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The Effect of Online Prediction -Explanation-Observation-Explanation Method on Fifth Grade Students' Conceptual Understanding of Frictional Force in the Classroom[#]

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Research Article

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ABSTRACT
The ability of students to comprehend concepts is dependent on their capacity to think deeply, understand the relationships between concepts, and make connections. Various factors, such as logical thinking ability, attitude, physical environment, needs, and teaching approach, can affect students' ability to learn concepts. The study focused on fifth-grade students and examined the impact of the online Predict-Explain-Observe- Explain (PEOE) method on their conceptual understanding of friction force. The study employed a pre-test post-test experimental design, which is considered a weak experimental design. The sample of the study consists of 16 fifth grade students of a secondary school in Bursa province. The experimental application of the research was conducted online in the 2021-2022 academic year, which coincided with the pandemic period. A measurement tool called the Friction Force Conceptual Understanding Test was used as a data collection tool to determine conceptual understanding. Wilcoxon Signed Ranks Test, one of the non-parametric statistical methods, was used to compare the pre-test and post-test data. As a result of the study, it was determined that the PEOE method applied in the online education environment was effective in improving students' conceptual understanding of friction force. These findings highlight the importance of interactive and participatory learning approaches applied in an online environment for students' conceptual understanding processes. This study can be an important reference point for the development of distance education applications.

Keywords: Online education, science ınstruction, conceptual understanding, friction force, predict-explain-observe-explain method

Çevrimiçi Tahmin-Açıklama-Gözlem-Açıklama Yönteminin Beşinci Sınıf Öğrencilerinin Sürtünme Kuvveti Konusundaki Kavramsal Anlamalarına Etkisi[#]

Bilgi
[#]Bu çalışma birinci yazarın yüksek lisans tezinin bir parçasıdır.

**Sorumlu yazar*

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ÖZ
Öğrencilerin kavramları kavrama yeteneği, derinlemesine düşünme, kavramlar arasındaki ilişkileri anlama ve bağlantılar kurma becerilerine bağlıdır. Mantıksal düşünme yeteneği, tutum, fiziksel ortam, ihtiyaçlar ve öğretim yaklaşımı gibi faktörler öğrencilerin kavramları öğrenebilmesini etkilemektedir. Araştırma, beşinci sınıf öğrencileri üzerinde gerçekleştirilmiş ve bu öğrencilerin sürtünme kuvveti konusundaki kavramsal anlamalarına çevrimiçi Tahmin-Açıklama-Gözlem-Açıklama (TAGA) yönteminin etkisi incelenmiştir. Araştırmada, zayıf deneysel desenlerden tek grup ön test son test deneysel deseni kullanılmıştır. Araştırmanın örneklemi, Bursa ilinde bulunan bir ortaokulun, 16 beşinci sınıf öğrencisi oluşturmaktadır. Araştırmanın deneysel uygulaması, pandemi dönemine denk gelen 2021-2022 öğretim yılında çevrimiçi olarak gerçekleştirilmiştir. Kavramsal anlamanın tespiti noktasında veri toplama aracı olarak Sürtünme Kuvveti Kavramsal Anlama Testi adı verilen ölçme aracı kullanılmıştır. Ön test ve son test verilerinin karşılaştırılmasında, non-parametrik istatistiksel yöntemlerden Wilcoxon İşaretli Sıralar Testi kullanılmıştır. Çalışma neticesinde, çevrimiçi eğitim ortamında uygulanan TAGA yönteminin, sürtünme kuvveti konusunda öğrencilerin kavramsal anamalarını iyileştirmede etkili olduğu belirlenmiştir. Bu sonuçlar, öğrencilerin kavramsal anlama süreçleri için çevrimiçi ortamda uygulanan etkileşimli ve katılımcı öğrenme yaklaşımlarının önemini vurgulamaktadır. Çalışma, uzaktan eğitim uygulamalarının geliştirilmesi için önemli bir referans noktası olabilir.

Anahtar Kelimeler: Çevrimiçi eğitim, fen bilimleri dersi, kavramsal anlama, sürtünme kuvveti, tahmin- açıklama-gözlem-açıklama

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Introduction

The Covid-19 pandemic, which began in Wuhan, China, in December 2019, has exerted a profound influence worldwide, including in Turkey. This global health crisis has impacted numerous facets of daily life including the economy, mental health, societal interactions, education, and healthcare across many nations. Particularly notable are the transformative effects on the educational sector, where the pandemic has led to the suspension and in some cases, complete closure of universities and schools. In this period, the continuity of education was ensured in Turkey through platforms such as Education and Informatics Network (EBA), Google Meet, Skype and Zoom (Ayaz, 2021). With the use of these tools, technology, which has gained an important place today, has started to be used more and has made education and training activities sustainable by eliminating time and space limitations. At the same time, online education has helped to ensure equality in education for students, both economically and socially (Kırık, 2014).

It is crucial for students to learn concepts meaningfully rather than memorising them. This is because their conceptual understanding of the subject will help them form relationships between concepts and facilitate their progressive learning and understanding of new concepts (Sinan, 2007). With the shift to online education due to the pandemic, teaching concepts has become more challenging.

The challenges encountered during çevrimiçi education have made communication between teachers and students more difficult, hindering the full comprehension of scientific concepts. The absence of a physical classroom environment has made it challenging for students to actively participate in lessons, leading to the expectation that teachers should guide students more effectively. Research has shown that question-answer, lecture, and problem-solving are the most commonly used teaching methods in online education (Bakioğlu & Çevik, 2020). However, these methods have been found to be inadequate for promoting students' conceptual understanding (Başaran et al., 2020). Therefore, it is crucial to employ teaching techniques that facilitate conceptual understanding in online education. It has been observed that the Prediction-Observation- Explanation (POE) method contributes to students' conceptual learning (Chen, 2022).

The POE method is an effective teaching technique that enables students to actively participate in the lesson, question any subject or concept, and take an active role in the teaching process, thus facilitating conceptual change (White & Gunstone, 1992). The POE method, also known as Prediction-Observation- Explanation, is a three-stage process that reveals students' knowledge on a subject. It is important to note that this method is widely discussed in the literature. In

the first stage, students are asked to make predictions about a topic or concept and express their reasoning. This activates their prior knowledge. In the second stage, students are asked to make observations to verify their predictions. Finally, in the third stage, students are asked to provide an explanation. At this stage, students test their knowledge and observe the results. During the third stage, the individuals compare their predictions with their observations and explain any contradictions. Finally, students analyze their experiences and observations using a scientific approach to deepen their learning and better understand the concepts (White & Gunstone, 1992).

The POE method, developed by Kıryak (2013), has been modified to include an explanation stage between the prediction and observation stages. This modified version is known as the Prediction-Explanation- Observation-Explanation (PEOE) method. The PEOE method involves predicting the outcome of an event or experiment, explaining the predictions, observing the actual events, and then explaining any contradictions between the predictions and observations (Coştu et al., 2012). This technique encourages students to actively participate in the learning process by expressing their opinions and making connections between their prior knowledge and new information (Kearney & Treagust, 2000).

The PEOE method is an effective approach to ensure conceptual understanding. This learning method involves identifying distinctions, similarities and connections between concepts that can then be applied to other environments and used to solve problems (Sinan, 2007). Prior knowledge plays a very important role in this process. If students' prior knowledge is scientifically correct, it can help them acquire new knowledge. Incomplete or incorrect knowledge, on the other hand, can prevent the learning of new concepts (Ergun, 2017). Therefore, it is very important to prioritise students' acquisition of conceptual knowledge (Malatyalı & Yılmaz, 2010). In addition, PEOE method encourages students to question the reasons underlying the concepts and events presented to them. As a result, it is widely accepted as a method that improves students' conceptual understanding and facilitates conceptual change (Köseoğlu et al.,, 2002).

In this study, the subject of "friction force", which is included in the scope of the 5th grade primary school Science course, was discussed. Friction force is one of the basic physical forces that students can relate to daily life and easily understand with concrete examples (Yılmaz & İnce Aka, 2022). The main reason for choosing this subject is that it contributes to the development of scientific thinking skills by allowing students to actively participate in observation, experiment design, research and questioning processes (Maden, 2022). In addition, since friction force is a phenomenon frequently encountered in daily life, it is also important for students to develop their skills in transferring the learned information to real life (Taşkın & Moğol, 2017; Yüzbaşıoğlu & Kurnaz, 2022). Therefore, by focusing on the subject of friction force in the study, it was aimed to help students understand this concept more deeply and to support them with the PEOE method.

When the literature is examined, it is seen that many studies have been conducted on the POE method (Bilen et al., 2011; Bilen et al., 2016; Rusçuklu & Özdilek, 2019; Uyanık, 2017; Yıldırım & Maşeroğlu, 2016). These studies reveal that the POE

method positively affects students' conceptual understanding, increases their satisfaction with the courses, and provides opportunities to correct misconceptions. Various teaching methods are used in science education to improve students' conceptual understanding. Among these methods, approaches such as POE and PEOE stand out for helping students understand scientific concepts more deeply and ensuring active participation. When the literature is examined, it is seen that many studies have been conducted on the POE method (Bilen et al., 2011; Bilen et al., 2016; Rusçuklu & Özdilek, 2019; Uyanık, 2017; Yıldırım & Maşeroğlu, 2016). These studies reveal that the POE method positively affects students' conceptual understanding, increases their satisfaction with the course, and provides an opportunity to correct misconceptions. However, studies in the field of online education have indicated that teachers face various difficulties. These difficulties include connection problems, internet outages, limited technological opportunities, and difficulties in using digital tools. In addition, teachers stated that they could not fully achieve the outcomes (Kurt & Aydın, 2021; Bakırcı et al., 2021a; Koşar & Bakır, 2022; Bakırcı et al., 2021b). Similarly, students also stated that they experienced various problems in internet connection and communication during the online education process. In addition, they stated that the experiments conducted were insufficient and that more practices should be done (Bakırcı et al., 2023; Batır & Sadi, 2021). In addition, it has been observed that various teaching methods such as the use of web applications, watching experiment videos, conducting experiments in front of a camera, and the question-answer method are used in online science courses (Bostan Sarıoğlan et al., 2020; Kurt & Aydın, 2021; Yunus et al., 2021). Studies show that more studies have been done on the POE method compared to the PEOE method. However, it is seen that research on online education mostly focuses on teacher and student views (Yunus et al., 2021; Kurt & Aydın, 2021; Bostan Sarıoğlan et al., 2020; Bakioğlu & Çevik, 2020; Bakırcı et al., 2021b; Ayaz, 2021; Batır & Sadi, 2021; Bakırcı et al., 2023). This situation reveals that the effect of different teaching methods on students' conceptual understanding levels in online education has not been examined sufficiently. The PEOE method, which includes a structured prediction-explanation-observation-explanation process, has the potential to increase online learning efficiency by supporting students' cognitive processes. Therefore, investigating the effectiveness of the method in the online environment is important both for improving the quality of distance education and for determining effective teaching strategies. In addition, it aims to contribute to this field by experimentally examining the effectiveness of the PEOE method in online environments and to contribute to the literature on its effect on the conceptual understanding of fifth-grade students. In order to address this deficiency, this study aims to examine the effect of the PEOE method on the conceptual understanding levels of fifth-grade middle school students on the subject of friction force in an online education environment.

Method

Research Design

This study was designed using a one-group pretest- posttest experimental design, which is one of the weak experimental designs within quantitative research methods. There is no control group in the research design. The effectiveness of the experiment was evaluated by comparing the data obtained as a result of the measurements between the pretest and posttest, which was used to determine the effect of the experimental intervention.

Participants

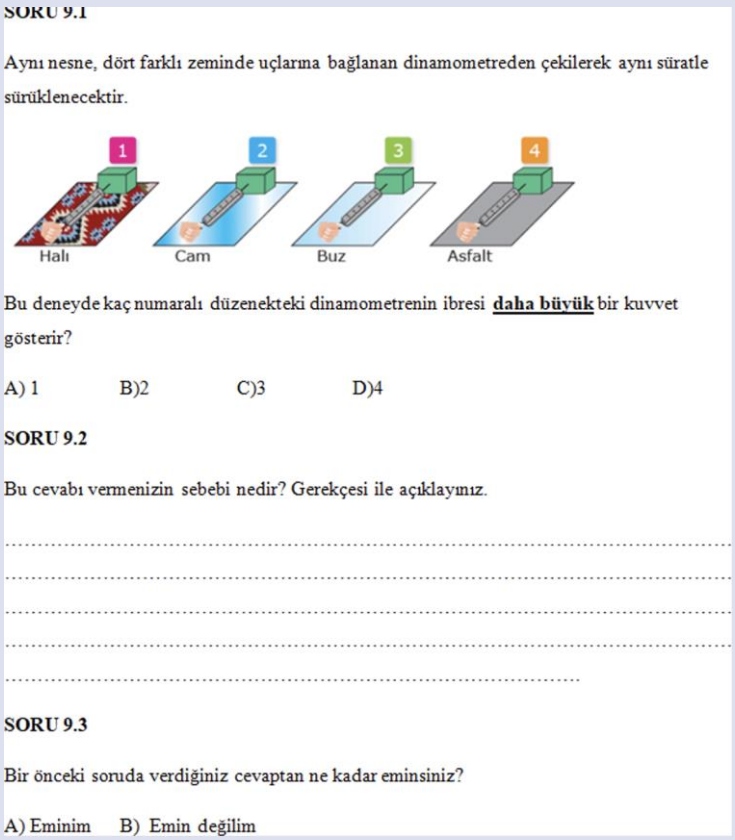
The sample of the study was determined by the easily accessible case sampling method, which is one of the non-random sampling methods. This sampling method provides speed and practicality to the research by selecting a sample that is close, easily accessible, and ready to be studied (Yıldırım & Şimşek, 2016). Sixteen middle school students (9 boys, 7 girls) studying in the 5th grade participated in the study. The application was conducted online at the end of two weeks.

Data Collection Tools

In the study, the concepts of friction force and air-water resistance in the 'Measurement of Force and Friction' unit of the 5th grade Science course were implemented by the first author of the study in accordance with the time and outcomes specified in the science curriculum. The test was applied face-to-face to the students at the beginning and end of the study. In the first stage of the items, there is a multiple-choice conceptual question. In the second stage, students were asked to explain the rationale for their answer to the first question in an open-ended format. In the third stage, students were asked to rate their confidence in their answers in the first two stages. Figure 1 presents a sample test item from the measurement tool. The students were given one lesson hour.

Reliability and Validity Studies of FFCUT

In order to ensure the validity and reliability of the three-stage Friction Force Conceptual Understanding Test (FFCUT), the opinions of two experts in the field of science education, two science teachers and one physics teacher, were obtained and 3 items were removed in line with the suggestions. For validity and reliability analyses, the test was piloted with 5th and 6th grade students in a secondary school in Bursa. Due to the pandemic, the test was administered to 99 students online via Google Form. As a result of the pilot application, 2 more items were removed and the Cronbach's Alpha value of the final version of the conceptual understanding test was calculated as 0.828. This value is above the threshold value of 0.70 and shows that the test is reliable (Özgüven, 2000; Tavşancıl, 2002).


SORU 9.1

Aynı nesne, dört farklı zeminde uçlarına bağlanan dinamometreden çekilerek aynı süratle sürüklenecektir.

Bu deneyde kaç numaralı düzenekteki dinamometrenin ibresi **daha büyük** bir kuvvet gösterir?

A) 1 B)2 C)3 D)4

SORU 9.2

Bu cevabı vermenizin sebebi nedir? Gerekçesi ile açıklayınız.

.....

.....

.....

.....

.....

SORU 9.3

Bir önceki soruda verdiğiniz cevaptan ne kadar eminsiniz?

A) Eminim B) Emin değilim

Figure 1. Three examples of study questions included in the FFCUT

Implementation of the Study

In the study, the concepts of friction force and air-water resistance in the 'Measurement of Force and Friction' unit of the 5th grade Science course were implemented in accordance with the time and outcomes specified in the science curriculum. The implementation was carried out by the first author of the study. Before starting the implementation, students were interviewed face to face. Information about the process was provided, the features of the PEOE method were introduced, and students were asked to complete the FFCUT pre-test during a lesson. Before the online implementation, the PEOE worksheet containing prediction, explanation, observation, explanation, and discussion questions was distributed to the students and they were asked to keep it with them during the lesson. The online education was implemented online for two consecutive weeks; two hours in the first week and two hours in the second week. Students received a link from their partner groups to join the lesson via the Zoom application. Then, students were asked to individually answer open-ended questions about prediction, explanation, observation, and explanation on the worksheet during the online lesson. Finally, at the end of the implementation, students were interviewed face to face and given one class hour to complete the FFCUT post-test.

Data Analysis

Non-parametric tests are used when normal distribution cannot be assumed due to small sample size (Drew et al., 1996). Therefore, considering the small sample size, non-parametric tests were preferred for this study and the data were analysed by Wilcoxon Signed Rank Test using SPSS 22 software.

The FFCUT analysis calculates the total score by adding up the scores of the final codes. The highest possible score is 15, while the lowest is 0. The final codes were evaluated based on the situations presented in Table 1 and analyzed using the SPSS 22 program. The analysis of the final codes for the FFCUT is presented below: The coding process involved four stages. The first three stages were coded using the codes provided in Table 1. In the final stage, a score of '1' was assigned if the correct option was selected in stages 1 and 2, and the option 'I am sure' was selected in stage 3. A score of '0' was assigned if at least one of the incorrect options was selected in stages 1 and 2, or the option 'I am not sure' was selected in stage 3.

To evaluate students' conceptual understanding levels more thoroughly, the number of categories was increased instead of only two categories (correct or incorrect) in the analysis of the second and third stages of the FFCUT (Karataş et al., 2003). Student responses were coded under the categories of scientific knowledge, lack of knowledge, lack of confidence, misconception, misconception false positive and misconception false negative. Nine scores were calculated and evaluated based on the scoring system developed by Arslan et al. (2012) in Table

1.

Table 1. All possible answers of the stages in the test and related categories

Category*	First Phase (Code)	Second Phase (Code)	Third Phase (Code)	Final Code
Scientific Knowledge	True (1)	True (1)	I am sure (1)	1
Lack of Knowledge	True (1)	False (0)	Not sure (0)	0
Lack of Knowledge	False (0)	True (1)	Not sure (0)	0
Lack of Knowledge	False (0)	False (0)	Not sure (0)	0
Lack of Confidence	True (1)	True (1)	Not sure (0)	0
Misconception	False (0)	False (0)	I am sure (1)	0
Misconception False Positive	True (1)	False (0)	I am sure (1)	0
Misconception False Negative	False (0)	True (1)	I am sure (1)	0

• The FFCUT analysis involved the calculation of nine different score types: first stage (FS), first two stages (FTS), being sure (BS), scientific knowledge (SK), lack of knowledge (LK), lack of confidence (LC), misconception (M), misconception false positive (MFP), and misconception false negative (MFN) (Arslan et al., 2012). The following section explains the contents of these score types.

• First Stage (FS): This section displays the frequency and percentage of students who answered the first stage of each question correctly. Students who answered the first stage correctly were coded as '1', while those who did not were coded as '0'.

• First Two Stages (FTS): This section displays the frequency and percentage of students who answered the first two stages of each question correctly. Students who answered both the first and second stages correctly were coded as '1', while those who did not were coded as '0'.

• Being Sure (BS): The data displays the frequency and percentage of students who responded with 'I am sure' in the third stage. Only the third stage was analysed, and students who selected 'I am sure' were coded as '1', while the others were coded as '0'.

• The section on Scientific Knowledge (SK) displays the frequency and percentage of students who answered the first two stages of each question correctly and were confident in their responses. Students who answered correctly in the first and second stages and selected 'I am sure' in the third stage were assigned a code of '1', while the remaining students were assigned a code of '0'. This scoring type includes three different ways of answering, which are categorized as Lack of Knowledge (LK).

- The table displays the frequency and percentage of students who answered correctly in the first stage, incorrectly in the second stage, and selected 'not sure' in the third stage. Students who answered the first stage correctly were assigned a code of '1', while those who answered the second stage incorrectly were assigned a code of '0'. Students who selected 'not sure' in the third stage were also assigned a code of '0'.

- The table displays the frequency and percentage of students who answered the first stage incorrectly, the second stage correctly, and marked 'not sure' for the third stage. - The table displays the frequency and percentage of students who answered the first stage incorrectly, the second stage correctly, and marked 'not sure' for the third stage. The coding used was '0' for incorrect answers in the first stage, '1' for correct answers in the second stage, and '0' for 'not sure' in the third stage.

- The table displays the frequency and percentage of students who answered incorrectly in the first and second stages, and selected 'not sure' in the third stage. Students who answered incorrectly in the first and second stages were coded as '0', while those who selected 'not sure' in the third stage were also coded as '0'.

• Lack of Confidence (LC): It shows the frequency and percentage of students who answered the first two stages of each question correctly and answered "not sure" in the third stage. Students who answered the first stage correctly were coded as "1", those who answered the second stage correctly were coded as "1", and students who chose "not sure" in the third stage were coded as "0".

• Misconception (M): It shows the frequency and percentage of students who answered incorrectly in the first two stages of each question and answered "I am sure" in the third stage. Students who answered the first stage incorrectly were coded as "0", those who answered the second stage incorrectly were coded as "0", and students who chose "I am sure" in the third stage were coded as "1".

• Misconception False Positive (MFP): It shows the frequency and percentage of students who answered correctly in the first stage, incorrectly in the second stage and "I am sure" in the third stage. The students who answered the first stage correctly were coded as "1", the students who answered the second stage incorrectly were coded as "0", and the students who chose "I am sure" in the third stage were coded as "1".

• Misconception False Negative (MFN): It shows the frequency and percentage of students who answered incorrectly in the first stage, correctly in the second stage and "I am sure" in the third stage. The students who answered the first stage incorrectly were coded as "0", the students who answered the second stage correctly were coded as "1" and the students who chose "I am sure" in the third stage were coded as "1".

Results

Statistical Difference in FFCUT Pre-Test-Post-Test Final

In The study investigated the effect of using the PEOE method in online education on conceptual understanding in a class of 16 students. Wilcoxon Signed Ranks test results were analysed to determine if there was a significant difference in the number of correct answers on the conceptual understanding test before and after the application. The results are presented in Table 2. Table 2 shows that the average score obtained from the FFCUT pre-test increased from 10 to 12.18 in the post test. The Wilcoxon Signed Ranks test revealed a statistically significant difference between the number of correct scores achieved by students before and after the application of the study (Z=-2.76, p<0.006). The negative ranks (initial measurement) suggest that the study had a significant effect on conceptual understanding.

Friction Force: Findings on the Effect on Conceptual Understanding

As a result of the analysis of the data, the data obtained from the pre-test and post-test on the subject of frictional force were analyzed together and the percentages of first stage (FS), first two stages (FTS), scientific knowledge (SK), lack of knowledge (LK), lack of confidence (LC), misconception (M), misconception false positive (MFP), misconception false negative (MFN) and being sure (BS) were calculated. The mean percentages of correct answers are presented in Table 3.

When the data in Table 3 are analyzed, while the rate of those who answered the first stage correctly was 65.62% in the pre-test, this rate increased to 75% in the post- test. While the rate of those who answered the first two stages correctly was 30% in the pre-test, this rate increased to 75% in the post-test. increased to 58.33%. While the percentage of students who answered the first two stages correctly and were sure of their answers was 68.87% in the pre-test, this rate increased to 77.77% in the post-test. The percentages of the first stage, first two stages and being sure in the pre-test and post-test are given in Figure 2.

Table 2. FFCUT pretest-posttest Wilcoxon Signed Rank Test results

Post-test-Pre-test	N	Rank Mean	Row Total	z	p
Negative Rows	3	4	12	-2,76	0,006*
Positive Rows	12	9	108		
Non-Difference	1				

*Based on negative rows

Table 3. FFCUT pretest-posttest Wilcoxon Signed Ranks Test result

	FS	FTS	SK	LK	LC	M	MFP	MFN	BS
Pre test	65,62	30	27,5	31,25	12,5	17,96	28,9	6,25	66,87
Post test	75	58,33	50	18,75	15	15,62	12,5	-	77,77

Explanation: First stage (FS), first two stages (FTS), scientific knowledge (SK), lack of knowledge (LK), lack of confidence (LC), misconception (M), misconception false positive (MFP), misconception false negative (MFN) and being sure (BS)

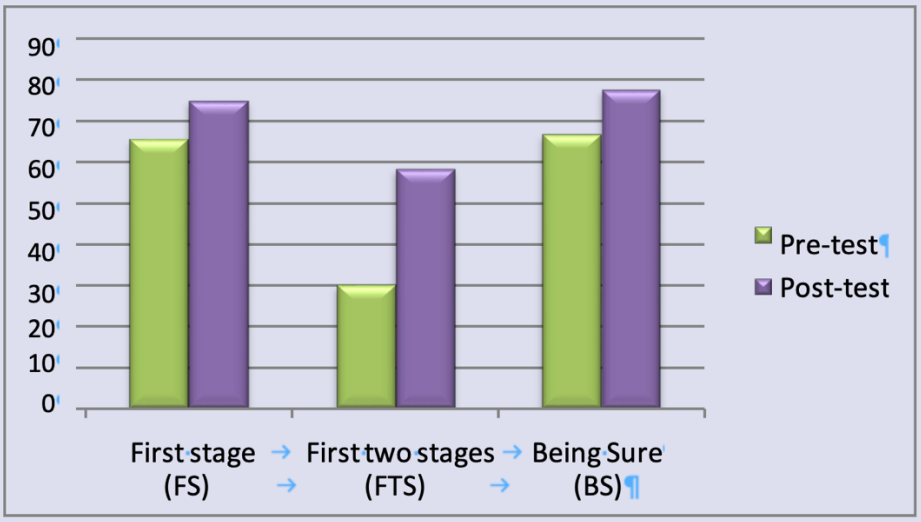


Figure 2. Percentage distribution of the pre-test-post-test first stage, first two stages and being sure in the conceptual understanding test on the subject of friction force

The rate of students' scientific knowledge increased from 27.5% in the pre-test to 50% in the post-test, the rate of lack of knowledge decreased from 31.25% in the pre-test to 18.75% in the post-test, the rate of lack of confidence increased from 12.5% in the pre-test to 15% in the post-test, and the rate of misconceptions decreased from 17.96% in the pre-test to 15.62% in the post-test, While the misconception false positive rave was 28.9% in the pre-test, this rate decreased to 12.5% in the post-test, and while the misconception false negative rate was 6.25% in the pre-test, there were no students with this misconception in the post-test. The percentages of scientific knowledge, lack of knowledge, lack of confidence, misconception, misconception false positive and misconception false negative in the pre-test and post-test are given in Figure 3.

Air and Water Resistance: Findings on the Effect on Conceptual Understanding

As a result of the analysis of the data, the data obtained from the pre-test and post-test on the subject of air and water resistance were analyzed together, and the first stage (FS), the first two stages (FTS), The percentages of scientific knowledge (SK), lack of knowledge (LK), lack of confidence (LC), misconception (M), misconception false positive (MFP), misconception false negative (MFN), and being sure (BS) were calculated. The mean percentages of correct answers are presented in Table 4.

When the data in Table 4 are analyzed, while the rate of those who answered the first stage correctly was 67.5% in the pre-test, this rate increased to 81.25% in the post- test. While the rate of those who answered the first two stages correctly was 27.5% in the pre-test, this rate increased to 57.5% in the post-test. Those who answered the first two stages correctly While the percentage of students who were sure of their answers was 61.25% in the pre-test, this rate increased to 67.5% in the post-test. The first stage, the first two stages and the percentages of being sure in the pre-test and post-test are given in Figure 4.

The rate of students' scientific knowledge increased from 23.75% in the pre-test to 51.25% in the post-test, the rate of lack of knowledge decreased from 30% in the pre- test to 25% in the post-test, and the rate of lack of confidence increased from 9.37% in the pre-test to 10.41% in the post-test, The rate of misconceptions decreased from 12.5% in the pre-test to 8.33% in the post-test, the rate of misconception false positives decreased from 27.45% in the pre-test to 14.06% in the post-test, and the rate of misconception false negatives decreased from 6.25% in the pre-test to 0% in the post- test. The percentages of scientific knowledge, lack of knowledge, lack of confidence, misconception, misconception false positive and misconception false negative in the pre-test and post-test are given in Figure 5.

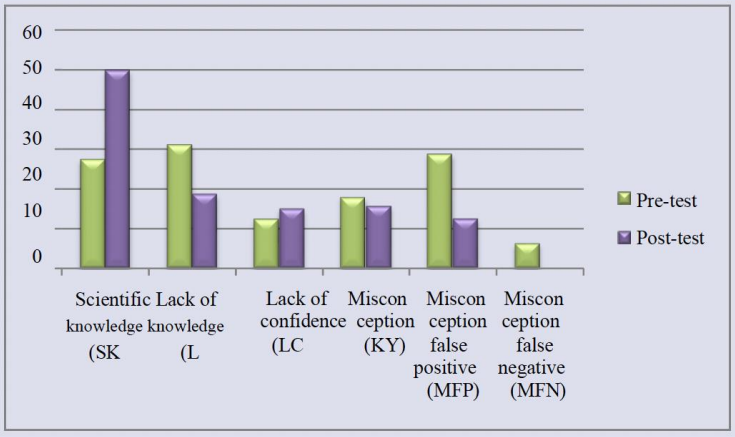


Figure 3. Percentage distribution of scientific knowledge, lack of knowledge, lack of confidence, misconception, false positive misconception, false negative misconception in the pre-test-post-test of friction force subject of conceptual understanding test

Table 4. Percentages of students' answers to the pre-test and post-test questions on air and water resistance in the conceptual understanding test

	FS	FTS	SK	LK	LC	M	MFP	MFN	BS
Pre test	67,5	27,5	23,75	30	9,37	12,5	27,45	6,25	61,25
Post test	81,25	57,5	51,25	25	10,41	8,33	14,06	-	67,5

Explanation: First stage (FS), first two stages (FTS), scientific knowledge (SK), lack of knowledge (LK), lack of confidence (LC), misconception (M), misconception false positive (MFP), misconception false negative (MFN) and being sure (BS)

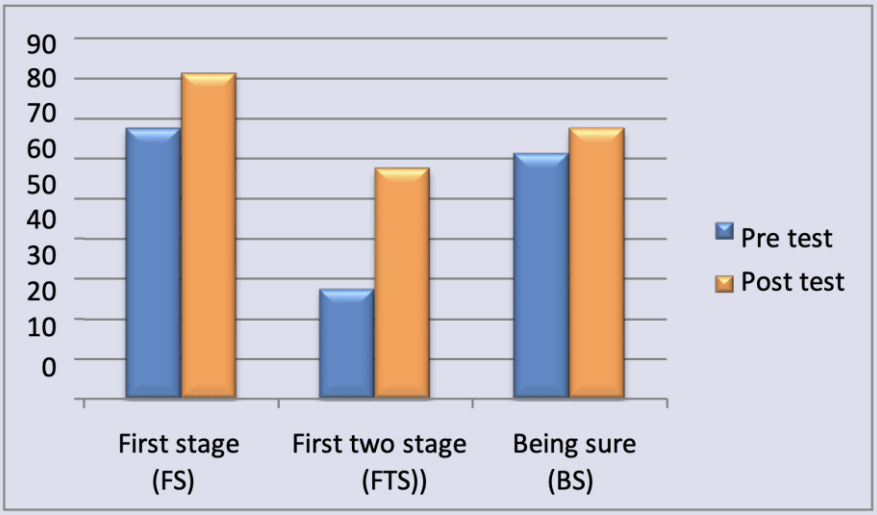


Figure 4. Percentage distribution of pre-test-post-test first stage, first two stages and being sure in the conceptual understanding test on air and water resistance

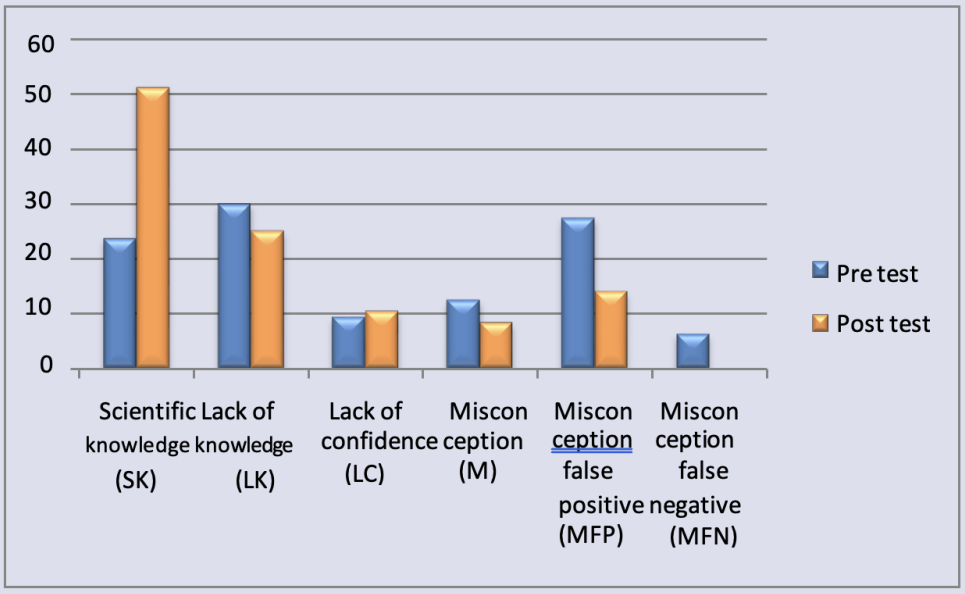


Figure 5. Percentage distribution of pre-test-post-test scientific knowledge, lack of knowledge, lack of confidence, misconception, false positive misconception, false negative misconception in the conceptual understanding test on air and water resistance

Discussion, Conclusion and Recommendations

The data on the effect of online education supported by the PEOE method on conceptual understanding of the subject "Friction Force" in science course was analysed. In this study, the data was obtained with the results related to the pre-test and post-test of FFCUT. The findings were interpreted in the discussion and conclusion sections.

The responses to the FFCUT questions before and after the online PEOE activities were evaluated. The FFCUT was used to determine whether there was a statistical difference between the pre-test and post-test scores.

A statistically significant difference was found between the pre-test and post-test in the total number of correct answers given by the students, favouring the post-test. In the application process of the PEOE method, it was observed that the correct answers given by some students in the prediction explanation increased after the observation phase. This shows that the observation phase of the PEOE method positively affects the conceptual understanding levels. In the study conducted with students in a science course by Kıryak and Özdilek (2019), it was observed that almost all students gave correct answers after the PEOE method. In the study conducted by Tekin (2008), it was concluded that the POE method provides a better understanding of concepts and

supports conceptual understanding. In the study conducted by Güngör and Özkan (2017) with teachers, it was concluded that conducting experiments according to the POE method improves the conceptual understanding level.

The three phases of the FFCUT were evaluated together before and after the online PEOE activities. The pre-test and post-test results were used to determine the students' conceptual understanding of friction force and air-water resistance. Pre-test and post-test results for FFCUT friction force and air-water resistance topics show a decrease in the rate of correct answers given by students as the number of levels increased. Additionally, the rate of correct answers in the first stage of a question was lower than the rate of correct answers in the first two stages of a question, and the rate of correct answers in the first two stages was the lowest. In summary, the proportion of students who demonstrated scientific knowledge in both the pre-test and post-test was lower than the proportion of correct answers in the first two stages combined. It can be inferred that the students possess conceptual knowledge about the subject of friction force, as the first stage of the test assesses this. However, they appear to lack sufficient understanding when it comes to providing reasons for their answers, which is evaluated in the second stage of the test. Köleli (2019) conducted a study which concluded that pre-service science teachers possessed content knowledge but lacked sufficient conceptual understanding of the reasons behind it. This finding was also observed in a study by Arslan et al. (2012) using a three-stage diagnostic test.

When the rates of the first stage and the first two stages of the friction force and air-water resistance questions in the FFCUT were examined, it was found that there was an increase compared to the pre-test period. In addition, there was a significant increase in the percentage of correct answers for all three levels of the FFCUT, i.e. the percentage of scientific knowledge. After the application of the online PEOE method, it was observed that there was an increase in the correct answers given by the students to the multiple-choice questions in the first stage, an increase in the correct reasons given by them to the open-ended questions in the second stage, and an increase in the rate of certainty of the answers given by them in the first two stages in the third stage. In this case, it can be said that the students had a conceptual understanding of friction force and air-water resistance after the application.

If we look at the pre-test and post-test results of the questions on frictional force and air-water resistance in the FFCUT, there was a decrease in the rate of lack of knowledge. In other words, it was observed that some students gave wrong answers to the multiple-choice question in the first stage, to the open-ended question in the second stage, or to the first two stages, i.e. to both multiple-choice and open-ended questions, and at the same time they were not sure of their answers. This can be said that as a result of using the online PEOE method, some students understood the concepts of friction force and air-water resistance, could interpret the reasons, and their confidence in their answers increased.

When we look at the pre-test and post-test results for the friction force and air-water resistance questions in the FFCUT, there was a slight increase in the rate of lack of confidence. In other words, it was observed that some students answered the multiple-choice question correctly in the first stage and the open-ended question correctly in the second stage, but they were not sure about these answers. This can be interpreted to mean that some students understood the concepts of friction force and air-water resistance and were able to interpret the reasons, but their confidence was low as a result of using the online PEOE method.

When analysing the pre-test and post-test results of the friction force and air-water resistance questions in the FFCUT, there was a decrease in the rate of misconceptions, false positive misconceptions and false negative misconceptions. In other words, there was an increase in the rate of correct answers by some students to the multiple-choice questions in the first stage and to the open-ended questions in the second stage. This situation can be interpreted as the application of the online PEOE method having a positive effect on the conceptual understanding of the topics of friction force and air-water resistance.

In reviewing the literature, the findings of this study are similar to other studies on PEOE and POE methods. Özbulut (2023), the online PDEODE teaching method has positive progress and developments in the academic success of science teacher candidates, the deficiencies, errors were corrected by reviewing them in the foreground and information containing new information has been reached. Güngör (2016), the POE method used in teaching biology concepts in a laboratory environment has created significant and positive effects on the academic success of teacher candidates, the development of advanced process characteristics and the permanence of learning. Özkan (2022), in his master's thesis, it has been reached because online science in-depth TGA teaching methods are more effective on academic success than the traditional teaching method. Kıryak and Özdilek (2019) concluded that the application of PEOE teaching methods on acid rain had a positive effect on students' conceptual understanding. Yaman (2012) concluded that computer-based POE activities were effective in developing students' conceptual understanding. Yavuz and Çelik (2013) concluded in their study that the POE method helped students to learn concepts better. Tereci et al. (2018) concluded in their study that the POE method helped students to better understand the concepts related to the topic of magnetism. Akgün et al. (2013) developed activities based on the POE method and found that it significantly changed students' conceptual achievement in the subject of pressure. In their study, Bilen and Aydoğdu (2012) showed that the activities prepared with the laboratory approach based on the POE method were significant on the conceptual achievement of pre-service science teachers. Bilen et al. (2011) showed that the activities prepared based on the POE method had a significant effect on the conceptual achievement of pre-service science

teachers.

According to the results of the study, the following suggestions were made:

The online PEOE method, which has been shown to be effective in developing students' conceptual understanding, can be disseminated especially in teaching abstract science concepts.

Considering that it improves students' prediction and explanation skills, activities based on the PEOE method can be implemented by teachers by supporting them with digital content.

Considering the limitations of this study, the generalizability of the method can be tested by conducting similar studies in different socio-economic groups, different age levels and different subject areas.

Genişletilmiş Özet

Giriş

Aralık 2019'da Çin'in Wuhan kentinde ortaya çıkan Covid-19 virüsü, Türkiye dahil olmak üzere dünya çapında büyük bir etki yaratmıştır. Bu global sağlık krizi, birçok ülkede ekonomi, psikoloji, sosyal yaşam, eğitim ve sağlık gibi hayatın çeşitli yönlerini etkilemiştir. Covid-19 pandemisi, özellikle eğitim alanında önemli değişikliklere yol açmış, okulların ve üniversitelerin askıya alınmasına veya hatta kapanmasına neden olmuştur. Bu dönemde, Türkiye'de Eğitim ve Bilişim Ağı (EBA), Google Meet, Skype ve Zoom gibi platformlar aracılığıyla eğitimin devamlılığının kesintisiz bir şekilde sürdürülmesi sağlanmıştır (Ayaz, 2021).

Çevrimiçi eğitim sürecinde yaşanan zorluklar, öğretmen ve öğrenci arasındaki iletişimi güçleştirerek, bilimsel kavramların tam olarak kavranmasını engellemiştir. Fiziksel sınıf ortamının eksikliği, öğrencilerin derslere aktif katılımını zorlaştırmıştır ve bu durum, öğretmenlerden öğrencilere daha etkin bir şekilde yol göstermeleri beklentisini doğurmuştur. Yapılan araştırmalar, çevrimiçi eğitimde en sık kullanılan öğretim yöntemlerinin soru-cevap, anlatım ve problem çözme olduğunu ortaya koymuştur (Bakioğlu ve Çevik, 2020). Ancak, bu yöntemlerin öğrencilerin kavramsal anlamalarında yetersiz kaldığı belirlenmiştir (Başaran vd., 2020). Bu bağlamda, çevrimiçi eğitimde kavramsal anlamayı destekleyen öğretim tekniklerinin kullanılmasının önemi büyüktür. Çeşitli yöntemler arasında, Tahmin-Gözlem-Açıklama (TGA) metodunun öğrencilerin kavramsal öğrenmelerine katkıda bulunduğu gözlemlenmiştir (Chen, 2022).

TGA yöntemi, öğrencilerin derse aktif olarak katılmalarını, herhangi bir konu ya da kavramı sorgulamalarını ve öğretim sürecinde aktif rol almalarını sağlayan, böylece kavramsal değişimi kolaylaştıran etkili bir öğretim tekniğidir (White ve Gunstone, 1992). TGA yöntemi, Kıryak (2013) tarafından tahmin ve gözlem aşamaları arasında bir açıklama aşaması içerecek şekilde değiştirilmiştir. Bu değiştirilmiş versiyon Tahmin- Açıklama-Gözlem-Açıklama (TAGA) yöntemi olarak bilinmektedir. TAGA yöntemi, bir olayın veya deneyin sonucunu tahmin etmeyi, tahminleri açıklamayı, gerçek olayları gözlemlemeyi ve ardından tahminler ile gözlemler arasındaki çelişkileri açıklamayı içerir (Coştu vd., 2012).

TAGA yöntemi, kavramsal anlamayı sağlamak için etkili bir yaklaşımdır. Bu öğrenme yöntemi, daha sonra diğer ortamlara uygulanabilecek ve problemleri çözmek için kullanılabilecek kavramlar arasındaki ayrımları, benzerlikleri ve bağlantıları tanımlamayı içerir (Sinan, 2007). Ön bilgiler bu süreçte çok önemli bir rol oynar. Öğrencilerin ön bilgileri bilimsel olarak doğruysa, yeni bilgilerin edinilmesine yardımcı olabilir. Eksik ya da yanlış bilgi ise yeni kavramların öğrenilmesini engelleyebilir (Ergun, 2017). Bu nedenle, öğrencilerin kavramsal bilgi edinmelerine öncelik vermek çok önemlidir (Malatyalı ve Yılmaz, 2010). Ayrıca TAGA yöntemi, öğrencileri kendilerine sunulan kavram ve olayların altında yatan nedenleri sorgulamaya teşvik eder. Sonuç olarak, öğrencilerin kavramsal anlamalarını geliştiren ve kavramsal değişimi kolaylaştıran bir yöntem olarak yaygın kabul görmektedir (Köseoğlu vd., 2002).

Alanyazın incelendiğinde TGA yöntemi ile ilgili çok sayıda çalışma yapıldığı görülmektedir (Bilen vd., 2011; Bilen vd., 2016; Kıryak ve Özdilek, 2019; Rusçuklu ve Özdilek, 2019; Uyanık, 2017; Yıldırım ve Maşeroğlu, 2016). Bu araştırmalar, TGA yönteminin öğrencilerin kavramsal anlayışlarını olumlu yönde etkilediğini, derslerden aldıkları memnuniyeti artırdığını ve kavramsal yanılgıları düzeltmeleri için fırsatlar sağladığını ortaya koymaktadır. Çevrimiçi eğitimle ilgili yapılan araştırmalar genellikle öğretmen ve öğrenci görüşlerine odaklanmıştır, ancak çevrimiçi ortamda TAGA önteminin etkinliği üzerine detaylı bir araştırma bulunmamaktadır.

Dolayısıyla bu çalışmanın amacı, çevrimiçi eğitimde TAGA yönteminin, ortaokul beşinci sınıf öğrencilerinin sürtünme kuvveti konusundaki kavramsal anlama düzeylerine etkisini incelemeyi hedeflemektedir.

Yöntem

Bu çalışma, nicel araştırma yöntemleri içinde yer alan zayıf deneysel desenlerden tek gruplu ön test-son test deneysel deseni kullanılarak tasarlanmıştır. Araştırma deseninde kontrol grubu yer almamaktadır. Deneyin etkinliği, ön test ve son test arasında yapılan ölçümler sonucunda elde edilen verilerin karşılaştırılmasıyla değerlendirilmiştir, bu durum deneysel müdahalenin etkisini belirlemek için kullanılmıştır.

Araştırmanın örneklemi, seçkisiz olmayan örnekleme türlerinden kolay ulaşılabilir durum örneklemesi yöntemiyle belirlenmiştir. Araştırmaya, 5. sınıfta öğrenim gören 16 ortaokul öğrencisi (9 erkek, 7 kız) katılmıştır. Uygulama iki hafta sonunda çevrimiçi olarak gerçekleştirilmiştir. Çalışmada veri toplama aracı olarak Sürtünme Kuvveti Kavramsal Anlama Testi (SKKAT) kullanılmıştır.

Tartışma, Sonuç ve Öneriler

PEOE yöntemi ile desteklenen çevrimiçi eğitimin fen bilimleri dersinde "Sürtünme Kuvveti" konusunun kavramsal olarak anlaşılmasına etkisine ilişkin veriler analiz edilmiştir. Bu çalışmada veriler, SKKAT 'nin ön test ve son testine ilişkin sonuçlarla elde edilmiştir. Elde edilen bulgular tartışma ve

sonuç bölümlerinde yorumlanmıştır.

Çevrimiçi PEOE etkinliklerinden önce ve sonra SKKAT sorularına verilen yanıtlar değerlendirilmiştir. SKKAT, ön test ve son test puanları arasında istatistiksel bir fark olup olmadığını belirlemek için kullanılmıştır.

TAGA'nın çevrimiçi etkinlikleri sırasında ve sonrasında uygulanan SKKAT'ın üç aşamalı değerlendirmesi incelendiğinde, aşama sayısı arttıkça öğrencilerin doğru cevap verme oranlarının düştüğü görülmektedir. Testin ilk aşamasında öğrencilerin kavramsal bilgileri test edilirken, ikinci aşamasında ise öğrencilerin vermiş oldukları yanıtların gerekçeleri sorgulamaktadır. Bu durum, öğrencilerin sürtünme kuvveti gibi konularda temel kavramları anladıklarını, ancak bu kavramların altında yatan nedenleri açıklama konusunda yeterli kavramsal anlayışa sahip olmadıklarını göstermektedir.

SKKAT'ın, ilk aşama ve ilk iki aşama oranlarına bakıldığında uygulama öncesine göre artış olduğu görülmüştür. Ayrıca öğrencilerin SKKAT'de üç aşamasına da doğru cevap verme oranları yani bilimsel bilgi oranlarında belirgin bir artış gözlenmiştir. Bu sonuçlar öğrencilerin uygulama sonrasında sürtünme kuvveti ve hava-su direnci konusu ile ilgili kavramsal anlamaya sahip olduklarını söyleyebilir.

SKKAT'ın ön test ve son test sonuçları karşılaştırıldığında, öğrencilerin bilgi eksikliklerinde bir azalma gözlemlenmiştir. Bu durum, çevrimiçi TAGA yönteminin uygulanmasının ardından bazı öğrencilerin sürtünme kuvveti ve hava-su direnci gibi kavramları anlamalarının yanı sıra, bu konuların nedenlerini yorumlayabilmeleri ve verdikleri cevaplara olan güvenlerinin artışını göstermektedir.

SKKAT, ön test- son test sonuçlarına bakıldığında güven eksikliği oranında ufak bir artış olmuştur. Bu durum çevrimiçi TAGA yönteminin uygulaması sonucunda bazı öğrencilerin sürtünme kuvveti ve hava-su direnci kavramlarını anladığı ve nedenlerini yorum yapabildiği fakat kendilerine olan güvenlerinin az olduğu şeklinde yorum yapılabilir.

SKKAT'ın ön ve son test sonuçları incelendiğinde, kavram yanılgısı, yanlış pozitif oranı ve yanlış negatif oranında bir düşüş görülmüştür. Bu veriler, çevrimiçi TAGA yönteminin uygulanmasının sürtünme kuvveti ve hava-su direnci gibi konularda öğrencilerin kavramsal anlayışlarını olumlu bir şekilde etkilediğini göstermektedir. Bu sonuç, yöntemin bu konulardaki kavramsal yanılgıları azalttığını ve öğrencilerin daha doğru anlamalar kazandığını düşündürmektedir.

Bu araştırmanın sonuçları, literatürde TAGA ve TGA yöntemleri hakkında yapılan diğer çalışmalarla uyumlu olduğu görülmektedir. Kıryak ve Özdilek'in 2019 yılında gerçekleştirdiği araştırma, asit yağmurları konusunda TAGA öğretim yönteminin öğrencilerin kavramsal anlayışını olumlu yönde etkilediğini ortaya koymuştur. Benzer şekilde, Yaman'ın 2012'de yaptığı çalışma, bilgisayara dayalı TGA etkinliklerinin öğrencilerin kavramsal anlayışlarının gelişimine katkıda bulunduğunu belirtmiştir. Ayrıca, Yavuz ve Çelik'in 2013 tarihli araştırması, öğrencilerin kavramları daha etkin öğrenmelerinde TGA yönteminin önemli bir rol oynadığını göstermiştir. Bu çalışmalar, TAGA ve TGA yöntemlerinin öğrencilerin kavramsal anlamalarını geliştirmede etkili olduğunu desteklemektedir.

Araştırmada elde edilen sonuçlar doğrultusunda şu önerilerde bulunulmuştur:

- Çevrimiçi TAGA yönteminin fen bilimleri dersinin farklı konularında uygulanması önerilebilir.
- Çevrimiçi TAGA yönteminin öğretim uygulaması sırasında kullanılabilecek teknoloji destekli etkinlikler geliştirilebilir.

Etik Kurul İzni

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Araştırmanın Etik Taahhüt Metni

Yapılan bu çalışmada bilimsel, etik ve alıntı kurallarına uyulduğu; toplanan veriler üzerinde herhangi bir tahrifatın yapılmadığı, karşılaşılacak tüm etik ihlallerde "Cumhuriyet Uluslararası Eğitim Dergisi ve Editörünün" hiçbir sorumluluğunun olmadığı, tüm sorumluluğun Sorumlu Yazara ait olduğu ve bu çalışmanın herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiş olduğu sorumlu yazar tarafından taahhüt edilmiştir.

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