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Effects of Videos and Digital Formative Assessment Applications (Kahoot and Quizlet) in Addressing the Topic of "Greenhouse Effect"

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Abstract

This study aims to examine the effect of using environmental videos and as formative assessment tools of Web 2.0 game-based applications (Kahoot, Quizlet) and improving prospective primary school teachers' conceptual understanding of the greenhouse effect and global warming. The study, designed as action research, involved 41 prospective teachers enrolled in an environmental education course. A pre-assessment using multiple-choice achievement tests and open-ended questions revealed that most students had incomplete and incorrect conceptual knowledge. Throughout the process, data regarding the videos and formative assessment tools used in the lessons were collected through student opinion forms, researcher observations, and interview notes. The final assessment (achievement test and oral question-and-answer activities) at the end of the application found that the digital tools used significantly increased student achievement and the acquisition of correct concepts. Based on this study, it is suggested that, in collaboration with experts, teaching materials should be prepared by blending interdisciplinary information such as light, atmospheric layers and gases, and the carbon cycle in a cause-and-effect relationship, presenting them through engaging events and contexts in video content. Additionally, for students who dislike competition in formative assessment activities, team modes of apps like Kahoot and Quizlet can be preferred for collaborative learning.

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Introduction

The greenhouse effect is a crucial natural process in maintaining the Earth's thermal equilibrium. Electromagnetic radiation from the sun reaching the Earth's surface is converted into infrared radiation by the Earth's surface, which then radiates this infrared radiation back into space. However, greenhouse gases in the troposphere (non-diatomic gases such as carbon dioxide/CO_2, methane/CH4, nitrous oxide/N_2O, water vapor/H_2O, and chlorofluorocarbons/CFCs) trap

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this infrared radiation and send it back to the Earth, preventing it from escaping into space. This process prevents extreme fluctuations in the Earth's average surface temperature (Napomuceno, Pazinato, Gomes, 2024; Varela, Sesto, García-Rodeja, 2020).

To understand the greenhouse effect, it is important to know the properties of electromagnetic radiation (Ultraviolet (UV), Visible, Infrared (IR)) reaching the Earth's surface from the Sun and how it interacts with gases in the atmosphere. (Versprille, Towns, 2015; Versprille, Zabih, Holme, McKenzie, Mahaffy, Martin, & Towns, 2017). It is also important to understand how radiation from the sun reaches the Earth's surface, how landmasses, glaciers, seas, green areas, and man-made structures affect the Earth's surface, and to comprehend the carbon cycle (Porter, Weaver, Raptis, 2012).

Understanding the role of naturally occurring or man-made solid and liquid particles suspended in the air (atmospheric aerosols) in absorbing and scattering sunlight, cloud formation, and the greenhouse effect (Grassian, Stone, 2015), which is rarely covered in curricula, can provide a different perspective on the greenhouse effect.

Since the Industrial Revolution, as the tangible effects of global warming on daily life (floods, melting glaciers, etc.) have increased, topics such as global warming, climate change, the greenhouse effect, and greenhouse gases have begun to receive more attention on social media (Karpudewan, Roth, Abdullah, 2015) and in government policies (reducing greenhouse gas emissions, including them in curricula, etc.) (Ocal, Kışoğlu, Gürbüz, 2011; Skamp, Boyes, Staninstreet, 2009).

Environmental education.

The most effective way to solve the growing environmental problems is to raise conscious and sensitive generations. To reduce/prevent the emergence of environmental problems and to produce solutions to them, it is important to provide lifelong environmental education to every citizen (in all educational institutions, for public employees, etc.) (Erol, Gezer, 2006).

Determining how and in what way global warming and climate change will be addressed in the curriculum, identifying students' gaps in understanding and alternative concepts regarding these topics, is crucial for the effective implementation of the teaching process (Shepardson, Niyogi, Choi, Charusombat, 2009; Wan, Ding, Yu, 2023; Liu, 2021).

Greenhouse gases, superficial learned concepts about the greenhouse effect, and alternative concepts

In their study, Niebert & Gropengießer (2014) noted that students and scientists used similar visual diagrams to explain the greenhouse effect, but students were unable to explain the diagrams correctly.

Some researchers have noted that students do not have sufficiently accurate information about types of greenhouse gases, types of radiation (such as UV, visible, and IR), and the interaction between greenhouse gases and radiation (Niebert, Gropengießer, 2014; Versprille, Towns, 2015; Versprille, Zabih, Holme, McKenzie, Mahaffy, Martin, & Towns, 2017; Wan, Ding, Yu, 2023).

Some studies have shown that while students have accurate information about the consequences of global warming and the measures to be taken against it, they have misconceptions about the greenhouse effect and the effects of greenhouse gases (Kılınç, Stanisstreer, Boyes 2008; Niebert, Gropengießer, 2014).

A literature review reveals that some students do not view the greenhouse effect as a natural process, and some even consider it an environmental problem (Porter, Weaver, Raptis, 2012; McDonald & Dominguez, 2010; Ocal, Kışoğlu, Gürbüz, 2011; Varela, Sesto, García-Rodeja, 2020).

It has been observed that some students confuse global warming with ozone depletion, believing that global warming causes acid rain and that nuclear power plants cause ozone depletion (McDonald & Dominguez, 2010; Ocal, Kışoğlu, Gürbüz, 2011; Varela, Sesto, García-Rodeja, 2020), while some students only know CO2 as a greenhouse gas.

Based on the literature review, some of the reasons for students' superficial knowledge and alternative concepts can be listed as follows.

i. Incomplete or incorrect information on TV or in digital media, or the student's failure to correctly

interpret information in digital media (Ocal, Kışoğlu, Gürbüz, 2011; Ahi, 2016; Bozdoğan, 2011).

ii. Lack of sufficient information and explanations in textbooks. (Ocal, Kışoğlu, Gürbüz, 2011; Hurst, Quiroz-Martinez, Wissinger, 2025).

iii. Teachers lack the knowledge and experience to address environmental issues in their lessons (McDonald & Dominguez, 2010; Porter, Weaver, Raptis, 2012; Aksan, Çelikler, 2013; Kahraman, 2020; Bozdoğan, 2011).

iv. The inability of academics at universities to adequately connect their scientific fields with environmental issues (Shealy, Katz, Godwin, Bell, 2021).

v. The topics of global warming, the greenhouse effect, greenhouse gases, etc., consist of multidisciplinary knowledge (earth science, atmospheric science, physics, chemistry, biology, mathematics, etc.) (Versprille, Towns, 2015).

Identifying the concepts students possess and alternative concepts and organizing alternative concepts.

The greenhouse effect, greenhouse gases, global warming, and climate change are socio-scientific topics, and although these subjects are frequently discussed on social media and in digital environments, it has been determined that most students have only superficial knowledge and alternative concepts, and that they are unable to adequately explain these issues within a cause-and-effect framework (Ocal, Kışoğlu, Gürbüz, 2011; Aksan, Çelikler, 2013; Varela, Sesto, García-Rodeja, 2020; Kahraman, 2020; Ahi, 2016; Kılınç, Stanisstreer, Boyes, 2008; Aksoy, Erten, 2022; Erdoğan, Özsevgeç 2012; Pekel, 2019; Niebert, Gropengießer, 2014; Karpudewan, Roth, Abdullah, 2015; Bahar, Aydın, 2002; Shealy, Katz, Godwin, Bell, 2021; Versprille, Towns, 2015; Wan, Ding, Yu, 2023; Lester, Ma, Lee, Lambert, 2006).

In educational studies, methods used to determine students' understanding of greenhouse gases, the greenhouse effect, global warming, etc., include word association, writing, drawing, and explaining (Ahi, 2016; Kahraman, 2020), mental modeling (Varela, Sesto, García-Rodeja, 2020; Liu, 2021), and multi-stage diagnostic tests (Aksoy & Erten, 2022).

One method that contributes to the literature on making the teaching process for topics such as climate change, global warming, and the greenhouse effect more effective is the use of stories in the teaching process. Stories are effective on people, especially child readers, and can be used to develop environmental literacy (Koolen, Amelsvoort, Beek, Borst, Classen, Godbeek, Looji, 2026).

Niebert & Gropengießer (2014) stated in their study that addressing the interaction of visible light, heat, and CO2 through experience-based experiments helps students learn concepts better and that students seek answers to different scientific questions after the experiments. Dunnivant, et al. (2000) stated in their study that interdisciplinary digital modules and digital games (integrating physics, chemistry, biology, geology, and mathematics) created in a digital environment regarding the greenhouse effect and greenhouse gases increased student participation and learning efficiency. Hersh et al. (2025) stated that addressing the problems caused by climate change in the students' region as teaching activities in the classroom contributed to students' in-depth learning of concepts and their ability to generate solutions to environmental problems.

A literature review shows that concept cartoons (Erdoğan, Ozsevgeç, 2012), argumentation-based concept cartoons (Pekel, 2019), and interactive virtual laboratory activities contribute to students developing a deep and integrated understanding of topics such as the greenhouse effect and global warming, and to addressing alternative concepts (Varma, Linn, 2012).

The role of videos in education.

In the early 1900s, short videos covering the life cycle of bees and personal hygiene were among the first videos used for educational purposes. These videos, which garnered significant attention at the time, gradually began to be used in various sectors such as education, art, and entertainment. However, the initial popularity of educational videos created for use in classes gradually diminished (Mayer, Fiorella, Stull, 2020). With the widespread adoption of the internet in the 2000s, video conferencing and interactive digital videos were used. Subsequently,

with the advancement of technology and the proliferation of smartphones, tablets, and social interaction networks like YouTube, online education, flipped learning (Yousef, Chatti, Schroeder, 2014), and MOOCs (massive online open courses) were also implemented. Particularly during the Covid-19 pandemic, the closure of universities and schools led to a significant increase in the use of videos in distance learning (Dietrich et al., 2020; Kim, 2020; Cojean, Jamet, 2022).

Videos, with their visual and auditory elements appealing to multiple senses and their content, can make the information to be learned more engaging for the student, thus making it easier for them to remember what they have learned (Zhang, Zhou, Briggs, Nunamaker, 2006).

Some studies have shown that students remember events from videos they watch better than information from written notes. However, the success of using videos in education depends on how the videos are used (Choi, Johnson, 2005). Pakpahan (2022) indicated that of video-based learning and PowerPoint presentations positively impacted student performance in environmental studies; however, video-based instruction yielded superior outcomes compared to PowerPoint slides.

Online interactive game-based formative assessment in education.

Software stores have offered numerous digital tools and applications for digital formative assessment activities in recent years. These tools differ in terms of their functional features. Teachers and students need guidance in choosing among these tools and using them effectively (Çekiç, Bakla, 2021). In this respect, studies on how digital formative assessment applications are used and their effects are important for literature.

Formative assessment activities conducted during the teaching process provide feedback to both the student and the teacher about the student's learning level, enabling both teachers and students to take action to improve the effectiveness of the teaching process (Author, 2025). The more enjoyable and the faster feedback on the student's learning level is provided by formative assessment activities in the teaching process, the faster and more effective the teacher's and student's efforts to improve the effectiveness of the teaching process will be. Therefore, online, interactive, game-based formative assessment applications offer a great advantage (Author, 2023; Authors, 2023).

Research Problem

Literature review results indicate that many students, teachers, and academics from various fields of study, from primary school to university, have not learned about the greenhouse effect, greenhouse gases, and global warming in a scientifically accurate, holistic, and lasting way.

The main purpose of this study was to ensure that prospective primary school teachers, who are raising future generations, learn about the greenhouse effect and greenhouse gases accurately and holistically by creating a fun and educational classroom learning environment. The implicit aim of the study was to give prospective teachers ideas on how to make the learning-teaching environment fun and productive in their professional lives.

The Importance of Research

This study is expected to contribute to literature as a good practice example in the effective teaching of the interdisciplinary environmental topic of "the greenhouse effect." The study findings reveal that videos and interactive formative assessment activities positively impact student achievement and make the learning environment enjoyable and productive. Finally, it is expected that the researcher's suggestions on which topics (electromagnetic radiation, atmosphere, carbon cycle, etc.) should be addressed together in the teaching process of the greenhouse effect, an interdisciplinary (physics, chemistry, biology, geography) environmental topic, and the suggestions of the researcher and students on how to make videos and interactive formative assessment activities more effective in the learning environment, will contribute to the literature.

1.6. Research Questions

The research questions are listed below:

i. What is the student's prior knowledge about the greenhouse effect, greenhouse gases, and global

warming?

ii- What are the instructor's opinions and suggestions about the teaching process?

iii- How does the learning environment (videos, formative assessment activities) affect a student's academic achievement?

iv- What are the students' opinions and suggestions about the learning process?

Method

This study was conducted according to action research (Corey, 1954), which is used by practitioners such as teachers and educational researchers to solve existing problems in the field of practice or to improve and update existing practices.

The action research process is a cyclical and critical process consisting of:

i. Identifying the research problem and research questions,
ii. Initiating the action/implementation process,
iii. collecting and analyzing data about the process,
iv. Identifying changes in the implementation process,
v. The impact of the changes, and
vi. addressing the impact of the implementation process on the research questions (McMillan, Schumacher, 2006). In action research, data is generally obtained through experience, inquiry, and investigation. In experiential data collection, the researcher attempts to understand the situation by observing the participants and the current circumstances. In inquiry-based data collection, the researcher uses surveys, interview forms, and tests to collect data that is not yet available. In investigation-based data collection, the researcher uses data that has already been collected (McMillan, Schumacher, 2006).

Research Design

In this study, the researcher collected data using data collection tools prepared by drawing on their experience in conducting environmental education courses in previous years and digital and written resources on environmental issues.

Study participants

The study was conducted using typical case sampling with 32 female and 9 male students enrolled in the environmental education course and studying in the first year of the primary school teacher training program. The aim of typical case sampling studies is not to generalize from the data obtained at the end of the study, but rather to provide information about the subject under study and the effects of a new situation being applied (Patton, 2002).

Data Collection Tools

The data for this study were obtained during the "Environmental Education Course," which was taught for two hours per week between February 17, 2025, and March 17, 2025, in the spring semester of the 2024-2025 academic year. Table 1 summarizes how the data collection tools used in the study were used, at which stage of the study, for which purpose/research questions, and in what manner. This section contains information about validity, reliability, data collection tools, and analysis of the data collection

Table 1: The research process and the data collection tools used in the process.

	Action Research Questions and Process	Data Collection Tools Used in the Process
Before starting action research	What is the student's prior knowledge about the greenhouse effect, greenhouse gases, and global warming?	*Qualitative Data Collection Tools* 1 "Greenhouse effect and global warming information form" was used. Quantitative Data Collection Tool 1 "Greenhouse effect achievement test" pre-test. This test was used as both a pre-test and post-test in the study and consisted of four multiple-choice questions.

	Action Research Questions and Process	Data Collection Tools Used in the Process
Action research teaching process	What are the instructor's opinions and suggestions about the teaching process?	**Field Notes I** Field notes I is a report created based on the researcher's observations and verbal dialogues with students during the teaching process, which involved watching videos and conducting formative assessment activities.
Action research teaching end	How does the learning environment (videos, formative assessment activities) affect a student's academic achievement?	**Quantitative data collection tool** "Greenhouse effect achievement test" post-test. This test was used as both a pre-test and post-test in the study and consisted of four multiple-choice questions. **Qualitative data collection tool** **Field Notes II** The students' answers from the in-class oral question-and-answer activity were written down by the researcher to create Field Notes II.
	What are the students' opinions and suggestions about the learning process?	**Qualitative data collection tool** **Student opinion form about the course process** The "Student opinion form about the course process," consisting of two open-ended questions, was used to determine students' opinions about the process.

tools given in Table 1.

Validity and reliability of data collection tools

The validity of a data collection instrument relates to its ability to accurately measure the intended characteristic without confusing it with other characteristics (Baykul, 2015), while the validity of a research study can be ensured by controlling for possible errors originating from the subject, data collection and analysis tools, research process, and researcher (McMillan, Schumacher, 2006). The reliability of a measurement instrument refers to its freedom from errors, obtaining similar results from the same instrument at different times, or obtaining similar results from the same situation with similar measurement instruments (McMillan, Schumacher, 2006).

In this context, before preparing the "greenhouse effect achievement test," the researcher conducted a literature review in print and digital formats across disciplines (physics, chemistry, biology, geography), then prepared a specification table in the form of topics and learning outcomes, and finalized the test based on the opinions and suggestions of three experts in the fields of physics, chemistry, and geography. The KR-20 reliability coefficient of the test was determined to be .594, and the item analysis is given in Table 2.

In descriptive analysis of qualitative data, directly quoting sentences enhances validity by revealing the diverse opinions of participants and increases reliability by presenting views and opinions as they are (Corden, Sainsbury, 2006). This study also aimed to increase the reliability and validity of qualitative data by quoting the various opinions of the participants as they were. To ensure the validity of qualitative data (Greenhouse effect and global warming information form and Student opinion form about the course process), written opinions and suggestions obtained

were used quoted as is. Coding of and categori qualitative data was done separately by the lecturer and the different education researchers on condition of using the same sentences or words/synonyms of words used by the students. Inter-rater agreement was calculated using the formula Δ = C/ (C+ ð).100 (Δ: reliability coefficient, C: Number of agreements, ð: Number of disagreements) (Miles & Huberman, 1994; Baltacı, 2017). The reliability coefficient was calculated as 83%.

Data Collection Tools and Analyses

Qualitative data collection tools used before starting action research.

Greenhouse effect and global warming information form

The study consisted of an open-ended question, "What are the greenhouse effect and global warming? Explain," to determine how students defined the greenhouse effect/global warming before the application. Data was collected via Google Forms. Descriptive content analysis was performed on the collected data.

Quantitative data collection tools used before starting action research.

Greenhouse effect achievement test

In this study, a pre-test and a post-test were used to assess students' knowledge levels regarding greenhouse gases, the atmospheric layers containing greenhouse gases, and radiation (infrared, ultraviolet, visible). This was achieved through a "greenhouse effect achievement test" consisting of four multiple-choice questions (Appendix 1).

The item difficulty index and item discrimination index of the "greenhouse effect achievement test," prepared by the researcher based on a literature review, are given in Table 2. The KR-20 value of the test was determined as.594.

Qualitative data collection tools used in the action research implementation process

Field Notes I

Throughout the study, the impact of videos, Kahoot, and Quizlet used in the learning environment was examined in "field notes I," which was created based on the researcher's classroom observations and conversational interviews with students. The results of the descriptive analysis of the data are discussed in the findings section of the study.

Table 2: Item analysis results of the "Greenhouse effect achievement test".

	Q1	Q2	Q3	Q4
Item difficulty index	0,70	0,42	0,60	0,71
Item discrimination index	0,41	0,54	0,54	0,34

Qualitative data collection tools used at the end of action research implementation

Field Notes II

Field notes II, include

I. The accuracy of students' answers to questions asked orally in class by the teacher or fellow students at the end of the study,
II. The researcher's general observations at the end of the application process. Descriptive content analysis of the data was performed.

Student opinion form about the course process

To determine students' opinions and suggestions about the action research process, data was collected using the "Student Opinion Form on the Course Process," created with Google Forms. Descriptive content analysis was performed on the data. The following open-ended questions were addressed in the data collection tool:

1. What are your opinions and suggestions regarding the use of videos among the course materials?
2. What are your opinions and suggestions regarding the use of formative assessment tools (Kahoot, Quizlet)?

Findings

This section of the study presents the findings obtained using the research questions and data collection tools indicated in Table 1.

Greenhouse effect and global warming information form

The students' answers regarding the greenhouse

effect and global warming, based on the accepted definition, were evaluated by two experts in the field and categorized as: completely correct, correct but incomplete information, incorrect information, and those who did not answer. Students' knowledge of the accepted definition of the greenhouse effect is shown in Table 3.

Correct definition: "The greenhouse effect is the warming of the Earth because of the heat (infrared rays) emitted from the Earth due to radiation (rays) from the Sun heating the Earth, being trapped by greenhouse gases (such as carbon dioxide, water vapor, and methane) in the atmosphere. The greenhouse effect is a natural heat-trapping event that keeps the Earth at a habitable temperature. Excessive greenhouse effect, however, can lead to global warming." Visual information regarding the correct definition is given in Figure 1. The visual in Figure 1 was also used in the lesson.

Table 3 shows that none of the students gave a completely correct definition of the greenhouse effect and global warming. Three students had partially correct and incorrect information, 22 students had partially correct information, 21 students had incorrect information, and one student did not answer. Examples of sentences showing students correct but incomplete and incorrect information are given below.

Examples of statements from students who provided partially accurate information

S1: "Rays that need to be sent back into space pass through the atmosphere. However, some gases in the atmosphere trap these rays and prevent them from escaping into space. Because these gases trap the rays, the Earth cannot release them into space and heats up more. This is called the greenhouse effect"

S4: "Some of the sun's rays hit the surface, and some are reflected into space. The reflected rays encounter greenhouse gases on their way back

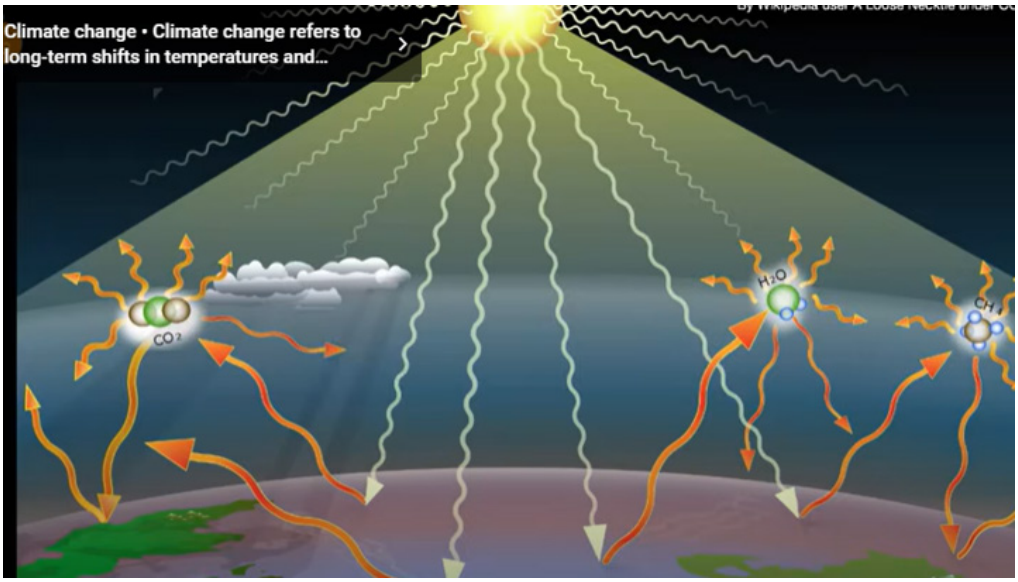

Fig. 1: Greenhouse effect (quoted from Khan Academy)

Table 3: Students' knowledge levels about the greenhouse effect and global warming.

Correct information	Partially correct information	False information	Unanswered
-	S1, S2, S3, S4, S5, S7, S8, S10, S11, S12, S13, S15, S17, S18, S19, S20, S21, S22, S23, S32, S37, S40	S3, S6, S9, S10, S14, S16, S25, S27, S28, S29, S30, S31, S33, S34, S35, S36, S37, S38, S39, S40, S41	S24,
f -	22	21	1

to the surface, warming the Earth; this is called the greenhouse effect"

S5: "Increase in temperature"

S7: "Some rays from Earth cannot be released into space, and the Earth heats up."

S8: "The world is warming more than it should be."

Examples of statements from students who provided incorrect information

S6: "Atmospheric gases absorbing heat from the sun"

S9: "The greenhouse effect is when fossil fuels and certain gases cause global warming, leading to the Earth overheating; this is called the greenhouse effect."

S10: "It is the Earth's natural warming, resulting from gases in the atmosphere trapping heat from the sun."

S16:"It is the Earth's natural warming, resulting from gases in the atmosphere trapping heat from the sun."

S25:"The inability to send the gases that were supposed to be sent into space."

Data obtained from student responses reveals that none of the 41 students could fully and accurately define the greenhouse effect and global warming.

Greenhouse effect achievement test (pre-test and post-test)

In this study, the "Greenhouse Effect Achievement Test" prepared by the researcher was applied as a pre-test and post-test. The descriptive analysis results of the data obtained from the pre-test and post-test are shown in Table 4, and the Wilcoxon Signed Ranks test results are shown in Table 5.

From Table 4, it was determined that the pre-test mean score was 37.19, the post-test mean score was 82.92, and there was a statistically significant difference between the pre-test and post-test scores ($p < .005$) (Table 5).

Table 4: Descriptive analysis results of the pre-test and post-test achievement test.

	Gender	N	$\bar{X}$
Pretest	Female	32	37,5
	Male	9	36,1
	Total	41	37,19
Posttest	Female	32	82,81
	Male	9	83,33
	Total	41	82,92

Field Notes I

Field Notes I presents findings on the impact of classroom video viewing and the use of Kahoot and Quizlet on the learning environment.

Video use and impact

Video used in lessons: Two lesson hours in Week 1., one lesson hour in Week 2.

Video content: Videos (Appendix 2) consisting of information on solar radiation (infrared (IR), ultraviolet (UV), and visible light), greenhouse gases, greenhouse effect, carbon cycle, and global warming were watched in class. Table 6 contains codes and quotes created by the course instructor regarding the use of video in the lessons.

The impact of using Kahoot and Quizlet in the lessons

Table 7 lists some of the instructor's notes on the effects and applications of using Kahoot and Quizlet in the lessons.

Field Notes II

At the beginning of the study, during oral question-and-answer activities with students in the classroom, it was determined that students had incomplete and incorrect information on the topics indicated in Figure 2, and that they generally learned

Table 5: Achievement Test Pre-test Post-test Wilcoxon Signed Ranks Test Table

	Rank	N	Rank average	Rank sum	Z	p
Posttest- Pretest	Negative ranks	2	6	12	-5,179	,000
	Positive ranks	35	19,74	691		
	Equal	4				
	Total	41				

Table 6: Examples from the instructor's notes on the use of video in lessons.

Codes	Quotations
Effective classroom management	"Short and engaging videos make classroom management more effective"
Classroom interaction	"It allows students to exchange ideas about video content."
Contribution to teaching professional skills	"It provides prospective teachers with ideas on how they can effectively use videos in their lessons during their professional careers"
Physical conditions of the classroom environment	"The classroom environment needs to be digitally proficient (internet access, smart board adequacy, classroom size)"
Effective video selection and usage.	"Different types of videos (films, cartoons, movies, documentaries, etc.) that are effective cognitively and affectively should be preferred" "The videos should definitely be watched critically beforehand by the course instructor"

Table 7: Examples from the instructor's notes on the use of Kahoot and Quizlet in lessons

Codes and sub codes		Quotations
Effects	Quick feedback	"It allows for the rapid determination of the student's level, enabling both the student and the instructor to plan the teaching process more effectively"
	Remembering information	"Frequent and abundant question-and-answer sessions help students remember learned information more easily."
	Fun classroom environment	"These applications make the classroom environment more fun and interactive."
Recommendations	Those who like and dislike competition	"Applications should be planned taking into account both students who enjoy competition and those who do not."
	Collaborative learning environment	"A group collaborative learning environment should be provided by using the team modes of Kahoot and Quizlet applications"
	Digitally renewable and adequate classrooms	"Classrooms should be made digitally proficient."
	Responsibilities of the course instructor	"Topics that were not covered sufficiently in class should be reviewed"

this information from digital platforms. However, towards the end of the application, it was determined that students updated their incomplete and incorrect information correctly.

Student opinion form about the course process

In this section, student opinions obtained from "the student opinion form about the course process" are examined in three categories: positive opinions, negative opinions, and suggestions. Students' opinions and suggestions are summarized in Tables 8 and 9, using direct quotations from the sentences they wrote. "The student opinion form about the course process" received voluntary responses from 29 students. The other 12 students participating in the study were unable to provide written opinions due to reasons such as not being in class or at school during the period when written opinions were collected.

Students' opinions about the videos used in the lessons are shown in Table 8.

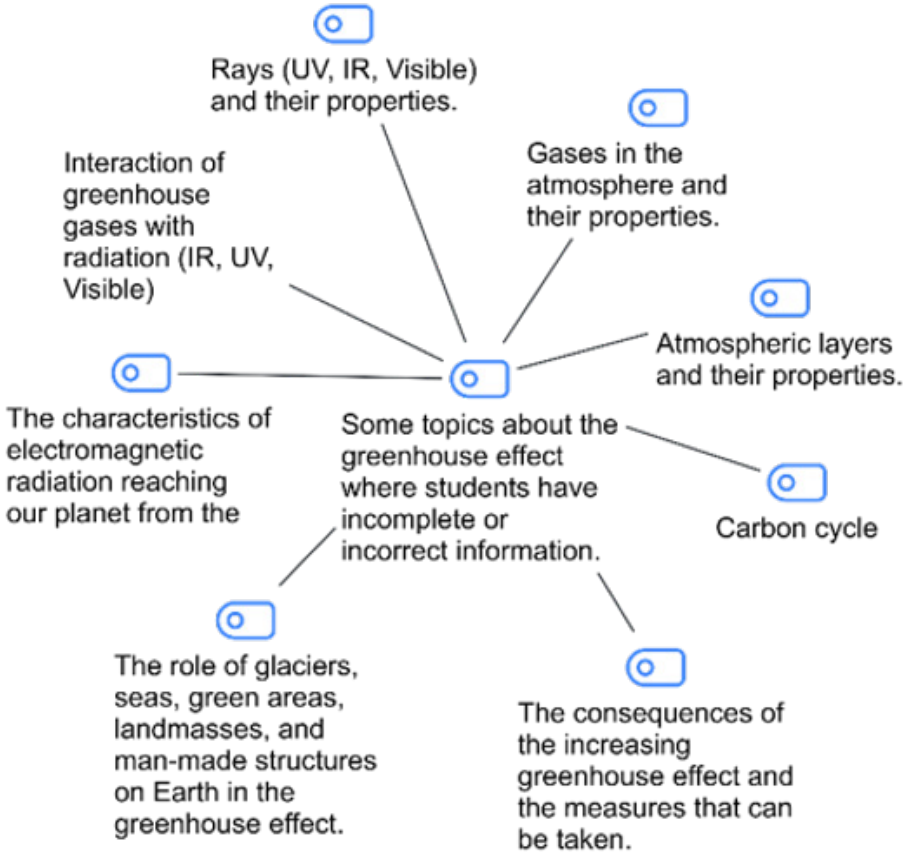

Fig. 2: Topics those students had incomplete or incorrect information about during the application process but learned correctly by the end of the application.

As seen in Table 8, students expressed positive opinions about the use of videos in lessons, such as increasing interest in the lesson, supporting learning, stimulating learning through senses and emotions, and improving the recall of learned information. Students' suggestions regarding videos included increasing the variety of video types about the greenhouse effect (animation, documentary, feature film, educational video, etc.) and making videos freely and easily accessible in digital environments.

Students' opinions on formative assessment activities conducted in the classroom using Kahoot and Quizlet are summarized in Table 9.

Table 9 shows that while there are positive opinions regarding game-based digital formative assessments making the classroom environment more enjoyable and supporting learning, students who dislike competition and whose self-confidence decreases when they cannot achieve high scores do not like these types of assessments, but they do express opinions that these formative assessments support learning.

Discussion and Conclusions

In this study, it was determined that at the beginning of the application process, the primary school teacher candidate students had limited accurate knowledge on the topics specified in Figure 2 within the scope of the greenhouse effect. This situation reveals that the past learning processes of the students were not effective enough on the greenhouse effect. Similarly, some studies reveal that despite the increasing level of education and access to information, individuals have incomplete and alternative concepts about the greenhouse effect and global warming (Lester, Ma, Lee, Lambert, 2006; Liu, 2021).

Table 8: Student opinions about videos watched in lessons.

Categories		Code/ "sample quotes"	f
	Positive opinions	**Increasing interest** "The videos increased my interest in the subject."	20
		Supporting learning "It allowed me to gain detailed information on the subject"	17
		Learning involves engaging many senses and emotions. "Visual, auditory, and emotional stimuli positively influenced my learning."	18
		Encouraging continuous learning "They also encourage watching videos after class."	5
		Making it easier to recall learned information. "I think information learned through videos is more permanent."	19
	Suggestions	**Documentary and story-style videos (scenario and types of videos)** "The variety of video types (documentary, animated film, movie, tutorial) should be increased." "Anime videos could be more engaging; environmentally themed anime films should be made." "Documentaries are more interesting; more documentaries should be made. More realistic, scientifically accurate films with environmental themes should be made"	22
		Access to videos and their use in lessons in digital environments. "Different types of videos related to the environment should be used in lessons." "Environmentally themed videos should be freely accessible to everyone in digital format." "Teachers should definitely use environmental themed videos in their lessons"	18

Table 9: Student opinions on in-class formative assessment activities.

Categories		Code/ "sample quotes"	f
	Positive opinions	**Fun** "In-class formative assessment activities were fun"	25
		Reinforcement "Kahoot and Quizlet helped me reinforce what I learned."	20
		Identifying gaps "It allowed me to immediately identify and correct my learning gaps."	20
		Competition "I enjoyed competing with my classmates in the classroom."	15
		Interest in the lesson "My interest in the lesson has increased"	23
	Suggestions	**It should be widespread** "Game-based formative assessment should be used in all subjects."	23
		It shouldn't be in the form of a competition. "Formative assessment in the form of a game shouldn't be in the form of a competition." "Each student should only know their own right and wrong"	10
	Negative opinions	**Competition** "The competitive nature of the learning environment negatively affected me."	10
		The negative impact of low scores/failure. "Failing in competitions affected me negatively."	11
		Lowering self-confidence "Failing in competitions destroys my self-confidence".	13

The reasons for this situation include: the complexity of global climate modeling (Harrison, Davies-Coleman, Rivett, Khan, Sewry, Wajrak, et all, 2024), incomplete and inaccurate information in the media, inadequate textbooks (Ocal, Kışoğlu, Gürbüz, 2011; Ahi, 2016; Bozdoğan, 2011), and teachers' lack of sufficient knowledge and experience (McDonald & Dominguez, 2010; Porter, Weaver, Raptis, 2012; Aksan & Çelikler, 2013; Bozdoğan, 2011; Kahraman, 2020). However, solving environmental problems requires well-educated and conscientious citizens who can explain the cause-and-effect relationships of these problems and generate solutions. Therefore, prospective teachers who will educate future generations need to receive good training in environmental issues. A literature review reveals that researchers use different teaching methods for effective environmental education. The use of videos in the teaching process is one of them. The use of videos in the teaching process started in the 1900s, and interest in the use of videos increased in some periods (invention of television, distance education applications, Covid-19 pandemic, etc.). Videos can be an effective learning tool because they affect emotions as well as visual and auditory senses. Scientific information can be included in science fiction films, documentaries, or videos that directly convey theoretical information visually and audibly. In addition, video types that allow interaction with the audience are also used for educational and entertainment purposes. In this study, videos that present scientific information theoretically to students and reveal the dramatic consequences of global warming were used. These videos both captured the students' attention and appealed to their emotions, and at the end of the study, it was determined that they contributed to the students' reorganization of information they had learned incompletely or incorrectly. Even though the film industry blurs the lines between real scientific information with technological scenes showing the world being saved in the final minutes of a film (Dunnivant, et al, 2000), people can still permanently learn some scientific information through films. Within the scope of this study, it is suggested that science fiction films containing accurate and complete scientific content that appeal to students' emotions be prepared through the collaboration of interdisciplinary experts. These science fiction films can be prepared according to the age and educational background of the viewers. Pekel (2019) stated in his study that teachers need resources they can use online. Science fiction films prepared by experts can also be added to online platforms that teachers can use. In the preparation of these films, universities can collaborate with faculties of basic science, geography, education, communication, art, and cinema. Some educational research shows the use of gamification-based online formative assessment applications. However, a review of the literature reveals few such studies in the teaching of environmental issues. Gamification-based online formative assessment activities can contribute to students learning information correctly and more quickly, and updating their knowledge, because they do not cause test anxiety in students and provide quick feedback to students and teachers about student levels. In this study, formative assessment activities helped students quickly identify their incomplete and incorrect learning and structure that information correctly in their minds. However, applications like Kahoot and Quizlet were criticized by students who dislike competition. Therefore, different online game-based applications could be used where only the students, and their teachers can see the formative assessment results.

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Appendices

Appendix 1 Greenhouse effect success test

Question 1: In which layer are the gases that directly cause the greenhouse effect located?

A)	Troposphere
B)	Stratosphere
C)	Mesosphere
D)	Ionosphere
E)	Other (I don't know)

Question 2: Which of the following are gases that directly cause the greenhouse effect?

I- Oxygen (O_2), II- Nitrogen (N_2),
III- Carbon dioxide (CO2), IV- Water (H_2Og)

A)	I
B)	I, II
C)	III, IV
D)	All
E)	III
Other /I don't know	

Question 3: Which of the following is true?

I. The greenhouse effect is necessary for the Earth to be habitable.

II. If there were no greenhouse gases, the Earth would be much colder.

III. Greenhouse gases make up less than 1% of all gases in the atmosphere.

A)	I
B)	I, II
C)	III
D)	I, III
E)	All
Other / I don't know	

Question 4: Which of the following is true?

I- Temperature generally increases as you go higher in the troposphere.

II- Visible, ultraviolet, and infrared rays reach the Earth from the sun.

III- Some living things and inanimate objects emit infrared radiation.

IV- Infrared radiation is emitted from the Earth's surface into the atmosphere.

A	I
B	II
C	III
D	II, III, IV
E	All
Other / I don't know	

Appendix 2. Links to the videos watched in the lessons.

https://www.youtube.com/watch?v=aS1yVxUQz-7k&list=PLudd4Je1ChPmqpy4SLy9kneWkj_JkFpPy&index=2 (Khan acadmy)

https://www.youtube.com/watch?v=gUX2x3Y_BJA-&list=PLudd4Je1ChPmqpy4SLy9kneWkj_JkFpPy&index=3 (Tübitak-bilim genç)

https://www.youtube.com/watch?v=P-fOA2VKZms&list=PLudd4Je1ChPmqpy4SLy9k-neWkj_JkFpPy&index=4 (Khan acadmy)

https://www.youtube.com/watch?v=6ZLmk8Ec-J08&list=PLudd4Je1ChPmqpy4SLy9kneWkj_JkFpPy&in-dex=5 (Khan acadmy)

https://www.youtube.com/watch?v=swPjjPXz-GhU&list=PLudd4Je1ChPmqpy4SLy9kneWkj_JkFpPy&in-dex=15 (Yeşil gazete)

https://www.youtube.com/watch?v=pdOqVieaWVU (BBC News)

https://www.youtube.com/watch?v=ilRaCR1_InI&list=PLudd4Je1ChPmqpy4SLy9kneWkj_JkFpPy&index=8