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Apuntes Universitarios

Mejorar la comprensión de los alumnos mediante el método POE basado en el debate

Enhancing pupils' understanding via discussion based POE method

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Resumen

El método Predecir-Observar-Explicar (POE) se destaca como un método eficaz para superar conceptos erróneos en la comprensión humana. Este enfoque se caracteriza por su flexibilidad y variabilidad. Los investigadores han creado una versión modificada del POE que se basa en la discusión y, por lo tanto, se denomina "POE basado en discusión" (abreviado POE-DE). La investigación actual tiene como objetivo examinar el efecto de este método de enseñanza mediante la revisión del éxito académico de los estudiantes y la corrección de conceptos erróneos. En el estudio participaron un total de 63 alumnos de octavo grado (de entre 12 y 14 años). 32 alumnos formaron parte del grupo experimental que participó en cursos con actividades basadas en POE-DE. Los 31 restantes representaron el grupo de control con actividades docentes acordes con el plan de estudios de ciencias actual. El tema de la unidad fue *Máquinas Simples*. Se empleó la *Prueba de Rendimiento Académico de Máquinas Simples* (AAT) para medir el cambio en el rendimiento académico de los estudiantes. Se administró la *Prueba Conceptual de Máquinas Simples* (SMCT) de dos niveles para determinar los conceptos erróneos de los estudiantes y observar si habían sido rectificados. Según los datos estadísticos, las actividades docentes basadas en POE-DE tuvieron un impacto sustancial tanto en la tasa de éxito académico como en las puntuaciones SMCT de los estudiantes.

Palabras Clave

método predecir-observar-explicar, concepto erróneo, educación científica, máquinas

Abstract

The Predict-Observe-Explain method (POE) stands out as an efficient method in order to overcome misconceptions in human understanding. This approach is characterized by its flexibility and variability. Researchers have created an altered version of the POE which is based on discussion and therefore called "discussion-based POE" (short POE-DE). The current research aims to examine the effect of this teaching method by reviewing students' academic success and the remediation of misconceptions. A total of 63 eight-graders (aged 12-14 years) took part in the underlying study. 32 pupils were part of the experimental group participating in courses with POE-DE based activities. The remaining 31 represented the control group with teaching activities in line with the current science curriculum. The subject of the unit was *Simple Machines*. The *Simple*

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Machines Academic Achievement Test (AAT) was employed to measure the change in the students' academic accomplishmen. The two-tier *Simple Machines Conceptual Test* (SMCT) was administered to determine the students' misconceptions and observe whether they had been rectified. According to the statistical data, POE-DE based teaching activities had a substantial impact on both the academic success rate and SMCT scores of the students.

Keywords

predict-observe-explain method, misconception, science education, simple machines

1 Introduction

According to the constructivist approach, students learn by actively constructing new knowledge schemes by combining the knowledge transferred to them with their existing knowledge and their own experiences (Bodner, 1986). This approach emphasizes the importance of students actively participating in the learning process and retaining the information they have acquired through experiential learning with activities that students engage in on a hands-on basis (Garmston & Wellman, 1994; Chuang, 2021; Hofstein & Lunetta, 2004). In addition, it has been stated that the individual's being at the center of his/her own learning also contributes to his learning motivation (Fay, 1996). In this approach of learning in which students have an active role, the precise structuring of the concepts is necessary because the students' perceptions of a concept play a critical role in terms of the outcome of the learning. Students acquire the concepts they have not scientifically, but from their own minds, from perceiving nature as they see it, so scientific concepts and laws should be precisely and meticulously introduced to students (Matthews, 1997).

The following instructions is suggested (Labudde et al., 1988) to transfer students' scientific concepts in a more memorable and meaningful way:

1. The knowledge required to interpret a concept should be taught with clearly definable information about the concept.
2. New content must be taught consistently so that it can be recalled when needed and compared with previous learning experiences.
3. The instructions should be clear and precise so that the knowledge can be easily integrated with other concepts.
4. In order to eliminate inconsistencies, preserve the coherence of the student's new information, and minimise interference from conflicting past knowledge, new knowledge should be explicitly contrasted with prior knowledge.

For a considerable amount of time, the literature has discussed misconceptions, problems that arise in the educational process related to the students' acquisition of conceptual understanding, and potential solutions to these issues. (Monteiro et al., 2012; Samsudin et al., 2021; Gil-Perez & Carrascosa, 1990; Smith et al., 1994; Rothman, 2014). Students, due to their learning experiences that occurred in the daily-life setting before their stepping out to formal education, frequently arrive at school with preconceived notions about topics, particularly those pertaining to science, that is not based on sound scientific evidence. According to Garnett and Treagust (1990), the reasons why students have diverse concepts about the same topic are their diverse backgrounds, misconceptions, existing knowledge about certain topics, and students' identification and perception systems. All of these factors contribute to the development of students' unique perspectives.

Conceptions are formed in children at a young age as a natural byproduct of their exploration of both their physical and social environments. Many misconceptions that children have about natural occurrences are formed before they ever participate in formal education (Zukerman, 1994). In addition, the content guidance style of teachers and incorrect interpretations of texts can also contribute to the misconceptions that pupils have (King, 2010). When these alternative conceptions have a meaning that students are willing

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to accept as true, it might be difficult to change them and replace them with the knowledge that is accurate. Alternative conceptions in children's cognition are resistant to change and require a special effort to overcome (Chi, 2005). Changing a concept that the student misunderstands depends on a number of variables, including the student's background knowledge, and the student is more open to changing the concepts in her mind against the content he/she finds interesting (Lombardi et al., 2013).

As a result of the abstract nature of the topics covered in the science curriculum, there is always the possibility that the concepts themselves are either misconstrued or not understood at all (Yağbasan & Gülçiçek, 2003). In order to find a solution to this problem, educators and researchers undertook studies to see how efficient other teaching strategies and techniques, in addition to more conventional approaches, are at dispelling misconceptions (Genç, 2008). One of the aims of science education is to try to make the students use these concepts in their life outside the classroom by structuring them in a meaningful and correct way with various activities in the school settings (Yürük & Çakır, 2000).

One way to look at the process of learning is as a process that involves modifications to one's cognitive conceptions about topics. This modifications, according to Piaget, are a result of the deterioration of the student's conceptual equilibrium and the evolution of knowledge (Piaget, 1970; Schunk, 2012). According to the constructivist approach, the teacher must provide the student with the experience of cognitive conflict and then assist them in resolving it in order to provide instruction and activities that will cause and encourage cognitive conflict in the student and, as a result, provide meaningful learning (Sandoval, 1995; Williams & Tolmie, 2000). It will be beneficial to guarantee that students participate in practical activities and to have them question experiences such as conversation and observation with the group, that is, to enable the students to interpret for themselves (Schunk, 2012).

The process of updating or altering one's current ideas or knowledge structures in response to new information or evidence is referred to as conceptual change. It is a key process in learning, and it is especially important in science education, where students often bring preconceived assumptions or prejudices to the classroom. Learning, according to the cognitive paradigm of conceptual change, entails both the acquisition of new information and the reorganisation of old knowledge (Posner et al., 1982). According to research, conceptual change informed teaching is typically better to more conventional methods of teaching. As a result, conceptual change remains a strong framework for enhancing teaching of scientific concepts (Duit & Treagust, 2003).

Using appropriate techniques in science teaching are important for students to better understand the scientific principles that will help them in their daily lives and academic performances (Maltese & Tai, 2010). One technique stands out in terms of making students active in the learning process, making observations and interpretations, and comparing previous learning with new learning, and eventually detecting misconceptions. The Predict - Observe – Explain (POE) approach is one of the most useful tools for spotting and resolving common misconceptions and providing meaningful conceptual change, which was introduced by White and Gunstone (1992). Students are able to work using the POE method (Ilma et al, 2022), which analyses an experimental procedure in its own context and verifies that they have accurate knowledge of the topic (Hilario, 2015). The fact that students can clearly express their current knowledge about a subject also allows these statements to be interpreted by the teacher, to be evaluated as well (Adebayo & Olufunke, 2015).

In its simplest form, in the POE method, students are expected to make a prediction about an experimental activity that will take place then make an observation to see the accuracy of their prediction and make an explanation for comparing the prediction and observation of the result after the event has occurred (e.g., Coştu et al., 2010). By asking questions and conducting research, students are able to construct their own learning in their minds using the POE method, which ultimately leads to the elimination of misconceptions and the provision of information that is both relevant and meaningful (e.g., Barış, 2022).

In order to better understand the subject explained to the students, there are many studies that have added the "discussion" section to the POE activities (Samsudin et al., 2021; Alabdulaziz, 2022; Wulandari et

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al., 2017; Demircioğlu 2017). In recent years, POE activities were diversified by putting the discussion method at different sections of POE steps (Coştu, 2021).

In this rigorously conducted study, after the standard explanation part of POE, a discussion part took place. There is a lot of room for discussion during POE activities devoted to explaining course topics (White & Gunstone, 1992). After the explanation part, the students had the opportunity to discuss their answers. Compared to other methods where the discussion element is added to the POE method (i.e PDEODE), in this research, the discussion session was added *after* the explanation session (i.e. POE-DE). The reason for this is the concern that students' discussions before the explanation session may affect their statements about the current concept in their minds about the event that took place. It has been stated that the use of discussions in the teaching process encourages the use of cognitive strategies and encourages them to keep them in mind in the long term (Kolari et al., 2005). Learning was described by as a process that makes use of logical procedures (Posner et al., 1982). Children tends begin to believe something after they have established that it is consistent with their worldview and makes sense. Assimilation is the process by which students utilize previously learned concepts to explain newly learned concepts. When students are unable to articulate newly learned concepts, they switch to editing mode which is called as accommodation. As a result, this process characterized as one that occurs over the course of two stages (Posner et al., 1982).

At this point, we believe that the discussions that are going to take place in the classroom setting will assist both to disclose the concepts that are already present in the students as well as to develop new concepts in the students' minds thanks to peer learning while the teacher is guiding the discussion. After the discussion part, the students can learn from each other by discussing and re-examining their explanations about why the observed event happened in this way and then adding to their explanations. In this study, after the discussion part, students are able to revise their explanation, in the second explanation part will took place. In this study, as a new contributed to related literature, the effect of POE-DE tasks on students' academic achievement and remediation of misconceptions will be examined compared to activities according to the current science curriculum.

In this regard, this study aims to determine the impact of POE-DE-supported instruction regarding with *Simple Machines* learning unit on students' academic achievement and their ability to overcome misconceptions. In line with this objective, the study sought answers to the following research questions:

1. Do POE-DE supported teaching activities have an effect on the academic achievement of students in Simple Machines unit?
2. Do POE-DE supported teaching activities have an effect on the overcoming of misconception of students and providing proper conceptual change in in Simple Machines unit?

2 Methodology

The study group is comprised of 63 eighth-grade pupils from a secondary school in Istanbul. The sample was selected using a convenence sampling technique. Consequently, students currently involved in two distinct classes, were selected as samples. There are 32 pupils in the experimental group and 31 pupils in the control group.

During the study, 8 POE-DE tasks (see Figure 1) were carried out and the use of POE-DE activity forms is explained by the instructor/researcher, since most of the students are not familiar with the POE-DE activity. It is worth mentioning that the instructor of teaching intervention is also the first author of the article, since he is already working as a science teacher where the research was carried out. Tasks were implemented in the classroom with real tools and materials prepared by the instructor. Thus, the students were able to see the real versions of the materials they saw as images in the POE-DE form. An example POE-DE form can be seen in Figure 1.

The current study extended and elaborated image and text relations by referencing the studies of van der Meij & de Jong, 2006; Chan & Unsworth, 2011; Tippett, 2016; Unsworth, 2014; and Meneses et al. 2018. These studies guided the current study in terms of determining levels of intersemiotic relations (from simple to complex) by providing qualitative and quantitative data. These studies also enlightened the

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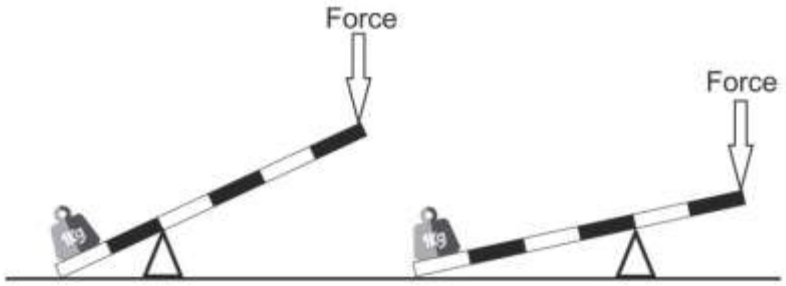
present study in terms of naming and classifying intersemiotic relations, and how to distinguish one form to another with characteristic aspects. The following titles will describe groups and categories of intersemiotic relations.



1. ***Predict (P)***

Predict in which option the weight can be lifted with less force. State and explain the reason(s) for your prediction.

....
....

2. ***Observe (O)***

In which case it was measured that less force was used to lift the weight? State and explain the reason(s) for your observation.

....
....

3. ***Explain (E)***

Compare your observation with your prediction. Are they in agreement or disagreement? Explain your reason(s).

....
....

4. ***Discuss (D)***

Discuss your statement in the "Explain" section in the classroom.

5. ***Explain (E)***

Did your statement change after the discussion with your friends? Is there any point that turned out missing? Did your statement justified?

....
....

Figure 1. A sample of the POE-DE task used in the experimental group.

2.1 Instruments

Simple Machines Academic Achievement Test (AAT) (Özkan & Mustu, 2018) is a multiple-choice test which has been used previously in the literature and was chosen to measure the academic success rate of students. It was multiple choice test with a high-reliability coefficient (0,882). The overall average difficulty index was determined (p=0,249), and the test's discrimination index was determined (r= 0,76). AAT was consisted of 19 multiple choice items, with 3 distracters and 1 correct answer. Every correct answer was worth 5 points, while 0 points for incorrect answers.

As for the other scale that has been used in this research, it was a two-tier Simple Machines Conceptual Test (SMCT). The two-tier SMCT was developed by the researchers and before the experimental procedures were started, a pilot study with students from a different branch of the same school was conducted. As a result of the SMCT's pilot implementation process, the overall average difficulty index was found as p=0.44, and the test's discrimination index was found as r=0.436. The test's reliability coefficient (Cronbach's alpha value) was determined as 0.82. A Cronbach's alpha value higher than 0.80 means that the test has a very high internal consistency (Cortina, 1993; Tavşancıl, 2010). SMCT consisted of 18 items. An

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example of the questions used in the SMCT can be seen in Figure 2(Topics of POE-DE tasks distribution can be seen in Table 1. Scoring method used for SMCT can be seen in Table 2).

Table 1. POE-DE task distribution used in the research.

No	Topic of the used POE-DE tasks
1	Mechanical advantages of levers, effort arm and load arm definitions
2	Type of levers, fulcrum position issues
3	Mechanical advantages of pulleys, pulley types
4	Compound pulleys, the direction of force and object in pulleys
5	Basics of inclined planes
6	Spinning wheels, effort arm issues
7	Gears as a simple machine, axial rotation and its amount
8	Driving and driven pulleys, axial rotation and its amount

Two-tier tests are seen as an important tool in determining the existing misconceptions in the minds of students, as they explain the reason for the answer given by the students to a question in the second section. The development of two-tier tests allows for the investigation of the reasons for the answers supplied by the students in the first stage, as well as the determination of any possible misconception related to the topic of the question (Soeharto et al., 2019) Two-tier tests is suitable for use in formative assessment as well as in summative assessment (Karataş et al, 2003), and they have been widely used in researches (Samsudin et al., 2021; Siswaningsih et al., 2017; Lin, 2004; Odom & Barrow, 1995; Adadan & Savasci, 2012; Supatmi et al., 2019; Coştu et al., 2007) to determine students' misconceptions. As can be seen in Figure 2, the second stage of the question often includes a false reason, a correct but irrelevant reason with the questions, a correct and relevant reason, and a fillable reason section for those who consider previous reasons are not suitable to explain the reason.

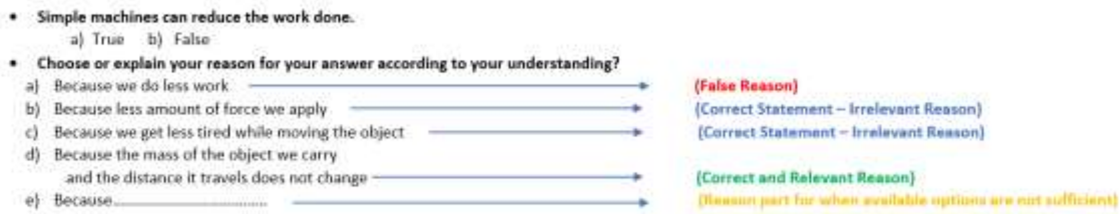

Figure 2. A sample two-tier test item of the SMCT.

A quasi-experimental design with a pre-and post-test control group was utilized in the study. The advantages of the pretest-posttest control group design are that measurements are taken on the same subjects, the effects of the experimental procedure are easily discernible, and the design requires less time and effort because fewer subjects are utilized (Büyüköztürk et al., 2012). The conceptual change model was utilized with POE-DE based teaching activities in this research (see Figure 3).

Figure 3. POE-DE model used in the study in order to provide pupils' conceptual change.

The Simple Machines unit was chosen as the subject of the research. The reason for this is that the concepts such as force, work and energy are used in daily life, so it is highly vulnerable for the occurrence of pupils' misconceptions, and it is a subject that is considered difficult for students. After the pilot implementation phase of the SMCT, teaching interventions were started in the groups. AAT and CT were applied to both groups as pre-tests. Then, while only the activities recommended by MoNE were applied to the control group, the experimental group was given additional training supported by POE-DE tasks. The activities used in the POE-DE tasks and the physical materials used in the activities were produced by the researcher for each of the eight POE-DE tasks. After a total of 3 weeks, which equals 12 class hours of

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implementation, AAT and CT were applied to the groups as a post-test and the results were reported. Research design for this study can be seen in Figure 4.

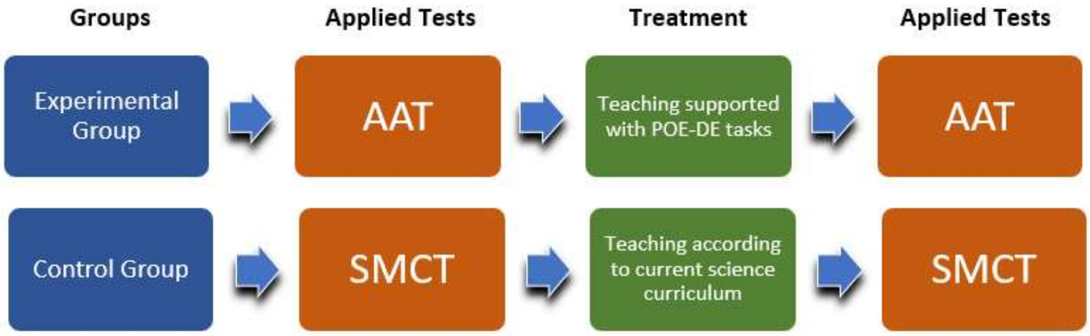

Figure 4. Research design of the study.

2.2 Data Analysis

At the stage of interpretation of the results obtained in the tests, the normality distribution of the data was first examined with the Shapphiro-Wilk normality test. Since normality of the scores has been ensured, independent t-tests were used when comparing the concept test and achievement test pre-test results of the experimental and control groups. While examining the pre-test and post-test scores, the dependent t-test was used and it was investigated whether there was a significant difference between the scores obtained from the tests, and the difference in favor of which group was investigated. As a result of these data, it was interpreted whether the POE-DE tasks had a significant effect on academic success and the elimination of misconceptions between the groups.

In SMCT Scoring, the criteria and scores included in a previous research conducted by Coştu (2021) were used. Since the SMCT consists of two phases, second phase need to be analysed in order to evaluate which category is appropriate for given answer. Therefore, two independent researchers checked whether the scores were similar and consistent, and the final scores were made accordingly. Scoring method used to analyze SMCT scores can be examined Table 2.

Table 2. Scoring method used for conceptual test.

Understanding Level	Explanation	Score
Sound Understanding	Answers containing accurate and relevant information in both parts	4
Partial Understanding with slightly misconception	Answers with correct choice in the first part and correct but irrelevant (but true) explanation in the second part	3
Partial Understanding with misconception	Answer with the correct choice in the first part and false reasoning or statement in the second part	2
No understanding	Other answers that don't fit other understanding levels	1
No Answer	No Answer for both parts	0

3 Results

The data and comments on the demographic characteristics of the participants participating in the research.

3.1 Findings related AAT

An independent t-test was conducted to see if there was a significant difference between the pre-test results of the AAT between the groups. The results are given in Table 3.

Table 3. Independent t-test findings for the experimental and control groups AAT pre-test results.

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	Groups	N	Mean	sd	t	p
AAT pre-test	Control Group	32	46.56	14,2		
results	Experimental Group	31	43,06	11,73	1,060	0,293

While AAT pre-test mean score was 46.56 in the experimental group, it was 43,06 in the control group. When the p values of the Experimental and Control Groups were examined, it was found that p=0.293. In this case, since the p-value is greater than 0.05, there is no significant difference between the Experimental Group and the Control Group.

Course carried out with both the Experimental Group and the Control Group before administering the post-test. An independent t-test was conducted to determine whether there was a statistically significant difference between the post-test AAT scores of the groups. The results are presented in Table 4 below.

Table 4. Independent t-test findings for the Experimental and Control groups AAT post-test results.

	Groups	N	Mean	sd	t	p
AAT post-test	Control Group	32	61,65	16,11		
results	Experimental Group	31	71,77	13,07	-3,812	0,000

While AAT post-test mean score was 61,52 in the experimental group, it was 71,77 in the control group. When the p values of the Experimental and Control Groups were examined, it was found that p=0.000. In this case, since the p-value is lesser than 0.05, there is a significant difference between the groups. The arithmetic mean of the AAT results of both groups between the pre-and post-test results and the increase between the scores are given in Table 5.

Table 5. Independent t-test findings for the Experimental and Control groups AAT post-test results.

	Pre-test Scores	Post-test Scores	Difference
Groups	x_1	x_2	x_2-x_1
Experimental	43,06	71,77	28,71
Control	46,56	61,65	15,09

While the increase between the arithmetic mean of pre and post-AAT test results determined as 28.71 points in the experimental group, an increase of 15.09 points was observed in the students in the control group. It is clear to see that the experimental group pre and post-test results more increased than the control group.

3.2 Findings related SMCT

An independent t-test was conducted to see if there was a significant difference between the pre-test results of the SMCT between the students in the experimental group taught with the POE-DE tasks, and the students in the control group, who were taught only with the teaching activities according to the current science curriculum. The results are given in Table 6.

Table 6. Independent t-test findings for the Experimental and Control groups SMCT pre-test results.

	Groups	N	Mean	sd	t	p
SMCT pre-test	Control Group	32	29,50	4,52		
results	Experimental Group	31	30,25	5,53	-0,596	0, 553

While SMCT pre-test mean score was 30,25 in the experimental group, it was 29,50 in the control group. The p-value for the comparison between the Experimental and Control Groups was found as 0.293. There is no statistically significant difference noticed between the groups, as the p-value is greater than 0.05. Teaching intervention was carried out with both groups before administering the post-test. To see if there was a statistically significant difference between the groups on the post-test results of SMCT , an independent t-test was applied. Table 7 below shows the final results.

Table 7. Independent t-test findings for the Experimental and Control groups SMCT post-test results.

	Groups	N	Mean	sd	t	p

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SMCT post-test results	Control Group	32	42,25	6,35		
	Experimental Group	31	48,25	7,35	-3,349	0,000

While the SMCT post-test mean score was 48,25 in the experimental group, it was 42,25 in the control group. The p-value for the comparison between the Experimental and Control Groups was 0.000. Since the p-value is lesser than 0.05, it can be said that the difference between the groups is statistically significant.

Below table 8 shows the percentage of pupils without misconceptions before and after POE-DE implementation. The *Pupils who don't have misconceptions* term implies that pupils who score 3 or 4 points on the Concept Test as shown in Table 2.

Table 8. Percentage of pupils without misconceptions before and after POE-DE implementation.

Question	Topic of the Question	Group	Pupils who don't have misconceptions before POE-DE tasks	Pupils who don't have misconceptions after POE-DE tasks	Percentage of change
1	Fulcrum position in lever, effort arm and load arm definitions.	EG	50,00%	59,38%	9,38%
		CG	48,39%	58,06%	9,67%
2	Mechanical advantages of pulleys, Pulley types.	EG	46,88%	56,25%	9,37%
		CG	58,06%	70,97%	12,91%
3	Mechanical advantages of pulleys and levers, Pulley types.	EG	46,88%	84,38%	37,50%
		CG	45,16%	54,84%	9,68%
4	Direction of applied force in lever and pulleys	EG	56,25%	78,13%	21,88%
		CG	45,16%	74,19%	29,03%
5	Compound pulley structure	EG	28,13%	37,50%	9,37%
		CG	48,39%	58,06%	9,67%
6	Mechanical advantages of pulleys types, compound pulley organization.	EG	50,00%	68,75%	18,75%
		CG	45,16%	38,71%	-6,45%
7	Differences between "work" and "labor," advantages of single machines.	EG	43,75%	59,38%	15,63%
		CG	54,84%	80,65%	25,81%
8	Advantages of using inclined planes, reduce of "work" by using simple machines.	EG	37,50%	87,50%	50,00%
		CG	38,71%	64,52%	25,81%
9	Amount of "work" to be done in inclined planes	EG	65,63%	78,13%	12,50%
		CG	38,71%	64,52%	25,81%
10	Amount of "work" to be done in inclined planes	EG	53,13%	81,25%	28,12%
		CG	54,84%	58,06%	3,22%
11	Fulcrum point, effort arm and load arm definitions.	EG	37,50%	62,50%	25,00%
		CG	35,48%	61,29%	25,81%
12	Whether screws are simple machines	EG	65,63%	59,38%	-6,25%
		CG	58,06%	67,74%	9,68%
13	Axial rotation of driving and driven pulleys	EG	25,00%	53,13%	28,13%
		CG	38,71%	54,84%	16,13%
14	Amount of rotation of driving and driven pulleys	EG	37,50%	65,63%	28,13%
		CG	45,16%	58,06%	12,90%
15	Mechanincal advantages provided by compound pulleys	EG	34,38%	59,38%	25,00%
		CG	54,84%	67,74%	12,90%
16	Fulcrum position in levers, effort arm and load arm definitions	EG	59,38%	56,25%	-3,13%
		CG	45,16%	58,06%	12,90%
17	Mechanincal advantages provided by levers	EG	15,63%	46,88%	31,25%
		CG	25,81%	48,39%	22,58%
18	Mechanincal advantages of levers, fulcrum position, effort arm and load arm definitions	EG	40,63%	59,38%	18,75%
		CG	45,16%	61,29%	16,13%

Table 8 shows that, with the exception of two questions, the number of students who had misconceptions between the pre-test and post-test decreased in all questions. The results of the study indicate that there

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was a significant decrease in the prevalence of alternative conceptions held by students after the implementation of a targeted teaching intervention. This suggests that the intervention was successful in correcting students' misconceptions and improving their understanding of the underlying scientific concepts. The decrease in alternative conceptions is an important indicator of the effectiveness of the teaching intervention, as it suggests that students were able to internalize the correct scientific concepts and integrate them into their existing knowledge structures.

Considering the misconceptions seen in students before and after the POE-DE applications, it was seen that POE-DE tasks remediated the misconceptions about subjects such as, amount of rotation of driving and driven pulleys (Ros et al., 2022), whether the simple machines reduce the amount of the work to be done (Garcia Carmona & García-Legaz, 2013) inability to distinguish between work and labor, amount and direction of rotation in driving and driven pulleys (Lehrer & Schauble, 1998), Fulcrum position in lever, effort arm and load arm definitions (Norbury, 2006), mechanical advantages provided by pulleys (Asghar et al., 2019), knowledge that it is always sufficient to apply more force than the load to lift the load in levers (Nalkiran & Karamustafaoğlu, 2020), Distinguish between lever and pulley types (Diani et al., 2020), inclined plane mechanics (Saputri, 2021; Yuberti et al., 2020), advantages of using Simple machines (İzzet et al., 2012) which are seen as difficult to understand by the students in the literature.

It was noticed that the number of students who had misconceptions increased in the experimental group in Question 12 & 16 and decreased in the control group in Question 6. Speaking for the experimental group, it should be mentioned that the 12th question is related to the fact that the screws are not seen as a simple machine, one of the reasons for the decrease in the score here is that it is difficult to understand the screw as a simple machine (Criado García-Legaz & García Carmona, 2011) and lack of POE-DE activity that specifically addresses for screws. As for the question 16, students were shown an example of a push-button hand sanitizer used in public areas, and the students could not identify the fulcrum of this tool, which could be seen as a lever. The reason for this is thought to be that although the students have knowledge about objects used in daily life such as tweezers and tennis rackets, which are essentially a lever, they cannot make inferences about this tool that they see as a lever for the first time. It is thought that the another possible reason for this issue may be factors that are not in the control of the researcher, such as the lack of motivation in the students or the poor adaptation to the lesson. It was also observed in some studies that very few misconceptions about various questions in concept tests increased slightly as a result of experimental procedures (Atasoy et al., 2013; Aykutlu & Şen, 2009; Yavuz, 2013; Solak, 2021; Case & Fraser, 1999).

4 Discussion

The results for the *Do POE-DE supported teaching activities have an effect on the academic achievement of students in Simple Machines unit?* subproblem is as follows.

The AAT was administered to students as a *pre-test* before the applications began to examine the efficacy of POE-DE supported instruction employed in the research. There was no statistically significant difference in test results between the experimental and control groups, as determined by an independent t-test. This may be construed as showing that the two groups were equal before the study was conducted.

Results from the AAT post-test conducted after the POE-DE applications showed a statistically significant difference, as determined by an independent t-test. This difference is in favour of the Experimental group. The significant difference between the AAT test post-test results of the groups showed us that the POE-DE supported teaching activities had a greater effect on the academic success of the students than standard teaching activities. When compared to studies that investigated the impacts of discussion-enriched POE method, such as those by Özsoy (2020), Tetik (2019), Akarsu (2018), Nadelson et al. (2018), Kibirige et al. (2014), Karamustafaoğlu & Mamlok-Naaman (2015), and others, the conclusion is consistent with the findings of these studies. It can be clearly said that the POE-DE approach has a beneficial impact on the acquiring learning outcomes of eighth graders studying Simple Machines.

The results for the *Do POE-DE supported teaching activities have an effect on the overcoming of misconception of students and providing proper conceptual change in Simple Machines unit?* subproblem are as follows.

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The acquired data have demonstrated that the POE-DE approach has a statistically significant impact on reducing students' misconceptions. According to the results of the independent t-test for the SMCT post-test results applied after the POE-DE applications, a significant difference was found. The Experimental group benefits from these differences. It can be said for the Experimental Group, which showed a higher increase in the result of the Conceptual Test compared to the control group; it was concluded that POE-DE activities are more efficient than traditional lectures in terms of elimination of misconceptions. This result also supports the findings of previous similar studies. Such as; Coştu (2021) stated that POE-DE supported laboratory studies are effective in increasing pre-service teachers' academic achievement, scientific process skills, conceptual understanding and interpretation of daily life problems. Wulandari et al. (2017) found that students can develop their critical thinking skills effectively by using the discussion-enriched POE method. Kolari et al. (2005) suggested by making use of discussion-enriched POE activities, increased students' motivation towards the science course. Çalış (2019) declared that POE-supported teaching activities increased students' awareness to environmental issues and their academic success. Alabdulaziz (2022) stated that students' academic success, problem-solving skills and conceptual understanding increased by using the POE-DE teaching strategy supported by the e-learning environment. Ardillani and Sutama (2022) stated in their study that by using POE-DE learning strategies, students better comprehend science lesson outcomes. As a result of their study, Indriyani et al. (2021) used the POE-DE model to eliminate students' misconceptions and stated that when used together with inquiry-based teaching activities, students' misconceptions were reduced. It is possible to say that the current research findings also show parallelism with previous similar researches, such as Fuadi et al. (2020), Potvin et al. (2015), Banawi et al. (2019), Coştu et al. (2012), Astiti et al. (2020), Arfiani, (2017), Abdullah et al., (2017), and Ayvacı (2013) studies.

According to Chi (2008), conceptual transformation is the process of improving the accuracy of students' construction of scientific knowledge rather than just providing them with new material or filling up any gaps in their knowledge. It includes discovering the assumptions that pupils already have and assisting them in realising that these ideas are incorrect or lacking. Following the identification of students' misconceptions, the next step in the conceptual change process is to give them experiences that contradict their preconceived notions and encourage the development of more precise understandings. Wa have used POE-DE tasks to foster active and participatory learning. Since it is crucial to provide students feedback and encouragement throughout the conceptual transformation process (Asterhan & Dotan, 2018) so they may improve and amend their understandings, all process guided by the teacher with a set of dynamic intervention.

Although it is not an easy task to overcome misconceptions and ensure the correct conceptual change in science, as can be seen in Table 7, the significant decrease in students without misconceptions has shown us that POE-DE tasks are quite effective in this regard. It has seen that POE-DE tasks motivate students to think critically and reflect on their own reasoning. Students are pushed to assess their own learning by creating predictions and comparing them to their observations. Additionally, they enabled students to develop their own conceptual comprehend of scientific ideas. Students are asked to participate in the scientific method and provide their own explanations for events rather than merely memorizing facts or taking information at face value. In this research, POE-DE tasks were completed on paper and real materials were designed for each POE-DE task. Students took an active role in the learning process by interacting with the experimental setups designed under the guidance of the teacher, by making discussions, by learning directly and indirectly from the mistakes of themselves or friends. When students take an active role in the teaching process, it is easier for them to remember and self-reflect scientific information (Li, 2023), which is eventually desired in science teaching.

To ensure that students learn the correct concepts about a topic, it is essential to identify previous misconceptions as well (Asghar et al., 2019). Students in the eighth grade are required to have a nuanced comprehension of the mechanical advantage afforded by various types of simple machines. According to the results of the SMCT, the most prevalent misunderstandings among students are determined as follows, Table 9.

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Table 9. Percentage of pupils without misconceptions before and after POE-DE implementation.

	Misconception
1	The effect of the force increases when the place where the force is applied is close to the fulcrum
2	The fulcrum position does not affect the effectiveness of the applied force
3	Fixed pulley reduces the force required to lift an object
4	Pulleys do not move
5	In a single-loop system, the effort required to pull the weight is can not be equal to the weight itself.
6	Leverage systems always reduce the force required to lift an object
7	The direction of the force does not change in leverage systems
8	Moving pulleys always change the direction of the force.
9	Compound pulleys only have moving pulleys
10	In moving pulleys, we have to pull object for less distance to move it a certain distance.
11	Simple machines reduce the amount of the work to be done
12	We wouldn't use simple machines if they didn't reduce force required to lift an object
13	Shorter the inclined plane slant length the less force would be required to lift an object
14	Inclined planes do not change the force required to move an object
15	Inclined planes make no difference in terms of force applied
16	Height doesn't matter on inclined planes, it doesn't make any difference
17	The point of application of the force applied to an object does not matter, it is the amount of force that matters
18	The force applied to the fulcrum of the lever creates a greater effect
19	Screws don't provide a mechanical advantage
20	The direction of rotation of the driven pulleys does not change
21	The way the driven pulleys are connected does not affect the axial rotation
22	Interconnected driven pulleys always rotate an equal number of times
23	The driven pulley with the smaller diameter rotates less, the larger one rotates more
24	Compound pulleys never lower the force needed to lift a load
25	In levers, the fulcrum is the point of application of force
26	In the levers, the force is transmitted to the fulcrum
27	Levers don't reduce the force required to move an object
28	Force is always transmitted towards gravity
29	The effectiveness of levers only depends on the applied force
30	The larger force always determines the direction in which the object will go
31	The length of the effort arms does not make a difference in the effort force

The misconceptions that were identified in the students' answers were obtained mostly in the SMCT results, some of them from the POE-DE forms, and verbal feedback received from the students. It is thought that common misconceptions identified regarding about simple machines in this study will help both science teachers to overcome possible misconceptions and researchers who will study on this topic. It is essential to expose the children's alternative ideas about the principles being taught in the science course, for the instructor to assess those ideas using a variety of activities, and then to appropriately arrange those ideas. To prevent these misconceptions; it is thought that it would be useful to enrich science lessons with correct teaching material, the basic concepts of Simple Machines should be covered before the course and the pre-learning should be solidified, and the distinctive characteristics of simple machines with similar characteristics should be supported with experiments and activities, as well as expressing the concepts encountered in daily life can have different meanings in scientific terms.

Students may experience "disengagement" from the material being taught if the gaps that widen between the ideas they bring to class and the scientifically sound ideas continue to widen (Di Sessa, 1993). 8th-grade students have the skills and potential to go through complex mental processes called "mental experiments" (Brown & Clement, 1987). Science subjects encompass a range of interrelated topics that build upon one another and form a structured progression. As such, it is paramount to accurately identify any misconceptions that students may have developed during their studies and take steps to correct them. This is crucial not only for the development of a deeper and more comprehensive understanding of individual subjects but also for the broader goal of nurturing critical thinking skills and scientific literacy in students. By eliminating misconceptions and structuring subject matter correctly, teachers can help students build a solid foundation of knowledge that will serve as a strong basis for further learning in science and related fields. Ultimately, this will help students develop the skills and competencies necessary to excel in scientific concepts and contribute to the advancement of their future learning, and eventually a better understanding of the natural world.

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5 Conflict of Interest

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6 Author Contributions

Conceptualization, Sıriş, A.B., & Coştu, B.; methodology, Sıriş, A.B.; software, Sıriş, A.B.; validation, Sıriş, A.B.; formal analysis, Coştu, B.; investigation, Sıriş, A.B.; resources, Sıriş, A.B.; data curation, Coştu, B.; writing—original draft preparation, Sıriş, A.B.; review and editing, Coştu, B.; visualization, Sıriş, A.B.; supervision, Coştu, B. All authors have read and agreed to the published version of the manuscript.

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