Journal of Pedagogical Research
Volume 6, Issue 3, 2022
https://doi.org/10.33902/JPR.202215535

Research Article

The effects of the "Predict-Observe-Explain (POE)" strategy on academic achievement, attitude and retention in science learning

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This paper employed a quasi-experimental design with pretest-posttest control group to investigate the effects of the predict-observe-explain (POE) strategy on fourth grade students' academic achievement, attitudes towards science, and retention. Participants of the study were consisted of 60 students. Experimental ($n = 30$) and control groups ($n = 30$) were randomly selected. The activities in the intervention group conducted eight weeks and a total of 18 lesson hours were run. The pre- and post-test results of the students in the experimental group and the control group were compared using the t-test for independent groups. The results demonstrated statistically significant differences between the experimental and control groups in terms of both academic achievement and attitudes post-test scores. In addition, a retention test was applied five weeks later than post-test application. The retention test results of the study revealed that the difference between the experimental group and the control group was statistically significant in favor of the experimental group. In conclusion, the results suggest that POE is an effective strategy in increasing the academic achievement and providing positive attitudes towards science.

Keywords: Achievement; Attitude; Predict-observe-explain strategy; Science

Article History: Submitted 22 March 2021; 1 June 2022; Published online 28 June 2022

1. Introduction

In today's education and training programs, constructivist approach applications are employed in science lessons. Using the constructivist approach, learning occurs when an individual structures knowledge in his mind with his own effort, and, therefore, teachers have a lot of responsibilities (Atasoy, 2004). In keeping with this understanding, teachers need to determine appropriate methods and strategies and present them effectively in the classroom so that effective learning occurs in students' minds.

Learning with a constructivist approach requires the use of various strategies and techniques. POE is one of the strategies included in this approach. This strategy is characterized by the steps of estimating, verifying predictions, defining observations, comparing and explaining predictions

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How to cite: Erdem Özcan, G. & Uyanık, G. (2022). The effects of the "Predict-Observe-Explain (POE)" strategy on academic achievement, attitude and retention in science learning. *Journal of Pedagogical Research, 6*(3), 103-111. https://doi.org/10.33902/JPR.202215535

with observations, revealing students' prior knowledge, and allowing them to find alternative solutions to complex problems (Köse et al., 2003). It was first developed by Champagne, Klopfer, and Anderson in 1979 to measure the thinking skills of first-year physics students at the University of Pittsburgh. It was later given the name POE by White and Gunston (1992).

The POE is taught in science laboratories or in a classroom environment and enables students to associate science information with natural events they encounter in their daily lives. This method can thus be viewed as one of the methods that should be used by teachers in order for learning to occur in the minds of their students permanently. POE activates students' prior knowledge, leaves the solution of the conflict to the student, and tries to ensure that the student follows the method without skipping the stages of the method (Kearney, 2002). Furthermore, POE encourages students to develop their self-confidence, to take responsibility in individual and group work, to hold themselves responsible for their own learning, to express themselves well, to show motivation, to make a written prediction during the process and to explain this prediction, by forcing them to find answers and to be proactive. In other words, this strategy promotes a wide range of positive attitudes (Jaime et al., 2013; Tao & Gunstone, 1999).

Through the POE strategy, where students can construct and accurately express their knowledge by reasoning between what they have learned before and the new information they have acquired later, students can achieve successful results, especially in lessons based on experimentation and observation, such as in science (Bilen, 2009). POE improves students' participation in science lessons, their involvement in group or individual research, and their self-confidence, as well as their ability to express themselves (Kırılmazkaya & Kırbağ-Zengin, 2015). The POE strategy also removes students from the role of passive observers and actively incorporates them in the process from the beginning of the experiment to its completion. It can be employed in classroom activities at the primary and secondary school levels. In this way, students learn about their own understandings and knowledge while also starting to believe that knowledge is changeable (Güngör, 2016).

The POE strategy consists of three stages, namely prediction, observation, and explanation. In this method, which combines prediction, observation, and explanation, predictions are made about an experiment or subject at the beginning, followed by observations and explanations (White & Gunstone, 1992). In this context, students are required to first predict the outcome of a demonstration, event, or experiment, then to observe, and finally to state their findings in accordance with their predictions and observations (White & Gunstone, 1992).

Prediction is the first stage of the POE strategy. In this stage, students are given information about experiments, events, demonstrations, and topics to be researched, and their predictions and explanations are required. Thus, students' prior knowledge is activated, the subject is highlighted, and the concepts they are familiar with before are revealed (White & Gunstone, 1992). Observation is the second stage of the POE strategy. This stage involves students observing the experiment, event, or demonstration they predicted earlier. In the estimation phase, students should record their quantitative or qualitative observations, regardless of whether they use tools or not. All students should therefore be able to see the event, experiment, or demonstration to be observed. Teachers may repeat the observation if necessary. Explaining is the last stage of POE. In this stage, students become aware of their contradictions by comparing their predictions and observations (Kearney, 2002). Instead of informing students directly, teachers should guide them to explain the conflicting situations between their predictions and observations. In comparison to the other two stages, this stage is considered to be difficult for students. During this stage, students can discuss the contradictions they found among themselves or in small groups. Teachers at this stage should support all ideas and support students in developing different perspectives without judging them. Additionally, unlike other stages, students at this stage should be encouraged to express themselves correctly while being given sufficient time to do so (Dial et al., 2009).

It has been reported by various researchers that the POE strategy is effective in science education (Hong et al., 2021; Karaer, 2007) as it is in many other areas (Arsy et al., 2020). As such,

POE strategy is believed to be beneficial in helping students learn concepts, develop positive attitudes, and increase interest in science courses (Bilen & Aydoğdu, 2010; Liew, 1995; Köse et al., 2003; Tokur, 2011). Providing meaningful and permanent learning in science is thought to be difficult. Generally, science consists of intangible concepts, and students find it difficult to embody these concepts in their heads. It is crucial in this context to focus on how the student learns and design activities according to methods that are thought to be effective at achieving permanent and meaningful knowledge. In this study, it was investigated whether teaching based on the POE strategy was effective in the *Let's Recognize Matter* unit of primary school fourth grade science. In terms of understanding science subjects and making sense of daily life events, this unit is a basic unit. Furthermore, this unit contains many experimental activities. Due to this, it is considered a very suitable unit for teaching using the POE strategy. A student's progressive learning and understanding of new concepts will also be facilitated by learning the concepts in this unit correctly.

In the POE strategy, the students are expected to make predictions, observe results, and explain them. Thus, it is an active teaching stratey that involves students throughout. Children in the primary school period are in the concrete operational stage, so it is believed that teaching the subjects by concretizing will ensure more permanent learning. As a result, POE is thought to help primary school students better understand science subjects by concretizing teaching. According to the relevant literature, there are few studies at primary school level that use the POE strategy. It is believed that this research will contribute to filling the related research gap. Therefore, this research aims to examine the effects of POE-based teaching on students' academic achievement, their attitudes towards the science course, and their learning permanence. The following sub-problems were addressed in order to achieve this goal:

1. Is there a significant difference between the achievement test post-test scores of the experimental and control groups?
2. Is there a significant difference between the attitude scale post-test scores of the experimental and control groups?
3. Is there a significant difference between the retention test scores of the experimental and control groups?

2. Method

2.1. Research Model

A quasi-experimental research design was employed for the study (see Table 1). Experimental design is a type of research design to investigate cause-and-effect correlations between variables (Büyüköztürk, 2007). Moreover, this design uses fewer subjects, which saves both time and effort (Büyüköztürk et al., 2009).

Table 1
Symbolic View of the Experimental Pattern

Group	*Pre-test*	*Process*	*Post-test*	*Retention Test*
Experimental	T1-S1	X	T1-S1	T1
Control	T1-S1	Y	T1-S1	T1

Note. T1=Let's Get to Know the Matter Unit Achievement Test; S1=Attitude Scale Towards Science Course; X=POE Strategy-Based Teaching; Y=Current Teaching Activity

Table 1 shows that POE applications were the independent variable examined in the experimental group, while routine teaching activities were the independent variable studied in the control group. In other words, the experimental group was taught using the POE strategy throughout the experimental application process. Lessons in the control group were taught using teacher-centered lectures. Through POE, students in the experimental group make various predictions, observations, and explanations about the subject by attending the lesson personally. Alternatively, the method applied in the control group is described as other activities used by the

teacher during the course of teaching the subjects, which are not incorporated into the POE activities.

As a post-test, both groups were administered the achievement test at the end of the experimental process. As a permanence test, both groups were re-administered five weeks after the application process ended. Through the retention test, the effect of the POE strategy used throughout the experiment was examined on the permanence of the teaching. In order for learning to occur, permanent learning must have been experienced. Perpetuality plays a very important role in learning in this regard. The teaching methods used in the lessons are also expected to provide permanence in learning. Hence, in this study, the permanence test was applied and the suitability of the teaching method was evaluated.

2.2. Participants

This study selected the participants based on purposeful sampling, a non-probabilistic sampling method, and easy-to-access case sampling. The researcher uses his judgement about who will be selected in this type of sampling and selects those who are most suitable to the research objective (Balcı, 2016). The research was conducted in a public school in Ankara during the fall semester of 2016-2017. An experimental group of 30 students and a control group of 30 students were determined for the study. As a result, 60 fourth-grade students formed the study group. A random selection process was used to select the experimental and control groups.

2.3. Experimental Process

The researcher organized the activities according to the POE strategy and created worksheets for these activities. The experimental group received teaching materials prepared for the POE. To create a scientific infrastructure for activities and worksheets in the *Let's Know Matter* unit of fourth grade science lesson, we have prepared activities and materials compatible with POE for *Properties of Matter*, *States of Matter*, *Measurable Properties of Matter*, *Heat and Temperature*, and *Pure Matter and Mixtures* subjects. This research was undertaken based on the advantages that can be provided in terms of the fact that the unit selected is at the same time part of the development of the research, that it is being processed by the teacher according to existing methods, and that the researcher can compare the current method with the POE strategy. A POE-prepared activity was conducted in the experimental group, while existing activities recommended by the Ministry of National Education were carried out in the control group. Table 2 represents the topics related to the Let's Get to Know the Matter Unit.

Table 2
Topics Related to the Activities of the Let's Get to Know the Matter Unit

Weeks	*Name of Activitie*	*Topic Area*
1	Does it float or sink?	Characteristics of the matter
1	Does it absorb water or not?	Characteristics of the matter
2	Let's get to know the matter	Characteristics of the matter
2	The states of butter	States of matter
3	What state of matter am I?	States of matter
3	Can liquids and gases be compressed?	States of matter
4	Which one has more mass?	Measurable properties of matter
4	How shall we weigh?	Measurable properties of matter
5	I measure volume	Measurable properties of matter
6	Melting and freezing	Change of matter under the influence of heat
7	Cooling and warming	Change of matter under the influence of heat
8	Matter and object	Matter and object

The application process in the classroom on the topic of "Does it absorb water or not?" was carried out as follows:

This activity seeks to classify substances in terms of their ability to absorb or not absorb water. Students were asked to fill the graduated cylinders halfway during the prediction phase. We asked students to predict what would happen if we immersed the items on the list in graduated cylinders, waited one minute, and removed them, and then asked them to write their predictions. Students were asked to immerse sponges, paper towels, wool, cloth, and nylon bags completely in graduated cylinders half filled with water, wait for one minute, then remove the stickers and record their observations on a table. They were asked to explain why the result occurred. The objective of this experiment is to make the students realize that sponges, paper towels, and wool fabrics absorb water, while nylon bags do not. Students can predict what kind of situations will arise if other substances similar to those in this activity come into contact with water by conducting such experiments in the classroom.

2.4. Data Collection Tools

The *Let's Recognize Matter Unit Achievement Test* and *Science Lesson Attitude Scale* developed by Uyanık (2014) were used in this study. The achievement test is made up of 28 questions. KR-20 reliability value was 0.78, distinctiveness value was 0.48, and difficulty value was 0.51. The content validity of the test was ensured through expert faculty members' opinions. Each correct answer to a question in the test is worth 1 point, while a wrong answer is worth 0 (zero) points. Consequently, the highest score that can be obtained from the test is 28 and the lowest is 0.

The attitude scale consists of 18 items and is used to assess students' attitudes towards science courses. According to the validity and reliability analyses of the 3-point Likert-type scale, the Kaiser-Meyer-Olkin (KMO) coefficient was .819 and the Bartlett Sphericity test significance level was 0.00. In the four-factor scale, the total variance explained in terms of the determined factors was calculated as 53.17%. The Cronbach Alpha (α) reliability coefficient value of the scale was determined to be .86. Expert opinion was obtained to determine whether the scale was valid for its intended purpose. In the 18-item scale, the most positive answer received 3 points, whereas the most negative answer received 1. This resulted in the highest score possible on the scale being 54 and the lowest score being 18.

2.5. Analysis of Data

As the number of samples was greater than 30, the Kolmogorov Smirnov test was used to determine normality. The normality evaluation tests determined that the groups showed a normal distribution. The research data were analyzed with the SPSS program and the pre- and post-test results of the experimental and control groups were analyzed using the t-test for independent groups. In independent samples, a t-test tests whether a difference between these samples is significant (Büyüköztürk, 2007).

3. Findings

3.1. The Effect of the Intervention on Academic Achievement

To compare the academic achievements of the experimental and control groups, a pre-test was conducted before the eight-week intervention based on POE strategy began. The independent t-test results are presented in Table 3.

Table 3
Independent t-test Results on Academic Achievement Pre-test Scores of Experimental and Control Groups

Groups	*N*	*Mean*	*SD*	*df*	*t*	*p*
Experimental	30	13.97	3.49	58	1.515	.135
Control	30	12.73	2.78			

As can be seen from Table 3, the academic achievement test pre-test scores of the experimental and control groups were not statistically significant ($t_{(58)}$= 1.515; $p > .05$). It was concluded from this analysis that there was a similarity in academic achievement between the experimental and control groups before applying the POE strategy to the "Let's Know the Matter" unit.

A post-test was administered to the experimental and control groups after eight weeks of experimental applications for assessing their academic achievement. The results of the t-test for independent groups of academic achievement are presented in Table 4.

Table 4
Independent t-test Results on Academic Achievement Post-test Scores of Experimental and Control Groups

Groups	*N*	*Mean*	*SD*	*df*	*t*	*p*
Experimental	30	24.97	2.54	58	7.505	.000*
Control	30	18.60	3.90			

**Note.* $p < .05$

Table 4 shows that there is a significant difference in the post-test academic achievement scores between the experimental and control groups. According to the statistical analysis, the experimental group scored significantly higher ($t_{(58)}$= 7.505; $p < .05$). Following the completion of the experimental application process, the achievement test was administered again in the fifth week after the end of the experimental application process in order to compare the permanence levels of learning. Based on the independent t-test, Table 5 shows the comparison of the two groups.

Table 5
Independent Samples t-test Results on Retention Test Scores of Experimental and Control Groups

Groups	*N*	*Mean*	*SD*	*df*	*t*	*p*
Experimental	30	19.73	3.06	58	2.91	.005*
Control	30	16.70	4.80			

**Note.* $p < .05$

As shown in Table 5, a significant difference in the retention test scores between the experimental and control groups. Findings revealed statistically significant differences between the mean scores in favor of the students in the experimental group ($t_{(58)}$= 2.91; $p < .05$).

3.2. The Effect of the Intervention on Attitude towards Science Lesson

Before the topics were taught, a t-test was used to compare the mean scores on the Science Lesson Attitude Scale. Table 6 summarizes the results of the t-test.

Table 6
Independent t-test Results of the Attitude Scale Pre-test Scores of the Experimental and Control Groups

Groups	*N*	*Mean*	*SD*	*df*	*t*	*p*
Experimental	30	41.87	3.98	58	1.133	.262
Control	30	40.70	3.99			

The attitude scale pre-test scores for the experimental and control groups were not statistically significant, as shown in Table 6 ($t_{(58)}$= 1.133; $p > .05$). It is evident from this information that both the experimental and control groups had similar attitudes towards the science lesson prior to applying POE.

Students' attitudes towards the science lesson were assessed using the same scale after the intervention. Table 7 summarizes the results of the independent samples t-tests of the attitude scale students.

Table 7
Independent t-test Results of the Attitude Scale Post-test Scores of the Experimental and Control Groups

Groups	*N*	*Mean*	*SD*	*df*	*t*	*p*
Experimental	30	44.97	2.56	58	4.975	.000*
Control	30	40.63	4.02			

**Note.* $p < .05$

As can be seen from the Table 7, a significant difference in the attitude scale post-test scores between the experimental and control groups. The difference was significant and the mean scores for the experimental group were higher ($t_{(58)}$= 4.975; $p < .05$).

4. Discussion, Conclusion and Recommendations

In this study, the effect of POE-based science teaching on fourth grade students' academic achievement and attitudes towards science lessons was investigated. Before applying the POE strategy, the fact that the academic achievement scores of the two groups were close to each other showed equivalence between the two groups. Students in the experimental group had a higher level of academic success when their post-test scores were compared. According to the results, the difference between the experimental and control groups were statistically significant in terms of academic achievement test post-test scores for the experimental group with POE strategy. This result is consistent with the findings of the various research that demonstrate the effect of POE compared to the traditional lecture (Akgün et al., 2013; Bilen & Aydogdu, 2010; Bilen & Köse, 2012; Kırılmazkaya & Kırbağ-Rich, 2015; Sünkür et al., 2012; Uyanık, 2017). In the permanence test performed five weeks after the post-test application to the experimental and control groups, the academic achievement mean scores of the experimental group were higher than those of the control group. Accordingly, this difference was significant in favor of the experimental group. Both Yıldırım (2016) and Uyanık (2017) concluded that the retention test scores of experimental group students which were conducted through POE-based approach were significantly higher. These results can be interpreted as the POE strategy also leads to permanent learning.

It was stated by Kırlmazkaya and Kırbağ-Zengin (2015) that the POE strategy is very useful for teaching science subjects. Thanks to POE strategy, students are more active in the lesson, their motivation increases, and since they understand the concepts better, they can use them better in the real world. As such, the POE strategy is effective in making the knowledge that students learn within the scope of a science course permanent and implementing this knowledge both in the educational environment and everyday life. It may be that the students in the experimental group were statistically better than their counterparts in the control group because they were more interested in and more successful in the lesson. Thus, it can be concluded that the use of POE strategy -based teaching in the Let's Know Matter unit in the science course permanently increases the academic achievement of the students.

Along with academic achievement, attitudes towards science lessons were also compared in this study. Science lesson attitudes were similar between the two groups before implementation. In the independent t-test, the difference between the post-test attitude scale scores of the experimental group and the control group was statistically significant in favor of the experimental group. In other words, during the eight-week period, there was no change in attitude towards science lessons in the control group taught with the current curriculum, while the experimental group taught with the POE strategy showed more positive attitudes. This result suggests that the POE strategy positively influences students' attitudes toward science lessons. The results of this study are similar to those of the study conducted by Uyanık (2017). On the contrary, Aydın (2010) and Akgün et al. (2013) found that the POE strategy did not significantly affect students' attitudes. The difference in results between the current study and the literature is thought to be due to the implementation period, which should be long in order to change attitudes.

In Turkey, science is taught by classroom teachers in the fourth grade. Students' attitudes towards science are greatly influenced by the first science education they receive from primary

school teachers (Türkmen, 2002). From this perspective, it is considered crucial for classroom teachers who want their students to have a positive attitude toward the science lecture, to present the subject with this understanding. The POE strategy was found to make the students very active during the lesson in this research. Although observation data were not reported in this study, the majority of the students engaged fully in the lessons throughout the experimental application process. It has been noticed that they actively participate while engaging voluntarily. It was also apparent that they enjoyed themselves while learning during the lecture. In this sense, the use of POE strategy in primary school science courses both entertains, arouses students' curiosity, and contributes to a more permanent learning process. Based on the results obtained from this research, it is recommended that the POE strategy be used in the fourth grade science lesson for Let's Know the Matter. In terms of a constructivist learning approach, it is believed that the POE strategy is able to provide more effective activities for teachers. Future research can examine the effectiveness of the POE strategy in different units of the science course as well as other disciplines.

Author contributions: This research is based on the master's thesis conducted by the first author, under the supervision of the second author.

Funding: No funding source is reported for this study.

Declaration of interest: No conflict of interest is declared by authors.

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