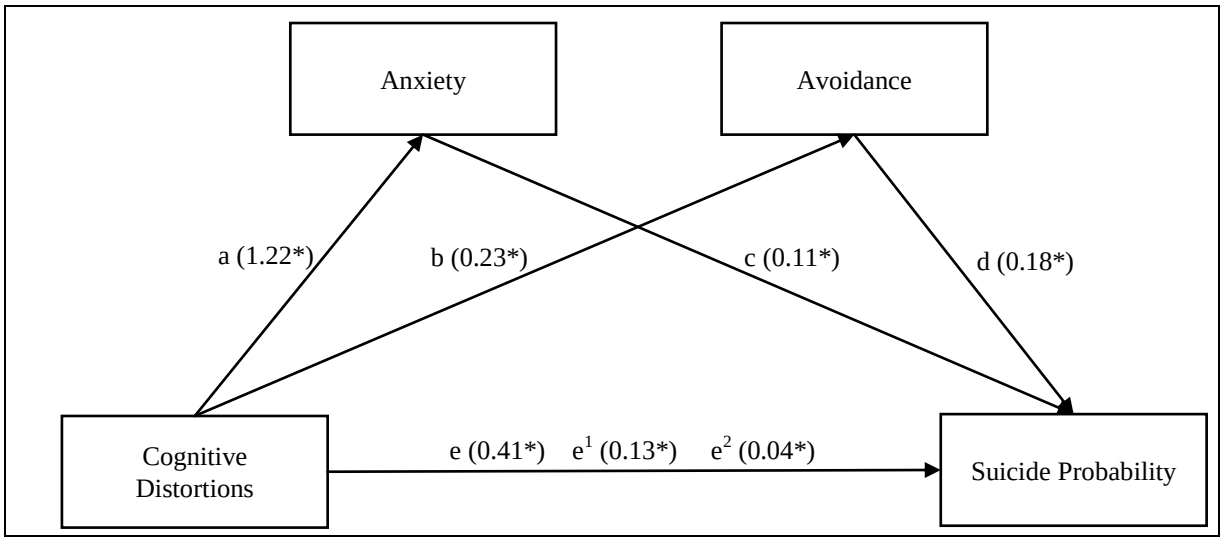

Figure 1. Mediator role of avoidance and anxiety in the relationship between cognitive distortion and suicide probability, *$p<0.05$, e=Direct effect on suicide probability with anxiety and avoidance, e1=Indirect effect on anxiety, e2=Indirect effect on avoidance

In Model 1, the total effect of cognitive distortion on suicide probability was examined ($F_{(1;439)}=154.17$; R=0.51; $p<0,01$). The fact that confidence interval 95% CI (0.49; 0.68) did not contain zero value indicated that total effect was statistically significant. Considering only the effect of independent variable on dependent variable, it was understood that cognitive distortion had a positive and significant effect on the probability of suicide ($\beta=0.58$; $p<0.05$).

In Model 2, the direct effect of cognitive distortion on suicide probability was examined ($F_{(3;437)}=73.03$; R=0.58; $p<0.01$). The fact that confidence interval 95% CI (0.30; 0.52) did not contain zero value indicated that direct effect was statistically significant. When cognitive distortion, anxiety and avoidance were included in the same model, cognitive distortion had a direct positive effect on suicide probability ($\beta=0.41$; $p<0.05$).

In Model 3, mediating role of anxiety and avoidance in the relationship between cognitive distortion and suicide probability was tested. The fact that confidence intervals calculated for state anxiety 95% CI (0.07; 0.20) and trait anxiety 95% CI (0.01; 0.07) did not include zero value indicated that indirect effects ($\beta=0.13$; $\beta=0.04$;

p<0.05) was statistically significant. The results showed that anxiety and avoidance had a partial mediating role in the relationship between cognitive distortion and suicide probability.

Table 4. Results of regression analysis performed to determine mediator role of avoidance and anxiety in the relationship between cognitive distortion and suicide probability

Models				β	SE	t	p	LLCI	ULCI
Model 1 (Total effect)									
Cognitive Distortion	---->		Suicide Probability	0.58	0.05	12.42	0.00	0.49	0.68
Model 2 (Direct effect)									
Cognitive Distortion	---->		Suicide Probability	0.41	0.06	7.45	0.00	0.30	0.52
Model 3 (Indirect effect)									
Cognitive Distortion	---->	Anxiety	----> Suicide Probability	0.13	0.03			0.07	0.20
Cognitive Distortion	---->	Avoidance	----> Suicide Probability	0.04	0.02			0.01	0.07

LLCI= Lower limit confidence interval ULCI= Upper limit confidence interval

Discussion and Conclusion

The results of the study revealed that both cognitive distortions related to relationships and anxiety and avoidance, which were attachment dimensions, had a predictive effect on suicide, and that attachment dimensions had a partial mediating role in the relationship between cognitive distortions related to relationships and suicide probability. In other words, individuals' cognitive distortions and higher scores on anxiety/avoidance dimensions increase suicide probability. High scores on anxiety and avoidance dimensions also increase effect of cognitive distortions related to relationships on suicide probability. Cognitive distortions related to relationships can be thought as an individual's making some mistakes while interpreting relationships established by the individual with his/her close environment, and having a negative bias in his or her thinking system. Similarly, attachment styles are structures that affect an individual's close relationships. The individual's thoughts and expectations about their relationships are affected by attachment styles. The interpretation of a behavior of other person by someone with a secure attachment style differs significantly from that of someone with an obsessive, indecisive or fearful attachment. Because this structure, which affects interpretation and evaluation processes of events, is negative in insecure attachment styles, it is an expected situation that this structure is associated with a phenomenon related to intense negative thought content such as suicide. No study was found in the literature which included variables in this study together. However, when variables were considered separately, it could be seen that there were many research findings reaching similar results.

Some studies revealed that suicidal tendency and suicidal behavior were closely related to negative thoughts (Kevlekçi, 2013). Eskin and Köskün (2019) emphasized that individuals showing suicidal behavior commonly used cognitive distortions and in the treatment processes of these individuals, that dysfunctional thoughts should be focused on. Studies showed that 74% of those who attempted suicide had a psychiatric disorder (Tezcan, Oğuzhanoğlu, & Ülkeroğlu, 1995), and that depressive disorders were the most common of these disorders (Gould & Kramer, 2001). Other research indicated that individuals with depression had higher level of cognitive distortions (Cannon & Weems, 2010; İshikkawa, 2015) and suicide probability (Sabancıoğulları, Avcı, Doğan, Kelleci & Ata, 2015). According to DSM V, recurrent thoughts of death are among diagnostic criteria for major depressive disorder. These findings point out that malfunction in the cognitive system is closely related to suicide and psychiatric diseases that will bring it. In the light of this information, it is seen that results obtained from the research are consistent with the literature. Results also showed that there was a significant relationship between cognitive distortions about relationships and attachment dimensions such as anxiety and avoidance. One of sub-dimensions of cognitive distortions scale used in the research is avoiding intimacy. This cognitive distortion used in close relationships is expected to affect our attachment dimensions to people being close to us. In other words, cognitive distortions that individuals use in evaluating their relationships also affect their attachment styles. In the literature, there are a lot of studies that have concluded that there is a significant relationship between attachment style and cognitive distortions (Gamble & Roberts, 2005). Also, it is seen that there is a bidirectional relationship between these two variables. Başbuğ et al. (2017) found that attachment styles of those who had high level of cognitive distortions about relationships were affected by this situation, while Çam and Şahin-Çelik (2018) concluded that attachment styles predicted cognitive distortions related to relationships. Studies with similar results are as follows: Şahin and Yaka (2010) state that insecure attachment

negatively affects cognitive functions in adulthood, Deveci-Şirin (2017) affirms that avoidant attachment predicts cognitive distortions, and Sarsıcı (2019) says that attachment styles predict cognitive distortions. Because a person who uses cognitive distortions about relationships intensely tends to evaluate people around him negatively and consider them untrustworthy and decliner, this situation strengthens insecure attachment styles. Therefore, it can be said that the finding cognitive distortions and attachment dimensions are related is consistent with the literature. Research findings also show that attachment dimensions are associated with suicide probability. There are some findings in the literature supporting this result. Mikulincer and Shaver (2007) found that insecure attachment patterns were associated with suicidal tendencies. Özer et al. (2015) evaluated attachment styles as a general risk factor for psychopathology and found out that the rate of suicide attempts in fearful attachment style was high. There are also various studies indicating that insecure attachment is associated with suicidal ideation and behavior (Step et al. 2008; Grunebaum et al., 2010). Studies on self-harming behavior, which is often associated with suicide and can be evaluated as a sign, similarly reveal that insecure attachment styles are associated with self-harming behavior (Ferguson, Woodward, & Horwood, 2000). Some research has shown that while individuals with insecure attachment develop inappropriate ways of coping with negative emotions (Kobak, Zajac, & Smith, 2009), individuals with secure attachment use their coping skills (Gültekin & Arıcıoğlu, 2017) and emotion regulation competencies (Miga et al., 2010) more effectively, and they regulate negative emotions more constructively (Consedine & Magai, 2003). Boysan and Çam (2016) state that insecurely attached people are more vulnerable in emotion regulation than securely attached ones.

To sum up, it can be said that an individual's tendency towards negativity in cognitive processes and the use of cognitive distortions negatively affect his or her attachment patterns in close relationships and increase the likelihood of suicide. The percentage of explaining suicide of cognitive distortions over attachment dimensions was found to be higher. Insecure attachment styles increase negative effects of cognitive distortions, which increase the probability of suicide. Considering harms of suicide on both the individual and the society, it is recommended to carry out extensive studies on this issue that handle different variables.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Authors Information

Gulin Yazici-Çelebi
Gümüşhane University
Gümüşhane/Türkiye
Contact e-mail: gulin_celebi@hotmail.com
ORCID iD: 0000 0002 6779 9123

Muge Yilmaz
Gümüşhane University
Gümüşhane/Türkiye
ORCID iD: 0000 0002 5171 1422

Muhammed Enes Karacoskun
Gümüşhane University
Gümüşhane/Türkiye
ORCID iD: 0000 0001 5865 3723

Aybuke Irem Sahin
Gümüşhane University
Gümüşhane/Türkiye
ORCID iD: 0000 0003 0716 7527

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Zero Waste Attitude Scale Development Study

Fuat Ozcan, Ali Meydan

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Abstract

The goal of this study is to create the Zero Waste Attitude Scale, which will be used to determine the zero-waste attitude of social studies teacher candidates and to conduct validity and reliability studies. The data for the study were collected with a 5-point Likert-type form from pre-service teachers studying in the social studies teaching department of some universities in Türkiye. Explanatory factor analysis, confirmatory factor analysis (CFA), and reliability studies were performed on the collected data. Cronbach's alpha and McDonald's Omega methods were used for reliability analysis. As a result of the analysis, it was determined that the scale consisted of 27 items and 3 factors. In total, the factors explained 50.09% of the common variance. As a result of the analysis, the fit index values of the scale $\chi 2/sd$ =1.96, RMSEA=0.06, PGFI=0.70, GFI=0.85, RMR=0.08, SRMR=0.06, NFI=0.95, AGFI=0.81, PNFI=0.84, CFI=0.97, RFI=0.94, NNFI=0.97, IFI=0.97, while GFI, RMR, AGFI, SRMR, and RFI values correspond to acceptable fit; $\chi 2/sd$, RMSEA, IFI, NFI, NNFI , PGFI, PNFI, and CFI seem to correspond to a perfect fit. The reliability coefficient of the scale was 0.90 for both Cronbach Alpha and McDonald's Omega. The scores obtained from the scale are valid and reliable.

Introduction

It is not correct to understand the environmental problem only as environmental pollution, and all degradation events (excessive consumption of natural resources, etc.) occurring in the ecosystem are considered environmental problems (Özkan, 2018). The degradation of the environment because of human production and consumption activities carried out within the context of their essential activities is the root cause of environmental issues (Ertürk, 2018). Today's economic systems, established with the industrial revolution, which is accepted as the beginning of environmental problems, aim at unlimited economic development and an increase in welfare. However, these purposes have led to the unconscious consumption of natural resources and excessive waste generation (Karalar & Kiracı, 2011). To combat environmental issues, which have grown more serious and widespread from the past to the present, societies must create speedy solutions to these issues.

The most important activity to prevent increasing environmental problems is to protect the ecological system. Systems are required in this context to manage production and consumption, segregate wastes, render them harmless, and reuse them whenever possible (Baykal & Baykal, 2008), prevent waste, value material efficiency, and recover resources (Lehmann, 2010). The name of this needed system is zero waste (Zaman & Lehmann, 2013). Zero waste is the protection of all resources by ensuring the recycling and recovery of wastes consisting of goods, materials, and packaging during production and consumption, and disposal in a way that does not threaten the environment or human health (Rathoure, 2020). The zero-waste system has gained importance in the solution of the waste problem, which has been one of the most important problems since the twentieth century, with the effect of the return to natural processes and the circular economy model (Bilgili, 2021).

The term "zero waste" was first used by Palmer in 1973 to reduce the amount of chemical waste (Song et al., 2015). Zero waste is the next stage of recycling and is a policy, path, goal, process, and way of thinking. In addition, "zero waste" refers to the discipline required to create a sustainable interaction with the natural environment (Liss, 2021). Zero waste does not see the waste generated because of human activities as a material to be disposed of or burned, but rather as a resource that needs to be reused (Glavic & Lukman, 2007). Zero waste covers all elements such as producer responsibility, economic design, waste reduction, waste reuse, and recycling (Murray, 2002). Zero waste is a holistic system approach to waste management and elimination (Curran & Williams, 2012).

Zero waste is seen as one of the most rational solutions to solve waste problems (Zaman & Lehmann, 2013; Kabirifar et al., 2020). Zero waste aims to maximize resource recovery by using natural resources at the

minimum level to encourage waste producers to take responsibility and reuse the waste they produce (Khawngern et al., 2021). Zero waste policy protects resources, minimizes environmental pollution, protects public health, contributes to the economy, improves the ability of communities to solve their own problems, and saves energy (TEA, 2021; Zero Waste International Alliance, 2021).

Zero waste is accepted by the governments of many countries. The fact that the zero-waste policy is accepted in many countries is due to the sustainable production and consumption approach, the highest level of waste recycling, and the recovery of vital resources (Zaman, 2015). There is the 5R rule to achieve zero waste on an individual basis (Figure 1). These are: reuse, refuse, reduce, recycle, and rot or replant (Johnson, 2013; Cowles, 2021).

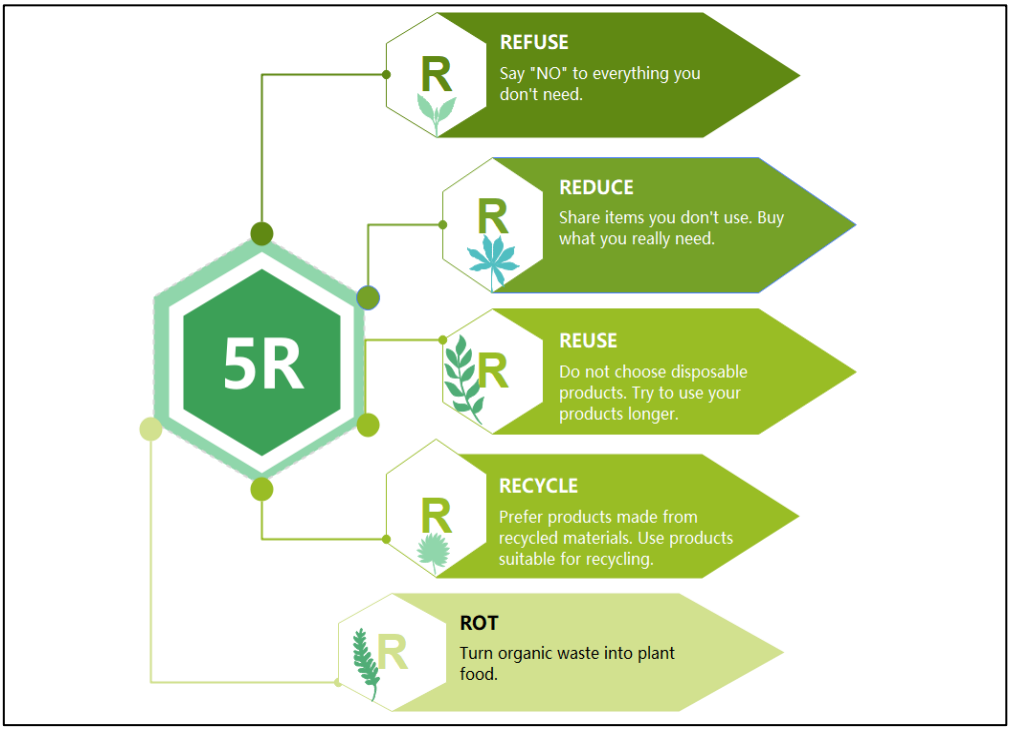

Figure 1. 5R rule

When the literature is examined, no direct scale for zero waste attitude has been found. However, Ugulu (2015) developed high school students' attitudes towards recycling; Paul et al. (2016) developed an environmentally friendly product consumption behavior scale; Kılıç & Kan (2020) middle school students' attitudes a scale towards environmental questions; Maskan et al. (2005) a scale of attitude towards the environment of teacher candidates; Avan et al. (2011) developed secondary school students' attitude scale towards the environment, recycling, plastic, and plastic waste; Karatekin (2013) developed pre-service teachers' attitude scale towards solid waste recycling; Taştepe (2017) developed high school students' attitude scale towards recycling; Coskun (2022) develop a zero waste management behavior scale; Yoldaş (2019) developed a waste and recycling scale for high school students; Gül (2020) developed a scale of waste management and zero waste project; and Coskun (2021) developed a scale to determine the awareness and habit levels of individuals about zero waste. Although individuals' attitudes are the source of environmental problems, individuals' attitudes must change positively to solve these problems. The goal of this study is to develop a scale to detect zero-waste attitudes of social studies teacher candidates. This study is important in terms of contributing to the field because it helps determine the attitudes of individuals towards protecting natural resources, reducing waste, and protecting the economy, and because there are not enough data collection tools for zero waste in the literature.

Method

Research Design

Since it is aimed to develop an attitude scale towards zero waste policy as a research model in this research, the survey model was used. The survey design aims to be a model that aims to reveal the past or existing structure

for what it is, and in this model, it is not aimed to affect or change the event, individual, or object that is the subject of the research. The survey design is a model made within the scope of sampling to be taken from all the elements in the universe or from the universe to reach a judgment about the universe consisting of many elements (Karasar, 2020).

Participants of Study

The participants in the research are students studying in the social studies teaching department of the education faculties of some universities in Türkiye in the 2021–2022 academic year. Table 1 shows the demographic information of the participants.

Table 1. Participants' demographic information

Variables		N	Mean
Class level	1	55	22.0
	2	64	25.6
	3	58	23.2
	4	73	29.2
Gender	F	143	57.2
	M	107	48.2
Total		250	100

Data Collection Tool Development Process

It is necessary to comply with some criteria and standards in the development, adaptation, and implementation of the scale (Karakoç & Dönmez, 2014). Cohen & Swerdlik (2010), Crocker & Algina (2006), DeVellis (2017), Hinkin et al. (1997), Murphy & Davidshofer (2005), and Rust & Golombok (2009) stated stages in their study. These stages were taken into account in the research, and the process of developing the scale consists of 8 stages. The stages followed during the development of the scale are given in Figure 2. The data for this research were collected in accordance with the decision of the Nevşehir Hacı Bektaş Veli University Ethics Committee dated January 25, 2022, and numbered 2022.01.22.

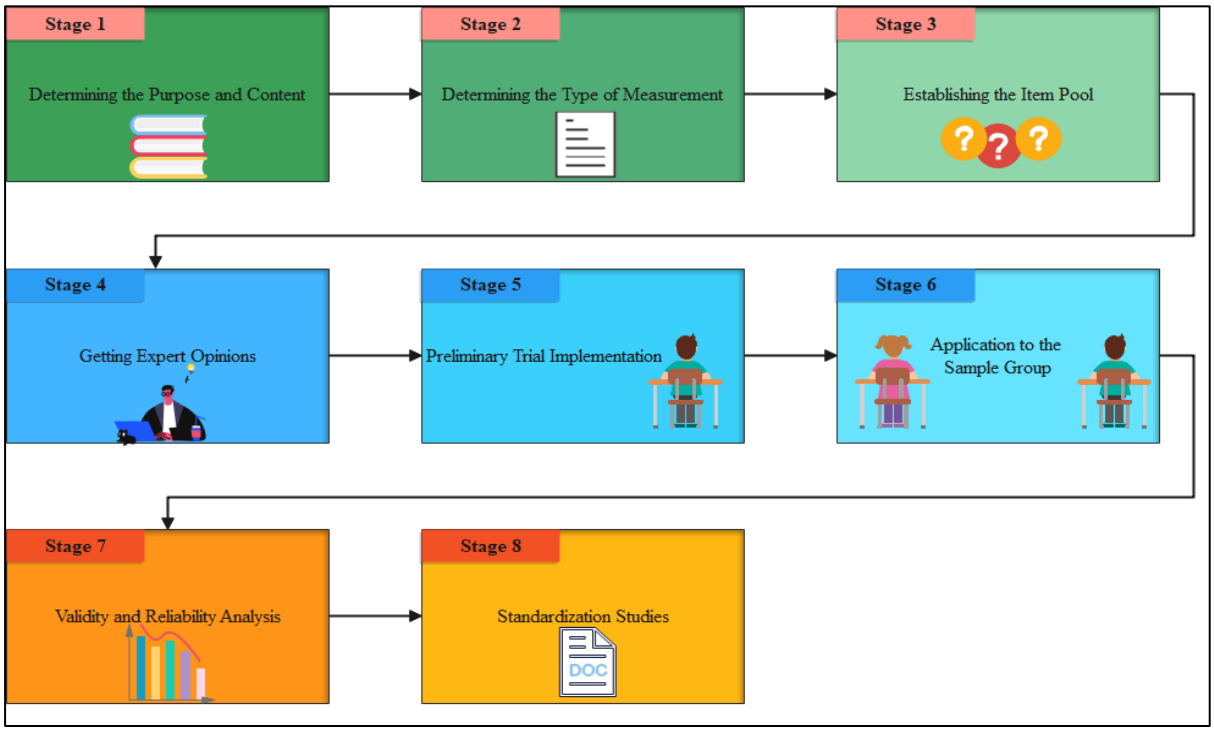

Figure 2. Scale development stages

Determining the Purpose and Content of the Scale: In order to develop the scale in line with the purpose of the research, a literature review was conducted on the concepts of waste, recycling, sustainability, recycling, and zero waste.

Determination of the Measurement Format: Due to its compatibility with the structure to be measured, the Likert-type scale format was chosen as the scale form developed to collect data in the study. The items on the attitude scale were arranged in a five-point Likert type using the expressions "Strongly agree, I participate, I'm undecided, I don't participate, I strongly disagree" The scoring of the items on the scale is given in Table 2.

Table 2. Scoring of items in the scale

Options	Positive Substances	Negative Substances
Strongly agree	5	1
I participate	4	2
Undecided	3	3
I don't participate	2	4
Strongly disagree	1	5

Creation of the Item Pool: In the process of creating the item pool, Concepts such as recycling, zero waste, recycling, and sustainability in the literature were researched, the items of the scales made for the related concepts were analyzed and information was collected from experts who had knowledge on the subjects related to the research. The item pool was created in accordance with the information obtained from the studies and experts on the structure to be measured by writing the items in accordance with the subject and the Likert-type scale format. After item writing, a 55-item scale pool containing positive and negative items was obtained. No additions were made to the item pool from the questions asked in the studies conducted on concepts such as recycling, zero waste, and recycling in the literature. In item writing, attention was paid to ensuring that the items did not contain more than one judgment and that they were plain and simple.

Obtaining Expert Opinions and Content Validity: The 55-item pool prepared for the development of the attitude scale was evaluated by a grammar expert in terms of form and intelligibility. After the assessment of the attitude scale by the grammar expert, the online form was sent to eight people for expert opinion on the subject, to mark each item as "essential, useful, but not essential, not necessary." as used in the Lawshe (1975) technique. A field has been added to the form to indicate the reasons if the items are corrected and removed. In line with the opinions of the experts, the necessary corrections were made, and the analysis for the validity of the content was carried out. The results of the analysis are given in detail in the findings section.

Preliminary Trial Implementation: In scale development, the preliminary trial process focuses on the identification of unforeseen or overlooked problems (readability, understandability, time sufficiency, etc.) that are not foreseen or overlooked by the scale preparer rather than collecting data (Yurdabakan & Çüm, 2017; Crocker & Algina, 2006; Boateng et al., 2018). There are different opinions about the number of participants who will take part in the preliminary trial application. Crocker & Algina (2006) states that 5-30 people will be needed to participate in the preliminary trial application; Şeker & Gençdoğan (2020) states that 30-50 people will be needed; and Carpenter (2018) states that 5-100 people will suffice. Thirty people from representing the target audience, took part in the scale's preliminary trial application. The participants who participated in the application stated that the items on the scale were sufficiently understandable, that the explanation parts at the beginning of the scale were informative about the scale and appropriate in terms of timing, and that the items were suitable for the structure. After the preliminary trial application, the feedback from the participants and the necessary examinations of the data were made, and the scale was applied to the sample group (the main application) without the need to remove any item from the draft scale.

Application to the Sample Group: Although there are many different opinions in the literature regarding the size of the sample group in scale development, it is generally stated in the literature that the sample size can be determined as 5–10 times the items in the scale (Hatcher, 1994; Field, 2005; Hair et al., 2014; Nunnally & Bernstein, 1994). Sapnas (2004) stated that the sample size for scale development studies was at least 100 people; Guilford (1954) stated that it should be at least 200 people; Preacher & MacCallum (2002) stated that it should be 100–250 people; Tavşancıl (2014) and Gorsuch (1974) stated that it should be at least 5 times; if Cattel (1978) stated that it should be 3-6 times. The actual application was carried out with a total of 250 social studies teacher candidates, and it is seen that it is suitable for scale development. The Kaiser-Meyer-Olkin (KMO) coefficient and Barlett's Test were used to determine the suitability of the data for factor analysis, exploratory factor analysis, and confirmatory factor analysis for construct validity, and Cronbach Alpha internal consistency coefficients for reliability were applied. The analysis results are given in detail in the findings

section. At the last stage of the scale, standardization studies of the scale were carried out, and the scale's final shape was given.

Analysis of Data

The data obtained from the participants were transferred to the Excel application. The analysis of the data was carried out with the SPSS 26.0 and Lisrel 8.8 programs. The SPSS 26 and Lisrel 8.8 programs were preferred for the KMO coefficient and Barlett's Test, exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and Cronbach's alpha reliability coefficient processes performed within the scope of the research.

Findings

To determine the content validity of the 55-item question pool prepared for the development of the attitude scale, the qualitative data obtained from eight experts in the field were converted into numerical data in the Excel application. The content validity rates (CVR) and content validity index (CVI) of the scale were calculated in the Excel application.

The content validity rate was calculated using the formula CVR= (n_e-N/2)/(N/2). The "n_e" in the formula is the number of experts who state that the item is "essential"; "N" represents the total number of experts who gave their opinion on the item. Content validity ratios are directly removed from the item pool since items with zero or less than zero have no content validity (Lawshe, 1975; Yeşilyurt & Çapraz, 2018). For each of the items in the draft scale with a positive value, the content validity criterion (CVR) was checked at the significance level of 0.05. The content validity criterion expresses the value of the content validity rate required to decide the suitability of the items to be included in the scale. Content validity criterion values are determined according to the number of experts required to determine whether the items to be included in the scale are appropriate or unsuitable. This value differs according to the number of experts evaluating the scale (Yeşilyurt & Çapraz, 2018). In order to determine the CVC of the scale, the content validity criterion values in Table 3 determined by Ayre & Scally (2014) were taken into consideration. Table 2 shows that the CVC value for eight experts at the draft scale's =0.05 significance level is 0.750.

Table 3. Minimum content validity rates at significance levels of 0.05 (Ayre & Scally, 2014)

Number of Experts	CVC	Number of Experts	CVC	Number of Experts	CVC	Number of Experts	CVC
5	1.000	14	0.571	23	0.391	32	0.375
6	1.000	15	0.600	24	0.417	33	0.333
7	1.000	16	0.500	25	0.440	34	0.353
8	0.750	17	0.529	26	0.385	35	0.314
9	0.778	18	0.444	27	0.407	36	0.333
10	0.800	19	0.474	28	0.357	37	0.297
11	0.636	20	0.500	29	0.379	38	0.316
12	0.667	21	0.429	30	0.333	39	0.333
13	0.538	22	0.455	31	0.355	40	0.300

After the content validity criterion was calculated, the content validity index calculation was carried out for the entire scale. The content validity index is obtained by taking the average of the content validity rates of all the items to be included in the scale (Yeşilyurt & Çapraz, 2018). Within the parameters specified, the CVI value of our scale was determined to be 0.941 (Table 3). In line with the opinions obtained from the experts, the content validity rates calculated based on the items on our scale and the content validity index value calculated for the whole scale are given in Table 4.

16 items (5, 9, 12, 18, 20, 22, 24, 25, 33, 34, 36, 38, 40, 47, 48, 52) with CVR≤0 were directly excluded from the scale. It was decided whether the items with a CVR > 0 value would be excluded from the scale by looking at the CVC values in Table 3 regarding the statistical significance of the CVR values. When Table 3 is examined, item 42, whose CVC value for eight experts is less than 0.750, is removed from the scale in development. Thus, a total of 17 items were removed from the scale under development, leaving a total of 38 items.

Table 4. Content validity rates of items and content validity index value of the scale

Item Number	Essential	Useful, but not essential	Not necessary	CVR	Item Number	Essential	Useful, but not essential	Not necessary	CVR
1	8	0	0	1.000	29	7	1	0	0.750
2	8	0	0	1.000	30	8	0	0	1.000
3	8	0	0	1.000	31	8	0	0	1.000
4	7	0	1	0.750	32	8	0	0	1.000
5	2	0	6	-0.500**	33	2	0	6	-0.500**
6	8	0	0	1.000	34	2	0	6	-0.500**
7	7	1	0	0.750	35	8	0	0	1.000
8	8	0	0	1.000	36	2	0	6	-0.500**
9	1	1	6	-0.750**	37	8	0	0	1.000
10	8	0	0	1.000	38	1	0	7	-0.750**
11	7	1	0	0.750	39	8	0	0	1.000
12	2	0	6	-0.500**	40	2	0	6	-0.500**
13	8	0	0	1.000	41	8	0	0	1.000
14	8	0	0	1.000	42	6	2	0	0.500*
15	7	0	1	0.750	43	8	0	0	1.000
16	8	0	0	1.000	44	7	1	0	0.750
17	8	0	0	1.000	45	8	0	0	1.000
18	1	0	7	-0.750**	46	8	0	0	1.000
19	8	0	0	1.000	47	2	0	6	-0.500**
20	2	0	6	-0.500**	48	1	0	7	-0.750**
21	8	0	0	1.000	49	8	0	0	1.000
22	2	0	6	-0.500**	50	7	1	0	0.750
23	8	0	0	1.000	51	8	0	0	1.000
24	1	0	7	-0.750**	52	2	0	6	-0.500**
25	2	0	6	-0.500**	53	8	0	0	1.000
26	8	0	0	1.000	54	8	0	0	1. 000
27	7	1	0	0.750	55	8	0	0	1.000
28	7	0	1	0.750					

Total Number of Experts: 8
CVC: 0.750 - CVI: 0.941
*Substances below the CVC value (0.750) ** Substances with CVR≤0

The fact that the content validity index value determined because of the analysis is greater than the value of the content validity criterion (CVI > CVC) shows that the content validity of the items in the scale (except for those excluded) is statistically significant (Ateş, 2013; Lawshe, 1975; Öngöz, 2011). In addition, the items in the draft scale (38 items) are statistically significant since CVI (.941)>CVC (0.750). The results of the analyses show that our draft scale has content validity.

Exploratory factor analysis and confirmatory factor analysis were applied to determine the construct validity of the scale. Exploratory factor analysis is a technique to reveal how many sub-dimensions the items in the scale can have and what kind of relationship there is between them (Seçer, 2018). Confirmatory factor analysis is a powerful statistical method that examines the hidden structures in the scale and the relationships between them (Jackson et al., 2009). This analysis gives information about which variables in the model will be loaded on which factors, which factors are related to each other, and so on (Stevens, 2009). Before starting the exploratory factor analysis, the KMO coefficient was calculated, and Bartlett's test was performed (Table 5).

Table 5. Results on KMO coefficient and Barlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.918
Bartlett's Test of Sphericity	Approx. Chi-Square	5148.76
	Df	703
	Sig.	0.00

When the KMO coefficient and Barlett's test values in Table 5 were examined, the KMO was 0.918 and the Barlett's test was 5148.76 ($p<0.01$). The KMO value shows a value in the range of 0–1, and the resulting value

is close to 1 means that it shows a perfect fit (Field, 2005). According to Pallant (2001), the KMO value should be at least 0.60. The KMO value is between 0.70 and 0.80 for good, 0.80 and 0.90 for very good, and 0.90 and 1.0 for excellent, according to Hutcheson and Sofroniou (1999) and Field (2005). The KMO coefficient found because of the measurement was 0.918 was significant, indicating that the sample was adequate for exploratory factor analysis.

In the EFA to be performed to determine the construct validity of the scale, principal axis factoring (PAF) and the varimax rotation technique were used. PAF is an approach used to determine the factor structure in scale studies and can calculate the common variance between the observed variables (Fabrigar et al., 1999). The main priority of PAF is to define the basic dimensions and focus on common variance (Malhotra, 2010). The principal axis factoring method is the most widely used method in factor subtraction analysis (Harman, 1967). PAF aims to determine the maximum variance at right angles to each other from the dataset with successive factors (Tabachnick & Fidell, 2014). Since the main purpose of scale studies is to detect hidden structures among the variables (Fabrigar etc., 1999; Cattel, 1978), the PAF technique was preferred in EFA. In addition, PAF has few variables per factor and better recovers weak factors (Briggs & MacCallum, 2003; De Winter & Dodou, 2012). Principal axis analysis has an important advantage. In this method, the common factor variance is analyzed by subtracting the original and error variances. This is a method in line with the logic of factor analysis (Karaman, 2015). If a variable has a high degree of load on different factors, it becomes difficult to interpret the factor (Malhotra, 2010). Rotation is performed to make the factor structure more understandable and interpretable (DeVellis, 2017). The varimax rotation technique was preferred because the factors identified items with high correlation with them, providing ease of interpretation and frequency of use (Büyüköztürk, 2003; Yiğit & Kurnaz, 2010; Kahyaoğlu, 2011).

In Table 6, the variance values of each of the items on the scale belonging to a common factor are given. According to Seçer (2018) and Çokluk et al., (2012), the common variance of the items described by the factors should not be less than 0.10. The variance explanation rate for each item on our scale in the common factor is greater than 0.10.

Table 6. Rate of explaining variances of substances in common factor

Item	Initial	Extraction	Item	Initial	Extraction	Item	Initial	Extraction
T1	0.552	0.576	T14	0.739	0.720	T27	0.379	0.357
T2	0.567	0.531	T15	0.644	0.586	T28	0.472	0.483
T3	0.558	0.636	T16	0.499	0.636	T29	0.567	0.611
T4	0.532	0.538	T17	0.698	0.681	T30	0.332	0.298
T5	0.595	0.592	T18	0.654	0.644	T31	0.627	0.643
T6	0.494	0.456	T19	0.800	0.728	T32	0.534	0.499
T7	0.337	0.293	T20	0.766	0.692	T33	0.353	0.281
T8	0.678	0.607	T21	0.679	0.634	T34	0.617	0.551
T9	0.619	0.584	T22	0.464	0.473	T35	0.608	0.623
T10	0.443	0.413	T23	0.599	0.682	T36	0.271	0.290
T11	0.514	0.466	T24	0.447	0.394	T37	0.423	0.423
T12	0.704	0.666	T25	0.256	0.197	T38	0.511	0.501
T13	0.466	0.515	T26	0.555	0.486			

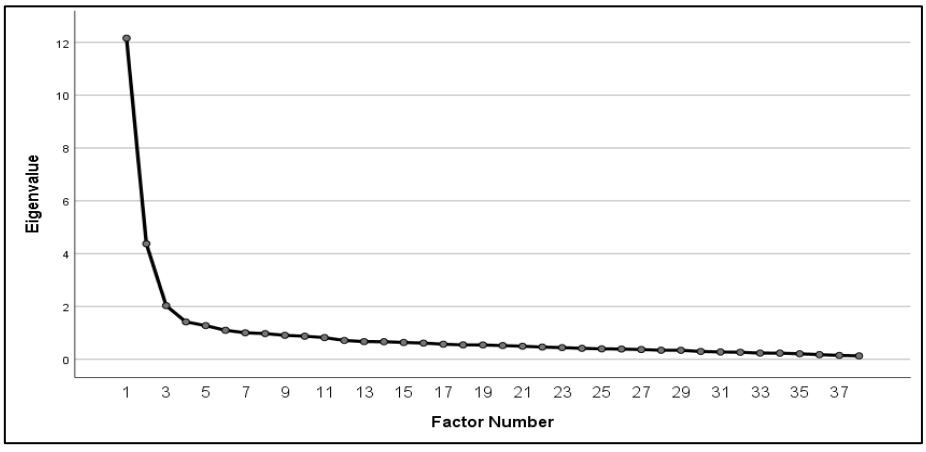

Figure 3. Slope-accumulation graph of the scale

Table 7. Announced total variance rates (without matter extraction)

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.158	31.996	31.996	11.746	30.910	30.910	8.389	22.076	22.076
2	4.376	11.516	43.512	3.866	10.174	41.084	3.213	8.456	30.532
3	2.032	5.346	48.858	1.584	4.168	45.252	3.148	8.285	38.817
4	1.414	3.722	52.580	0.974	2.563	47.815	2.941	7.740	46.558
5	1.275	3.354	55.934	0.764	2.010	49.826	0.897	2.360	48.917
6	1.098	2.888	58.823	0.579	1.524	51.350	0.751	1.976	50.893
7	1.003	2.640	61.462	0.470	1.238	52.588	0.644	1.695	52.588
8	0.971	2.555	64.018						
9	0.907	2.386	66.404						
10	0.873	2.297	68.701						
11	0.820	2.159	70.860						
12	0.714	1.879	72.739						
13	0.669	1.761	74.499						
14	0.666	1.752	76.252						
15	0.636	1.673	77.924						
16	0.612	1.611	79.535						
17	0.570	1.500	81.035						
18	0.544	1.431	82.466						
19	0.542	1.426	83.892						
20	0.518	1.364	85.256						
21	0.494	1.301	86.557						
22	0.461	1.214	87.771						
23	0.440	1.158	88.930						
24	0.414	1.090	90.019						
25	0.394	1.037	91.056						
26	0.387	1.019	92.075						
27	0.369	0.970	93.045						
28	0.342	0.900	93.945						
29	0.341	0.897	94.842						
30	0.295	0.777	95.618						
31	0.276	0.728	96.346						
32	0.264	0.696	97.042						
33	0.233	0.614	97.655						
34	0.232	0.609	98.265						
35	0.208	0.548	98.812						
36	0.175	0.461	99.274						
37	0.147	0.387	99.661						
38	0.129	0.339	100.00						

The K1 rule and scree plot methods were used in this study to determine the number of factors. Kaiser (1960) developed the K1 rule, which states that factors with eigenvalues greater than one are considered significant (Guttman, 1954; Pallant, 2010; Verma, 2013). Cattell developed another method for determining the factor number, the slope-accumulation graph (scree plot), and the factor number is obtained by determining the point where the lines in the graph flatten (Shrestha, 2021).

Table 7 shows the total variance values for the raw data described on the scale without any item extraction applied. When the slope-accumulation graph given in Figure 3 is examined, a horizontal trend is observed in the graph after the third factor, and the total variance effects of the fourth and subsequent factors are close to each other. When the literature is taken into consideration, it is decided that the scale consists of a 3-factor structure. The results of the K1 rule and the Scree Plot method were examined together, and it was decided that the scale consisted of a 3-factor structure when the field literature was taken into consideration.

In exploratory factor analysis procedures, it is necessary to determine the load values of the items in the minimum factor according to the sample size and to remove the items below this minimum value from the scale. The item load of each substance in the factors should be at least 0.45 (Tabachnick & Fidell, 1989, as cited in Büyüköztürk 1997). Furthermore, the difference in loads for the same substance across multiple factors should not be less than 0.10 (overlapping substance) (Büyüköztürk, 2020; Seçer, 2018). In addition, it is stated in the literature that there should be at least three items in a factor (MacCallum et al., 1999; Raubenheimer, 2004). The item removal process was continued during the scale development phase until the item load was more than 0.45 and no overlapping item was discovered. It was also considered that there should be at least three items in a factor. Substances that did not meet the conditions specified during the deletion of substances were removed one by one, not all together, and the results were examined and the delete process was carried out. In this context, 5 items (7-11-25-36-37) with factor loadings below 0.45 were deleted. Three items (2-4-34), which were included in more than one factor and had less than a 0.10 difference between item loads, were deleted. 3 items (1-3-13) that did not provide the minimum number of items required in a factor were deleted. A total of 11 items were removed from the scale. The item distributions related to the 3-factor structure that emerged after the item delete processes are presented in Table 8.

Table 8. Distribution of substances by factors

Item	Factor 1	Item	Factor 2	Item	Factor 3
T14	0.800	T23	0.820	T29	0.716
T19	0.790	T22	0.678	T31	0.701
T12	0.772	T10	0.579	T27	0.513
T20	0.770	T16	0.530	T26	0.480
T17	0.747	T28	0.527		
T18	0.746	T33	0.471		
T15	0.746	T30	0.450		
T21	0.741				
T8	0.729				
T5	0.714				
T9	0.661				
T6	0.627				
T35	0.626				
T32	0.552				
T38	0.547				
T24	0.524				

Loads of the items on the scale range from 0.450 to 0.820. The item deletion process was terminated because there was no item load of less than 0.45 on the scale and no substance in more than one factor (Table 8).

Table 9. Total variance values explained by factors

Factor	Declared Value of Variance (%)
Factor 1	30.606
Factor 2	10.643
Faktor 3	8.485
Total Variance Value Explained	50.094

As can be seen in Table 9, factor 1 explains 30.606% of the total variance, factor 2 explains 10.643%, and factor 3 explains 8.485%. For multi-factor structures in scale development, it is generally considered sufficient that the total declared variance value is 40–60% (Gorsuch, 1983; Kline, 1994; Tavşancıl, 2014). The total detected variance value determined is 50.094%, and it is seen that this value is sufficient.

After the exploratory factor analysis, a confirmatory factor analysis was applied to confirm the structure. In confirmatory factor analysis, we used the maximum likelihood calculation method. In confirmatory factor analysis, the evaluation of the suitability of the factor model is carried out according to some compliance indicators. These are some of the indices: Chi-square ($\chi 2$)/degrees of freedom (df), Goodness of Fit Index GFI), Adjustment Goodness of Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), Root Mean Square Residual (RMR), Standardized Root Mean Square Residual (SRMR), Incremental Fit Index (IFI), Normed Fit Index (NFI), Non-Normed Fit Index (NNFI), Parsimony Goodness of Fit Index (PGFI), Parsimony Normed of Fit Index (PNFI), Comparative Fit Index (CFI) and Relative Fit Index (RFI).

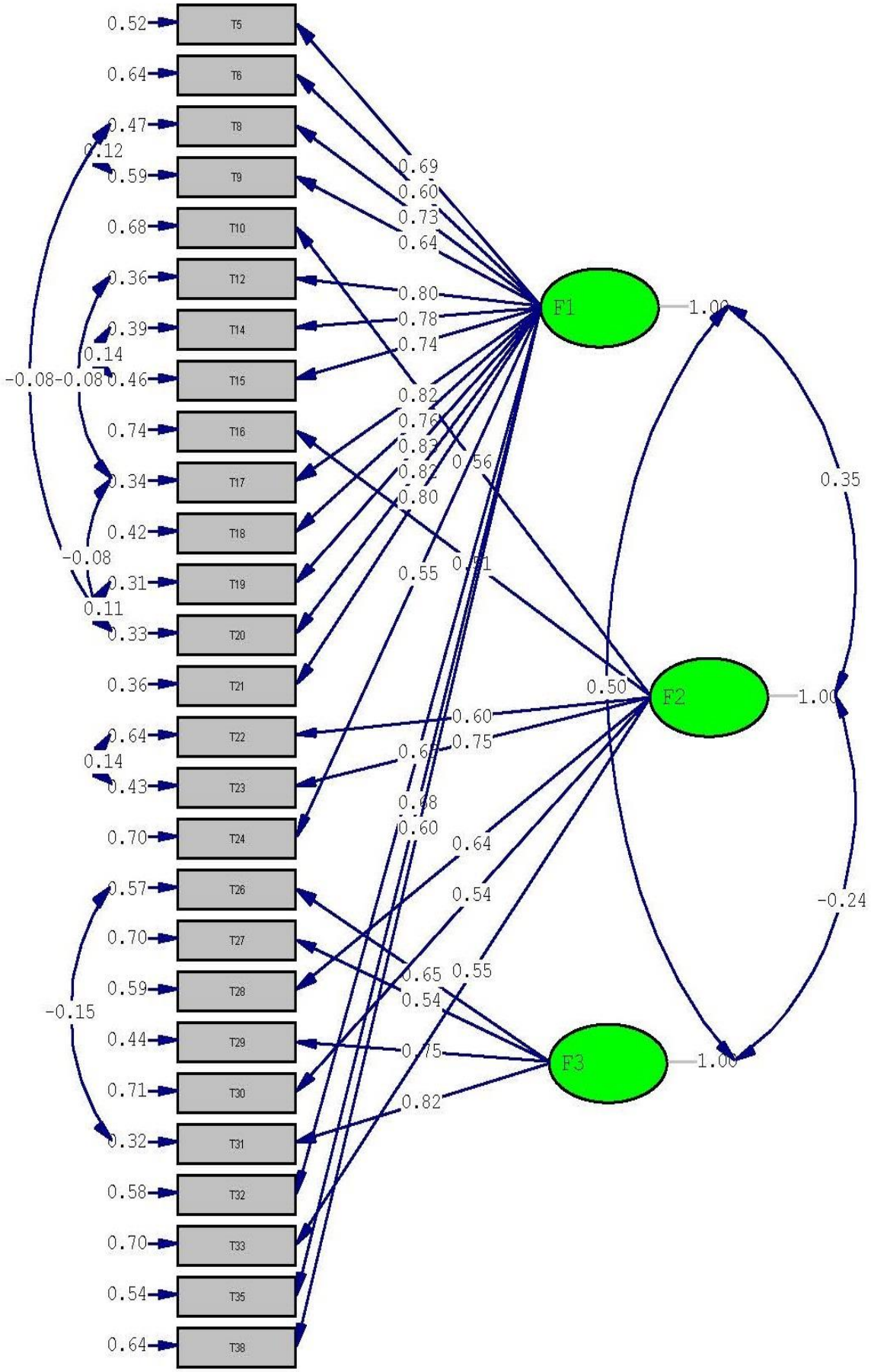

Figure 4. Model's standardized solutions

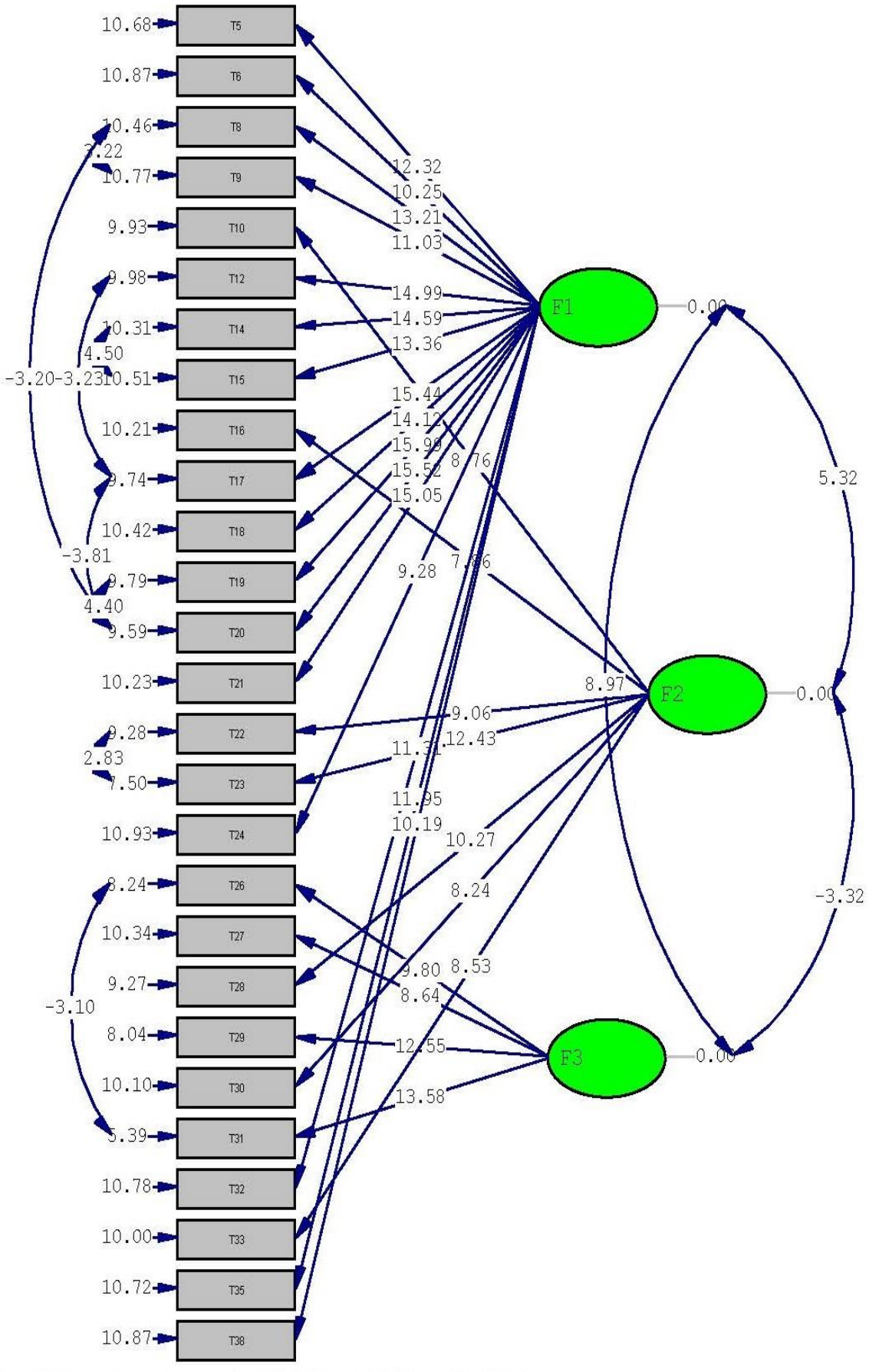

Figure 5. Model's t values

Table 10. Results of compliance indexes

Fit Index	Calculated Fit Index	Fit Indices in the Literature	References
$\chi 2/sd$	1.95	Perfect Fit ($\chi 2/sd \leq 2$)	Schumacker & Lomax (2004); Tabachnick & Fidell (2007); Kline (2011)
GFI	0.85	Acceptable Fit (GFI≥0.85)	Anderson & Gerbing, (1984); Cole, (1987); Marsh et al., (1988); Bryant et al., (1996); Chabrol et al., (2002); Schumacker & Lomax (2004); Weizmann-Henelius et al., (2010)
AGFI	0.81	Acceptable Fit (AGFI≥0.80)	Anderson & Gerbing, (1984); Cole, (1987), Marsh et al., (1988); Bryant et al., (1996); Chabrol et al., (2002); Weizmann-Henelius et al., (2010)
RMSEA	0.06	Perfect Fit (RMSEA≤0.06, 0.08, 0.10)	Steiger, (1990); Hu & Bentler, (1999); Byrne, (2001)
RMR	0.08	Acceptable Fit (0.05≤RMR ≤0.08, 0.10)	Anderson & Gerbing, (1984); Cole, (1987); Marsh et al., (1988); Bentler, (1990); Hu & Bentler, (1999)
SRMR	0.06	Acceptable Fit (0.05≤SRMR≤0.08)	Hu & Bentler (1999); Schermelleh-Engel et al., (2003); Şimşek, (2007).
IFI	0.97	Perfect Fit (IFI≥0.95)	Hu & Bentler (1999); Hooper et al., (2008); Karagöz (2019)
NFI	0.95	Perfect Fit (NFI≥0.95)	Hu & Bentler (1999); Kaplan (2000); Schumacker & Lomax (2010).
NNFI	0.97	Perfect Fit (NNFI≥0.95)	Bentler & Bonett (1980); Kelloway, (1998); Hu & Bentler (1999)
PGFI	0.70	Perfect Fit (PGFI≥0.50)	Mulaik et al., (1989); Chiao et al., (2018); Li et al., (2022)
PNFI	0.84	Perfect Fit (PNFI≥0.50)	Mulaik et al., (1989); Chiao et al., (2018); Li et al., (2022)
CFI	0.97	Perfect Fit (CFI≥0.95)	Bentler, (1995); Hu & Bentler (1999); West et al., (2012)
RFI	0.94	Acceptable Fit (0.90≤RFI≤0.95)	Bentler & Bonett, (1980); Baumgartner & Homburg, (1996); Marsh et al., (2006)

In the literature, there is no definite rule about which fit indices will be used in the studies. Researchers have come up with different recommendations about which indices should be used (Crede & Harms, 2019). Gerbing & Anderson (1992) explain which fit indices should be evaluated in research and state that this is as difficult as answering the question, "What is the best car on the market?" They emphasized the importance of purpose in choosing the fit index. Each of the fit indices serves different purposes and differs from each other (Iacobucci, 2010). According to the objectives of the study, the concordance indices preferred by the researchers may also vary (İlhan & Çetin, 2014). In our study, chi-square/degrees of freedom $\chi 2/sd$, GFI, AGFI, RMSEA, RMR, SRMR, IFI, NFI, NNFI, PGFI, PNFI, CFI, and RFI compliance indices were evaluated.

In cases where the fit indices do not meet the threshold values specified in the field literature or to improve the compliance indices, modification is required. When the modification process is carried out, it is done only between the substances included in the same factors (Seçer, 2015; Gürbüz, 2021). In order to improve the GFI fit index value, changes were made between the items under the same factors (9-8, 15-14, 17-12, 20-8, 20-17, 20-19, 23-22, and 31-26), depending on the structure of the scale.

Standardized solution values of the scale are shown in Figure 4 and t values are shown in Figure 5. Standardized solution factor loadings should be at least 0.30 and above (Doris et al., 2011; Seçer, 2015; Hashem-Dabaghian et al., 2022). When Figure 4 is examined, the standardized solution values of the scale are above 0.30. In addition, t values at the $p<0.01$ level in CFA should have values of 2.56 and above (Doris et al., 2011; Thomas & Devi, 2020; Çokluk et al., 2021). When Figure 5 is examined, it is seen that the t values are appropriate. The fit indices determined after the model modification procedures are given in Table 10.

When Table 10 is examined, $\chi 2/sd$, RMSEA, IFI, NNFI, PGFI, PNFI, NFI, and CFI fit indices show perfect fit, and GFI, AGFI, RMR, SRMR, and RFI fit indices show acceptable fit. After determining the factors, the factors

need to be named. When naming the factors, there is no rule other than giving the names that best express the items in the factors (Yong & Pearce, 2013). In this direction, factor 1 was named "Conscious Use and Protection of Resources", factor 2 "Being Sensitive to the Environment", and factor 3 "Developing Zero Waste Awareness" (Table 11).

After determining the validity of the scale, its reliability was checked. Reliability, one of the basic criteria, is a criterion used to evaluate the quality of the data obtained (Wagemaker, 2020). Different methods have been developed to calculate reliability. In addition to the Cronbach Alpha coefficient, which is one of the most reliable methods and widely used (Shelby, 2011; Tavakol & Dennick, 2011). in our study, McDonald's Omega method was also preferred due to the different factor loads (McDonald, 1985; Yurdugül, 2006). Reliability values vary between 0 and 1, and although the value of 0.70 is sufficient, some researchers state that smaller values can also be accepted (Nunnally, 1978). In general, less than 0.50 is considered unacceptable, 0.50-0.60 is considered poor, 0.60-0.70 is considered doubtful, 0.70-0.80 is considered acceptable, 0.80-0.90 is considered good, and 0.90 and above is considered perfect (George & Mallery, 2020). The reliability results of the scale are given in Table 12.

Table 11. Factors and items

Factor Name	Item Number	Item	Mean ($\bar{x}$)	Std. Deviation.
Conscious Use and Protection of Resources	T14	I know that the unconscious consumption of natural resources is a problem.	4.42	0.903
	T19	I am happy that people prefer packaged products that can be recycled.	4.40	0.940
	T12	I am happy to encourage people to use packaged products that can be recycled.	4.21	0.998
	T20	I am happy to use packaged products that are reused after recycling.	4.37	0.860
	T17	Zero waste plays an important role in solving environmental problems.	4.28	0.975
	T18	I know that the zero-waste policy prevents waste.	4.33	0.916
	T15	I know that the zero-waste policy contributes to the economy.	4.24	0.982
	T21	Leading people to zero waste makes me happy.	4.30	1.002
	T8	I recognize the recycling symbol.	4.43	0.960
	T5	I think that with the zero-waste policy. natural and energy resources will be consumed less.	4.28	0.889
	T9	I know how to protect natural resources.	4.15	0.989
	T6	I think that with the zero-waste policy. the amount of waste left in the environment will decrease.	4.24	1.021
Being Sensitive to the Environment	T35	I am aware of the environmental problems caused by waste.	4.22	0.945
	T32	I am happy to use products with recyclable packaging.	4.04	0.991
	T38	I know that waste is a raw material with economic value.	4.10	0.993
	T24	I separate my waste and leave it in the relevant waste bins.	3.86	1.000
	T23*	The gradual increase in environmental problems caused by waste does not bother me.	4.05	1.318
	T22*	It doesn't bother me that waste is thrown directly into the trash.	3.66	1.351
	T10*	I think the problems caused by waste are exaggerated.	3.75	1.401
	T16*	I don't think the zero-waste policy improves the quality of life.	3.59	1.542
	T28*	Harming the environment does not make me unhappy.	4.20	1.339
	T33*	I do not think that environmental education is important in preventing waste.	3.66	1.585
	T30*	I think it is not possible to reduce waste.	3.47	1.321
Developing Zero Waste Awareness	T29	I participate in events organized about zero waste.	3.23	1.209
	T31	I do research on what can be done to reduce waste.	3.33	1.181
	T27	I buy products with packaging suitable for recycling. even if they are expensive.	2.75	1.191
	T26	I make an effort to provide products with packaging suitable for recycling.	3.64	1.104

*Negative Items: 10-16-22-23-28-30-33

Table 12. Cronbach's Alpha Coefficient and McDonald's Omega values of the scale

Total Number of Items	Alpha Coefficient	McDonald's Omega
27	0.90	0.90

When Table 12 is examined, the reliability value for the sum of the scale was determined as 0.90 (excellent) according to the alpha and omega results. These values show that the reliability of the scale is appropriate (excellent), according to George & Mallery (2020).

Conclusion

In the literature research, no zero-waste attitude scale was directly found for social studies teacher candidates. This scale was developed to evaluate the attitudes of social studies teacher candidates towards the zero-waste policy. The processes for the development of the scale were meticulously implemented. The scale was developed in a five-point Likert type. The content validity process was performed on the data obtained from the experts, and the items that should be removed were determined. In the content validity process, in line with the opinions of the experts, it was decided to remove 17 items from a total of 55. KMO and Barlett tests show that the scale is valid and reliable for measurement. An exploratory factor analysis was performed for the remaining 38 items in the draft scale. As a result of the EFA process, a scale consisting of 27 items in three dimensions emerged. As a result of the EFA process, confirmatory factor analysis was applied to verify the scale. As a result of the CFA process, it was decided that the scale developed was appropriate. After the factor analysis procedures, Cronbach's alpha and McDonald's omega reliability tests were applied to determine the reliability of the scale. Cronbach's alpha and McDonald's omega reliability values on the scale were found to be 0.90. According to this value, it was determined that the reliability of the scale was "perfect".

The five items with the highest average on the scale are as follows: "I recognize the recycling symbol ($\bar{x}$=4.43)", "I know that the unconscious consumption of natural resources is a problem ($\bar{x}$=4.42), "I am happy that people prefer packaged products that can be recycled ($\bar{x}$=4.40)", "I am happy to use packaged products that are reused after recycling ($\bar{x}$=4.37)", and "I am happy to use packaged products that are reused after recycling ($\bar{x}$=4.33)". The five items with the lowest average on the scale are as follows: "I buy products with packaging suitable for recycling. even if they are expensive ($\bar{x}$=2.75)", "I participate in events organized about zero waste ($\bar{x}$=3.23), "I do research on what can be done to reduce waste ($\bar{x}$=3.33)", "I think it is not possible to reduce waste ($\bar{x}$=3.47)", and "I don't think the zero-waste policy improves the quality of life ($\bar{x}$=3.59)".

Individuals' attitudes and behaviors play an important role in achieving the goal of a zero-waste policy in the fight against environmental problems. However, it is possible for individuals to have a positive attitude with a good education. The social studies course has a high effect on transferring subjects related to environmental problems to the students. The meticulous conduct of this course by a well-equipped social studies teacher is important for the positive development of students' attitudes towards the environment. Equipped teachers will ensure that the course is carried out better and that teacher behaviors reflect positively on students. With this scale developed in this respect, it will be possible to determine the attitudes of social studies teacher candidates about zero waste. Studies to be carried out in line with the data obtained from the scale will contribute to the training of a good social studies teacher of the future. Thus, more solid steps will be taken in the fight against environmental problems.

Recommendations

By using this developed scale, the zero-waste attitudes of social studies teacher candidates can be evaluated using different variables. This developed scale can guide researchers who want to work on a related subject in different disciplines. By adding this scale to different disciplines, it can be studied by increasing its diversity.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Appendix

Zero Waste Attitude Scale

	Expressiones	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1	I know that the unconscious consumption of natural resources is a problem.					
2	I am happy that people prefer packaged products that can be recycled.					
3	I am happy to encourage people to use packaged products that can be recycled.					
4	I am happy to use packaged products that are reused after recycling.					
5	Zero waste plays an important role in solving environmental problems.					
6	I know that the zero-waste policy prevents waste					
7	I know that the zero-waste policy contributes to the economy.					
8	Leading people to zero waste makes me happy.					
9	I recognize the recycling symbol.					
10	I think that with the zero-waste policy. natural and energy resources will be consumed less.					
11	I know how to protect natural resources.					
12	I think that with the zero-waste policy. the amount of waste left in the environment will decrease.					
13	I am aware of the environmental problems caused by waste.					
14	I am happy to use products with recyclable packaging.					
15	I know that waste is a raw material with economic value.					
16	I separate my waste and leave it in the relevant waste bins.					
17	The gradual increase in environmental problems caused by waste does not bother me.					
18	It doesn't bother me that waste is thrown directly into the trash.					
19	I think the problems caused by waste are exaggerated.					
20	I don't think the zero-waste policy improves the quality of life.					
21	Harming the environment does not make me unhappy.					
22	I do not think that environmental education is important in preventing waste.					
23	I think it is not possible to reduce waste.					
24	I participate in events organized about zero waste.					
25	I do research on what can be done to reduce waste.					
26	I buy products with packaging suitable for recycling. even if they are expensive.					
27	I make an effort to provide products with packaging suitable for recycling.					
Negative Items: 17-18-19-20-21-22-23						

Zero Waste Attitude Scale (Turkish)

	Maddeler	Kesinlikle Katılıyorum	KAtılıyorum	Kararsızım	Katılmıyorum	Kesinlikle Katılmıyorum
1	Doğal kaynakların bilinçsizce tüketilmesinin bir sorun olduğunu bilirim.					
2	İnsanların geri dönüştürülebilir ambalajlı ürünleri tercih etmesi beni mutlu eder.					
3	İnsanlara geri dönüştürülebilir ambalajlı ürünleri teşvik etmek beni mutlu eder.					
4	Geri dönüştürülerek tekrar kullanıma sunulan ambalajlı ürünleri kullanmak beni mutlu eder.					
5	Sıfır atık, çevre sorunlarının çözümünde önemli bir rol oynar.					
6	Sıfır atık politikasının, israfı önlediğini bilirim.					
7	Sıfır atık politikasının ekonomiye katkı sağladığını bilirim.					
8	İnsanları sıfır atığa teşvik etmek beni mutlu eder.					
9	Geri dönüşüm sembolünü tanırım.					
10	Sıfır atık politikası ile doğal ve enerji kaynaklarının daha az tüketileceğini düşünüyorum.					
11	Doğal kaynakların nasıl korunacağını bilirim.					
12	Sıfır atık politikası ile çevreye bırakılan atıkların azalacağını düşünüyorum.					
13	Atıklardan kaynaklanan çevre sorunlarının bilincindeyim.					
14	Geri dönüştürülebilir ambalajlı ürünleri kullanmak beni mutlu eder.					
15	Atıkların ekonomik değere sahip bir hammadde olduğunu bilirim.					
16	Atıklarımı ayırarak ilgili atık kutularına bırakırım.					
17	Atıklardan kaynaklı çevre sorunlarının giderek artması beni tedirgin etmez.					
18	Atıkların doğrudan çöpe atılması beni rahatsız etmez.					
19	Atıklardan kaynaklanan sorunların abartıldığını düşünüyorum.					
20	Sıfır atık politikasının, yaşam kalitesini artırdığını düşünmüyorum.					
21	Çevreye zarar vermek beni mutsuz etmez.					
22	Atıkları önlemede çevre eğitiminin önemli olmadığını düşünüyorum.					
23	Atıkların azaltılmasının mümkün olmadığını düşünüyorum.					
24	Sıfır atık ile ilgili düzenlenen etkinliklere katılırım.					
25	Atıkları azaltmak için neler yapılabileceğine dair araştırmalar yaparım.					
26	Geri dönüşüme uygun ambalajlı ürünleri pahalı da olsa alırım.					
27	Geri dönüşüme uygun ambalajlı ürünleri temin etmek için çaba harcarım.					
Olusuz Maddeler: 17-18-19-20-21-22-23						

Author(s) Information

Fuat Ozcan
Nigde Omer Halisdemir University
Nigde/Türkiye
Contact e-mail: *fuatozcan42@gmail.com*
ORCID iD: 0000-0003-0032-0947

Ali Meydan
Nevsehir Haci Bektas Veli University
Nevsehir/Türkiye
ORCID iD: 0000-0002-1278-096X