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The Effect of POE Method with PhET Simulation on Primary School Student's Science Attitudes and Success: Greenhouse Effect

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Abstract
In this research, Purpose is to eliminate primary school student's delusions about concept of greenhouse effect and to study its effect on student's attitudes towards science. In the research, quasi-experimental study with pre-post control group has been used. The research was performed with 34 primary school students in the state located in southwest part of Turkey. The experimental group consists of 18 students and the control group consists of 16 students. While POE method supported with PhET simulations is used in the experimental group, traditional teaching method is implemented in control group. In the research, greenhouse gas concept and science attitude scale as data collection tool have been used. Data obtained from the research has been analyzed with SPSS program. According to the findings from the research, Students have had much more information about greenhouse gas thanks to POE method supported by PhET. Moreover, POE method supported by PhET has positive effect on students' attitudes towards science.

Keywords: Greenhouse Effects, PhET, POE, Primary School Students

1. Introduction

Science is a kind of science that researches the situations happening in the nature, explains it reasons and has prediction for future (Kaptan, 1998). It can be defined as the purpose to enable students to be aware of their environment, to try explaining, to observe nature and understand the unobserved cases. (Çepni,2014.) Science lesson includes so many abstract concept and it is considered as complicated lesson for students unless there are no practical applications. Concordantly, with the development of computer Technologies, Applications that are developed in computer environment can be more frequently seen. It can be said that simulations are one of them. Experiments that can't be performed in the class and simulations that teach dangerous are one of the minor examples of realistic models. Simulations contributes so much things to both students and teachers in case of lack of well-qualified laboratory, lack of enough time and lack of teachers' inadequate information and abilities about the subject. Because of that fact that simulations allow users to interact with each other, students can take part actively in the process and correct their mistakes thanks to the feedbacks. Simulations includes not steady

situations but variable ones and offer different outputs in terms of users' behaviours. With the help of simulations, students save on time and moreover these programs serve students with different learning abilities as productive tools (Hegarthy, 2004.) Simulations prepare easy learning enviroment for students by simplifying complicated situations. Well prepared simulations simplify complicated situations and findings, making them more understandable for students without explanations (Minaslı, 2009.) Simulation thanks to its fidelity feature, offers opportunity for realistic experiencing for students. (Maran, & Glavin, 2003.) When experiments in science lesson considered, simulations provide important advantages. Thanks to simulations, safe processing of lessons can be expressed as watching slowly the event instantly happening, providing opportunity of observing, simplifying complicated situations. Physics Education Technology is a Project that consists of initials (PhET) and developed by Colorado Boulder University in 2002 (PhET, 2016.) PhET is an application that offers simulations in the fields such as Math, Physic, Chemistry, Biology and Geography. PheT is a education source that can be reached by anybody. PheT was founded with the aim of changing and improving learning habits in the world. Thanks to PhET, students can practice what they learn. It enables students to involve in scientific discovery, design experiment, use evidence and to develop conceptional understanding, make connection with daily life and see science as accesible and enjoyable tool. It has been observed that Students who use PhET can learn concepts easier and have higher motivation than the ones who don't PhET. In our rapidly developing and changing world, Education systems also need to constantly improve themselves in parallel with these developments. In this direction, curricula in many countries undergo changes in line with the needs of the day. (İyibil & Sağlam-Arslan, 2010). Global warming and climate change caused by this situation are the leading environmental problems that have been increasing in recent years. As a result of the changes, we see that these topics, which are of interest to everyone, are included in Science Curriculum in Turkey in 2018.When the specific objectives of the program are examined, "Greenhouse effect is explained" within the framework of "Discuss the causes and possible consequences of global climate changes" at the 8th grade level, Subjects and concepts are included within the framework of the achievements of "The impact of environmental problems on the future of the world and human life in the context of global climate change is questioned". (Ministry of National Education [MoNE], 2018). When the achievements of the science course are examined, it is seen that it is tried to gain basic knowledge about the environment, to understand the environment-human relationship, to create awareness and awareness against natural and economic resources and environmental problems. Student-centered methods should be preferred in teaching subjects such as global warming, greenhouse gases, measurement of carbon footprints, which are not possible for students to observe directly. In this study, POE method based on the constructivist approach which is one of the student-centered methods, was used. POE method includes the steps of making predictions, supporting predictions, comparing and explaining predictions and observations, taking into account the students' prior knowledge.POE method was introduced by White and Gunstone (1992). In the POE method, students are compared with experimental situations, they are asked to make predictions about the experiment, then they are expected to make observations and then to explain by comparing their predictions with their observations. While it is effective only in its own field at first, it becomes a global problem over time. The most important of these global problems is the greenhouse effect. Reducing the negative effects of global warming, combating global warming and putting forward solutions is possible by taking measures at international and national level, especially by raising awareness of people on this issue.Education is the most basic way of raising people's awareness on this issue.When it is considered as a global problem, it should be noted that it is important to introduce subjects such as global warming, greenhouse gas, and carbon footprint to individuals at a younger age. This subject should be conveyed to students, especially in science courses at different levels of education. In this study, it is aimed to investigate the effect of PhET simulated POE method on the detection and elimination of the misconceptions of 8th grade secondary school students about the greenhouse effect.The second aim of the study is to examine the effect of PhET simulated POE method on students' attitudes towards science.

1.1 Research Questions

What are the misconceptions of 8th grade students about the greenhouse effect?
What is the effect of PhET simulated POE method on eliminating 8th grade students' misconceptions about the greenhouse effect?
What is the effect of PhET simulated POE method on 8th grade students' attitudes towards science?

2. Method

This study was conducted using a quasi-experimental research model. The difference that distinguishes this method from the full experimental method is that the sample cannot be created by random assignment. The quasi-experimental methods, which are widely used in educational research after full experimental studies, can be used despite some control difficulties, but with the caution of consideration of their limitations. (Cohen, & Mannion, 1998). While the PhET simulation POE method was applied to the experimental group, courses in accordance with the science curriculum were taught to the control group. The appearance of the quasi-experimental design in the study is presented in Table 1.

Table 1: The Appearance of the semi-experimental model in the research

Groups	Pre-test	Application	Post-test
Experiment	Success Test Attitude Scale	PhET simulated POE	Success Test Attitude Scale
Control	Success Test Attitude Scale	Traditional Teaching Method	Success Test Attitude Scale

2.1 Working group

The study was carried out with the participation of 8th grade students studying in a public secondary school in the southeast of Turkey in the 2021-2022 academic year. The groups participating in the study consist of pre-formed classes in the form of random distribution by the school administration. Total of 34 students, 18 in the experimental group and 16 in the control group, participated in the study.

2.2 Data collection tool

The Greenhouse Effect Concept Test developed by Bakırcı, &Yıldırım (2017) and the attitude scale towards science belonging to Geban, Ertepınar, Yılmaz, Altın, & Şahpaz (1994) were used as data collection tools in the research. The greenhouse effect concept test consists of 5 two-stage questions. The validity of the test was established with the opinions of two science educators and two science teachers.
Sample items from the test are presented below:

1- Which of the following occurs as a result of the greenhouse effect? Please explain.
A- People are poisoned by food
B- No more desert areas are formed.
C- As a result of the greenhouse effect, the temperatures on the earth's surface increase.
D- There will be more earthquakes in the world.

Explain:.....

3- Which of the following reduces the greenhouse effect? Please explain.
A- If power plants using nuclear energy are installed instead of coal-using power plants, the greenhouse effect will decrease.
B- Reducing the number of nuclear bombs reduces the greenhouse effect.
C- Reducing the use of spray gases (Chlorofluorocarbon cfc) and sprays reduces the greenhouse effect.
D- Using unleaded gasoline will reduce the greenhouse effect.

Explain: ……..
The highest score that can be obtained from the concept test is twenty and the lowest score is zero. In the study, data on students' attitudes towards the Science course was obtained with "Science Course Attitude Scale" developed by Geban et al. (1994). The Cronbach's Alpha reliability coefficient of the scale is 0.83.

2.3 Data analysis

In order to determine the normality of the data obtained from the concept test and attitude test, the kurtosis-skewness coefficients were examined. When Pallant (2001), the Skewness and Kurtosis values are between +2 and -2, the scores show a normal distribution.Accordingly, it was accepted that the concept achievement test showed a normal distribution and the groups were compared with the t-test without parametric tests. When the data of the attitude scale towards science were examined, it was determined that it did not show a normal distribution. (Table 3.) Therefore, it was decided to apply Wilcoxon Signed Ranks test, which is one of the nonparametric tests, for the pre- and post-test scores of the experimental and control groups. In the study, the frequency and percentages of the responses of the study group to the achievement test were also examined.

Table 2: Greenhouse effect concept test evaluation and scoring criteria

Evaluation Level	Score
Correct Answer – Correct Reason(CA-CR)	4
Correct Answer –Partly Correct Answer (CA-PCA)	3
Wrong Answer –Correct Reason (WA- CR)	2
Correct Answer –Wrong Reason (CA - WR)	1
Wrong Answer –Wrong Reason (WA-WR)	0

2.4 Implementation

While the activities prepared according to the POE method using PhET simulations were applied to the experimental group, the course was taught to the control group in line with the achievements in the MoNE curriculum. The application was carried out with the Experimental Group in 2 class hours for 6 weeks. Before starting the application, pre-tests were applied to the experimental and control groups. Afterwards, the students were given the necessary information about the Prediction-Observe-Explain (POE) method. Sample applications were carried out so that students could better understand the POE method. PhET simulations were introduced to the students and they were asked to practice on any subject they wanted to get to know PhET simulations better. Theoretical information about the gases that cause the greenhouse effect and the environmental problems experienced as a result of the greenhouse effect is given. In practice, students are divided into groups of 3-4 people. In the experimental group in which the POE strategy was applied, the estimation phase, the observation phase and the explanation phase were followed in order. The question “How does greenhouse gas affect our world?” was directed to the students. Students were asked to write their answers to this question in the estimation section of the POE worksheet. At this stage, students' prior knowledge and misconceptions were revealed. In the second stage, the students followed the PhET simulation and wrote their observations in the observation section. PhET simulations were followed to show how the Earth's temperature increased over the years during the observation phase. In the simulation, the density of greenhouse gases was changed in line with the wishes of the students and the change in the temperature value of the world was observed. Students are asked to make predictions about the causes or consequences of this situation, together with the reasons, and to take notes of their predictions. In addition, pre-industrial and post-industrial greenhouse gas density and, accordingly, the temperature of the world were also observed in the simulation. In addition, it has been shown to students in the simulation that the temperature of the world will be very low when the density of greenhouse gases is reset (Physics Education Technology Project, 2021). Hereby, it is aimed to make students realize that greenhouse gases are an event that provides the temperature balance in the atmosphere and to make them think about what can happen if the density of these gases increases or decreases with the effect of human activities. In the last stage, the explanation stage, the students analyzed their predictions and observations and discussed whether their predictions were correct or not, and if not, why they made a wrong prediction. At this stage, the students were asked to compare the predictions and observations and write them with the reasons of whether they were correct or not. The link and photo of the greenhouse effect simulation on my PhET platform are given below.
https://phet.colorado.edu/tr/

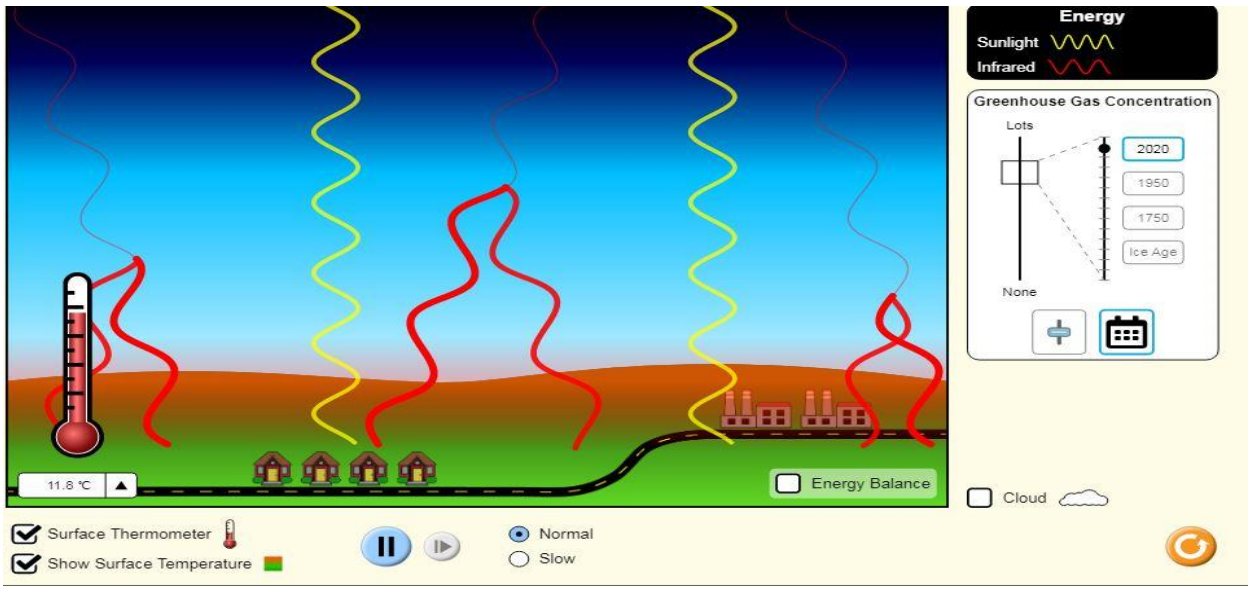

Figure 1: PhET greenhouse effect simulation

In the control group, the lessons were taught with the activities specified in the textbook according to the program prepared by the Ministry of National Education.

3. Findings

In the study, descriptive statistical findings related to the experimental and control groups were examined (Table 3).

Table 3: Descriptive statistics of achievement and attitude scales

		Achievement		Attitudes	
		Pretest	Posttest	Pretest	Posttest
Experimental	M	8.63	19.31	40.9	51.7
	Median	8.00	19.0	43.5	54.00
	Variance	7.29	7.94	75.89	31.82
	Min.	5.00	14.0	26.0	34.0
	Max.	14.00	24.0	54.0	58.0
	Skewness	.761	-.386	-.395	-1.94
	Kurtosis	-.267	-.693	-1.030	3.780
Control	M	8.45	14.81	30.7	34.50
	Median	8.50	16.00	31.0	35.50
	Variance	8.26	37.75	64.66	82.73
	Min.	4.00	4.00	16.00	14.0
	Max.	16.00	23.00	48.00	52.0
	Skewness	.422	-.504	.336	-.413
	Kurtosis	.822	-1.141	.189	.027

Looking at the descriptive statistics of academic achievement and attitude scale in Table 3, the experimental group pre-test skewness (.761) and kurtosis (-.267), post-test skewness (-.386) and kurtosis (-.693) in the achievement test; control group pretest skewness (.422) and kurtosis (.822), posttest skewness (-.504) and kurtosis (-1.141); In the attitude scale, the experimental group pre-test skewness (-.395) and kurtosis (-1.030), the post-test skewness(-1.94 and kurtosis (3.780) and the control group pre-test skewness (.336) and kurtosis (.189) in the attitude scale, The final test skewness (-.413) and kurtosis (.027) values were calculated.

After it was determined that the academic achievement scores of the study showed a normal distribution, the pre-test achievement scores of the experimental and control groups were examined with the independent samples t-test.

Table 4: Independent t-test results of academic achievement pretest scores' for comparison and experimental groups

	Group	n	M	SD	t	p
Academic achievement	Experimental	18	8.63	2.70	.216	.830
	Control	16	8.45	2.87		

According to the results of the independent sample t-test, there was no significant difference between the academic achievement experimental group (M=8.63, SD=2.7) and the control group (M=8.45, sd=2.87) pretests (t(32)=.216, p=.830). Accordingly, it can be deduced that there is no difference between the groups' prior knowledge before starting the application. Since there is no statistically significant difference between the pre-test scores, it can be said that the greenhouse gas conceptual understandings of the experimental and control groups were similar before the research.

An independent t-test was conducted to examine the effect of PhET-simulated POE method on 8th grade students' misconceptions about the greenhouse effect. The independent t-test results related to the difference between the achievement test post-test scores of the experimental and control group students are presented in Table 5.

Table 5: Independent samples t-test of academic achievement post-test for comparison and experimental groups

	Group	n	M	SD	t	p
Academic achievement	Experimental	18	19.31	2.81	3.122	.003
	Control	16	14.81	6.14		

Considering the obtained values, the average of the experimental group's post-test achievement score was 19.31 (sd=2.81), and the control group's post-test achievement average was 14.81 (sd=6.14). A statistically significant difference at the level of 0.05 was found between the mean success of the experimental and control groups (t(32)=3.122, p<0.05).

The frequencies and percentages of the answers given by the students participating in the study to the concept test pre-test and post-test were calculated (Table 6).

Table 6: Frequency and percentage of concept test answers of the study group

Questions	Evaluation	Pre- test		Post- test		The examples of students explanations
	Levels	f	%	f	%	
1	CA-CR	1	2.94	9	26.47	When there is a greenhouse effect, not all of the rays from the sun are reflected and the world gets warmer.
	CA-PCR	8	23.52	3	8.82	With the greenhouse effect, the temperature increases between the layers and the world warms up.
	WA-CR	-	-	-	-	-
	CA-WR	16	47.05	22	64.7	A greenhouse is formed because the earth's rays stay on the surface.
	WA-WR	9	26.47	-	-	Because the causes of earthquakes, our world begins to disappear gradually.
2	CA-CR	5	14.7	1	2.94	Spray gases keep gases in the air. As a result,

						the greenhouse effect increases even more.
	CA-PCR	2	5.88	11	32.35	Sprays gas the world, causing it to become more greenhouses.
	WA-CR	1	2.94	1	2.94	Unleaded gasoline is a substance that harms the world.
	CA-WR	15	44.11	16	47.05	Our use of harmful gases causes depletion of the ozone layer.
	WA-WR	11	32.35	5	14.7	All the gases we use are harmful.
3	CA-CR	1	2.94	6	17.64	Carbon dioxide gas is one of the greenhouse gases. Therefore, it increases the greenhouse effect.
	CA-PCR	16	47.05	9	26.47	The amount of carbon dioxide in the air should be reduced.
	WA-CR	1	2.94	-	-	As the greenhouse effect increases, the world gets warmer.
	CA-WR	18	52.94	14	41.17	As the amount of carbon dioxide in the ozone layer reflects the sun's rays, the greenhouse effect also increases.
	WA-WR	8	23.5	5	14.7	The greenhouse effect does not cause the melting of glaciers.
4	CA-CR	-	-	11	32.35	Methane gas from swamps and rice fields is a greenhouse gas that causes the greenhouse effect.
	CA-PCR	-	-	4	11.76	The methane gas produced in the garbage causes the greenhouse effect.
	WA-CR	1	2.94	1	2.94	As methane gas accumulates in the ozone layer, this also increases the greenhouse effect.
	CA-WR	-	-	7	20.58	The increase in harmful gases in the air increases the greenhouse effect.
	WA-WR	33	97.05	11	32.35	The release of harmful gases is the cause of ozone depletion.
5	CA-CR	5	14.7	6	17.64	It causes greenhouse effect as methane gas comes out from garbage and rotten waste.
	CA-PCR	4	11.76	6	17.64	Carbon dioxide gas causes the world's temperature to increase and the greenhouse effect.
	WA-CR	-	-	-	-	-
	CA-WR	20	58.8	15	44.11	The amount of garbage produced by humans is the result of the greenhouse effect.
	WA-WR	5	14.7	7	20.58	Unleaded gasoline affects less greenhouse effect.

When Table 6 is examined, it is seen that 2.94% of the answers given by the students to the first question of the Greenhouse Effect Stall Test in the pre-test and 26.4% in the post-test were at the CA-CR level, while the rates for the CA-PCR level were 23.5% and 8.8%, respectively. While the rates of answers placed at the CA-WR level were determined as 47% in the pre-test and 64.7% in the post-test, these rates were found to be 26.4%, respectively, for the WA-WR category. From the answers given by the students to the second question, it is seen that the level of CA-CR in the pre-test is 14.7%, in the post-test it is 2.9%. The rates for CA-PCRlevel were determined as 5.8% and 32.3%, respectively. While the rates of student answers at the CA-WRlevel were 44.1% in the pre-test and 47% in the post-test, these rates were 32.3% and 14%, respectively, at the WA-WRlevel. When the answers given by the students to the third question of the Greenhouse Effect Stall Test were examined; While 2.94% in the pre-test and 17.6% in the post-test were at the CA-CR level, these rates were 47% and

26.4%, respectively, for the CA-PCRlevel. The ratios of student answers at the CA-WRlevel; While it was determined as 52.94% in the pre-test and 41.1% in the post-test, these rates were found to be 23.5% and 14.7%, respectively, for the WA-WRlevel. While the answers given by the students to the fourth question were found to be at CA-CR level of 32.3% in the post-test, there was no student answer in the pre-test for the CA-PCRlevel, it was found to be 11.7% in the post-test. While 2.94% of the students' answers in the pre-test and 2.94% in the post-test were at the WA-WRlevel, while there was no student response in the pre-test for the CA-WRlevel, this rate was 20.58% in the post-test. It is seen that these rates are 97% and 32.3%, respectively, for the WA-WRlevel. While the percentages of the students' answers to the fifth question of the stall test were at CA-CR level, 14.7% in the pre-test and 17.6% in the post-test, these rates were found to be 11.7% and 17.6%, respectively, for the CA-PCRlevel. It is seen that the rates of student answers for the CA-WRlevel of the students are 5.8% and 44.1%, respectively. The rates of student answers at the WA-WRlevel were determined as 14.7% in the pre-test and 20.58% in the post-test.

The findings related to the problem “What is the effect of the PhET supported POE method of the research on the attitudes of 8th grade students towards science?” are shown in Table 7 and Table 8.

Table 7: Descriptive statistics analysis attitude tests’ results

		Group	n	M	ss	Min.	Max.
Attitude	Pretest	Experimental	18	40.9	8.7	26	54
		Control	16	30.7	8.0	16	48
	Post test	Experimental	18	51.7	5.6	34	58
		Control	16	34.5	9.0	14	52

When the results of the descriptive statistical analysis of the data obtained from the research are examined the control group pre-test score was 30.7 and posttest score 34.5; the experimental group's pretest score was 40.9 and post-test score 51.7 (Table 7).

In the study, the pre-test and post-test attitude scores of the experimental and control groups were analyzed with the Wilcoxon Signed Ranks test (Table 8).

Table 8: Findings regarding the differences between the pretest-posttest scores of the attitude test

Group	Posttest-pretest	N	Mean rank	Sum of Ranks	z	p
Experimental	Negative order	4	7.13	28.5	-3.183	.001
	Positive order	14	12.47	224.5		
	Equal	0				
Control	Negative order	6	9.06	81.5	-1.463	.144
	Positive order	10	13.19	171.5		
	Equal	0				

According to the results of Wilcoxon Signed Ranks test, a significant difference was found between the experimental groups' pre- and post-tests ($z=-3.183$, $p<0.05$). When the mean rank and rank totals of the experimental group are examined in Table 8, it is seen that this difference is in favor of the positive ranks, that is, the post-test score. According to these results, it can be said that the PhET simulated POE method increased in favor of the post-test in the students' attitudes towards science during the application process in the experimental group. In the control group, there was no significant difference between the pre-test and post-test averages ($z=-1.463$; $p>0.05$).

4.Results and Discussion

The aim of this study is to investigate the effect of PhET simulated POE method on students' understanding of the greenhouse effect and their attitudes towards science. As a result of the analysis, a significant difference was

found between the experimental and control groups in favor of the experimental group, in which the PhET simulated POE method was applied to the students' understanding of the greenhouse effect and their attitudes towards science.
As a result of the research, it was determined that the PhET simulated POE method was effective in eliminating students' misconceptions about the greenhouse effect. In previous studies (Minaslı, 2009; Bülbül, 2009; Teke, 2010; Güvercin, 2010; Koyunlu Ünlü, 2011) it was revealed that simulations have a positive effect on student achievement. Faour and Ayoubi (2018) stated that simulation-based courses are important for students to easily understand science subjects and improve their conceptual knowledge.

When the answers given to the first question of the greenhouse effect concept pre-test are examined, the students think that earthquakes occur as a result of the greenhouse effect. For example, the students who participated in the study showed that they have the misconceptions available in the literature by stating that "Our world is starting to disappear due to earthquake causes". In the literature, there are studies (Artun & Okur, 2015) in which secondary school students do not have enough knowledge about the concepts of climate change, global warming and greenhouse effect.

When the greenhouse effect concept test pre- and post-test results are examined in terms of the first two categories of the evaluation scale (AC-CR and PCA); It is seen that there is a significant increase in students' understanding of the greenhouse effect after the application. This can be interpreted as the POE method, in which PhET simulations are used, is effective in making students comprehend the concept of greenhouse effect. However, it was determined that the students gave wrong reasons in the explanation part of the correct answers. It can be said that students have difficulties in justifying the correct answer.

The results of previous studies are similar to the results of the research. In their study, Erdoğan and Özsevgeç (2012) concluded that the students gave similar answers and that many of the students had deficiencies in the effects of their daily activities on global warming. As a result of the application of POE method and its support with various animations and simulations, it was observed that the students' knowledge deficiencies and erroneous information were eliminated. Similarly, Atabey and Çiftçi (2019) found that the POE method is effective in eliminating the erroneous information in students and facilitating their learning.

According to the results obtained from this study, it is thought that it is an effective method in detecting and eliminating misconceptions, since students have the opportunity to test their current knowledge in the courses taught according to the PhET simulated POE method. In the study, it was observed that as a result of supporting the POE method with PhET simulations, the lack of knowledge and erroneous information in the students were eliminated. In addition, it can be said that during the application, it increases the interest in the science lesson and provides a better understanding of the subject.

Within the scope of the study, students' attitudes towards science of the PhET simulated POE method were examined. As a result of the findings, there was no significant difference between the pre-test and post-tests of the students in the control group, while a significant difference was found between the pre-test and post-tests of the students in the experimental group. In the literature, there are studies (Akgün, 2005; Daşdemir & Doymuş, 2012) that conclude that the use of simulation in science education affects science attitude positively.

Learning environments have positive effects on students' attitudes towards science (Cayvaz, Akcay, & Kapici, 2020). The use of simulation in science education improves students' learning and inquiry skills. The results obtained in this study are that the PhET simulated POE method increases student achievement in science teaching and develops a positive attitude towards science.

3.1 Suggestions

When the results of the study are evaluated, various applications can be made for the students' greenhouse gas concept, its causes and results. Studies can be carried out to improve the perception levels of students towards environmental problems.

In addition, within the scope of the study, it is suggested that the effect of the PhET simulated POE method should be applied in different science subjects to be clearly demonstrated. For this, teachers should be encouraged to use simulations in science lessons by giving various trainings on the use of simulation applications.

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