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Prediction-Observation-Explanation (POE) Method and Its Efficiency in Teaching "Work, Energy, Power" Concepts

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Abstract: With the developing technology educating students free from misconceptions, making sense of their learnings and using them in daily life are primarily aimed. This research is designed not only for teaching "work, energy and power" concepts and the relationships among them but also for investigating the effects of the teaching on students' achievements under the POE method. 6 students from the 9th grade studying at a private Anatolian High School chosen through easily accessible case sampling method, constituted the sample. 4 data collection tools (semi-structured interview, open-ended achievement test, concept map and concept cartoon) were applied. It was carried out within the scope of a single group pretest-posttest simple experimental study, a quantitative research method. For analysing the data, gap and content analysis methods were used. Thanks to the interviews, open-ended achievement test and concept map, as pre-tests, it was determined that students had many misconceptions about "work, energy, power" concepts and didn't have any scientific knowledge about the relationships among them. The students' drawings on these relationships were also far from scientific. After the concept teaching under POE was performed, the data collection tools were re-applied as post-tests. So, it was seen that students' misconceptions were largely eliminated by replacing them with scientifically-correct concepts and relationships as a result of that process. In the light of these findings, applying POE method in concept teaching on different classes, courses or subjects is higly recommended. Some suggestions are also made for the researchers wishing to work in this field.

1. INTRODUCTION

Waking up with many innovations and developments on every day, human has to keep up with them in order to survive. The importance of science is also increasing day by day. Not to be defeated and to be in secure in the economic and technological race that has been going on for centuries, make human follow scientific developments closely. Therefore, science education at schools has become extremely important in the relationship of the human with science. In "Science Curriculum", The Ministry of National Education MoNE (2018) in Turkey has aimed to gain many achievements that students can learn by doing and living and also which are important in terms of cognition, metacognition, sensory and psycho-motor skills. With the teaching of science lesson at schools, it is aimed to raise individuals who can think, research,

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inquire, discover, produce, use information without memorizing, and who are rational, scientific, open to communication and cooperation (Kaptan & Kuşakçı, 2002). However, it is stated that there are many factors that prevent students from reaching these goals in the education and training process, and also negatively affect their success. Misconceptions are foremost among these.

As one of the basic principles of science education, concepts must be structured in mind and associated with different schemes for students' processing information and using it in daily life without getting it ready. Because concepts are also at the heart of science lesson, the correct teaching of the them plays a key role in gaining the aims of science education. In the dictionary, "concept" term is defined as the general design of an object or thought in the mind (TLS, 2019). According to Ülgen (2001) concept is an information form showing the changeable common properties of objects and phenomena that people can visualize and make sense of in their minds. In the light of these definitions, "concept" may be explained as the common name of different kinds of objects which are capable of being transferred and grouped, also portrayed and interpreted in mind. Expressed as mental tools, concepts have a positive effect on people's thinking process and contribute to people not only for distinguishing one event, idea, thought, process from another but also for establishing a relationship by using them (Senemoğlu, 2013). The reason of this is that concepts having common features of objects, events and activities in number and species, have a certain relationship among themselves (Yel, 2015). Concepts, critical for learning in the educational process, reflect the characteristics of the events or objects that have made sense in the mind (Ülgen, 2001). In fact, concepts begin to be learned with the birth of a person. Until the end of human life, this process continuing from "easy and concrete concepts to complex and abstract concepts", will survive. In this period of time, some concepts are learned as a result of daily experiences or coincidences, while others are taught in a planned way in educational environments such as schools (Doğanay, 2005). Concept teaching one of the basic building blocks of the education and training process, is also considered as the first step in the realization of meaningful learning (Temizkan, 2011). In teaching of the concepts which have such a great importance and impact on learning process, several problems may occur.

Concept teaching includes theories such as social linguistics theory, social cognitive theory, constructivism (Baysen, Güneyli, & Baysen, 2012; Bozkurt, 2018; Hammer, 1996; Hein, 1991; Kocaman, 2006; Yağbasan, & Gülçiçek, 2003). In these theories, it is explained that generalization, distinction, definition, induction, deduction and both induction and deduction methods are used together in concept teaching. If concept teaching is not meaningful, some difficulties appear in effective learning.

For example some of concepts may be misleaded while some not being learned at all (Yılmaz & Çolak, 2011). The structures called misconceptions come first among these difficulties preventing learning of the concepts correctly (Byrd, McNeil, Chesney, & Matthews, 2015).

Concepts can be divided into two groups as abstract and concrete concepts. While concrete concepts can be perceived through the sense organs, abstract concepts cannot (Tokcan, 2015). There are many abstract concepts that students must acquire within the scope of science lesson during the education process at schools. If these concepts, which form the basis of science, cannot be understood and interpreted correctly, misconceptions that prevent establishing relationships between events and facts may arise (Ayyıldız & Altun, 2013). In this context, because science concepts have a more complex and abstract structure by its nature, more misconceptions can be seen in science education when compared other fields. The misconceptions defined in many ways in literature, appear when the concepts in human mind don't coincide with the scientifically-correct concepts (Nakhleh & Krajck, 1994). According to another definition, those are the problems which arise as a result of the inability in forming

concepts correctly in a scientific way (Yağbasan & Gülçiçek, 2003). In terms of education, misconceptions are the kowledge incompatible with the scientific facts acquired by students before or during teaching process (Atılboz, 2004). Misconceptions come into view as a result of these misinformation, beliefs or experiences (Yenilmez & Yaşa, 2008). In other words, it is the mismatch between the concept definition created by students in their own minds and the scientifically-correct concept definition (Gönen & Akgün, 2005). In fact, because misconceptions are accepted as a major obstacle in learning the correct concepts, it is widely thought that not having any concepual knowledge is better than having misconceptions. On the other hand, concept teaching reconstructed with correct information, is also effective in eliminating the existing misconceptions (Ecevit & Şimşek, 2017). Because learners form concepts in an integrity in their minds, eliminating misconceptions that are inconsistent with current scientific information, is a difficult task. This integrity is also affected by students' daily experiences. So, these experiences may resist the positive change or development of the concepts. For this reason, possible misunderstandings of students may have a negative effect on their learning of the next concepts (Keçeli & Turanlı, 2013). The wrong concepts that students create in their minds also adversely effect the establishment of healthy connections with the new information or concepts. In other words, if the concepts in students minds are transferred to the learning stages after the existing misconceptions are eliminated, meaningful learning can be achieved (Atılboz, 2004). With the developing technology in the modern world, it is aimed to educate students not only wisely understanding what they learn and use in their daily lives, but also free from misconceptions. When the related literature is analyzed, it is seen that there are misconceptions about the concepts of energy, work, power (Avcı, & Karaca, 2012; Töman, & Çimer, 2016; Yürümezoğlu, Ayaz, & Çökelez, 2009).

Yürümezoğlu, Ayaz, & Çökelez, (2009) have found that middle school 6th, 7th and 8th grade students have deficiencies in structuring the concepts of energy, source of energy, form of energy and transfer of energy in their minds. Töman & Çimer, (2016) in their studies in which the misconceptions about the energy concept of students at different education levels are determined, have concluded that the misconceptions regarding energy issues and its concepts are continuing at every education level. Avcı & Karaca (2016) concluded that pre-service science teachers have misconceptions about the work concept because they cannot distinguish between daily work and physical work and they also confuse the work and power concepts.

Therefore, in order to eliminate misconceptions, the educational environments should be arranged in a manner appropriate for the implementation of new approaches where students' cognitively active participation can be achieved (Ayyıldız & Altun, 2013). As stated above, it is necessary to use a teaching method that is compatible with the features of the concepts which are aimed to be taught (Yel, 2015). In other words, it is important to apply appropriate teaching materials and activities within the framework of the teaching plan for preventing possible misconceptions. Because almost all students already have misconceptions, teaching in an environment where there is no misconception is a like dream for teachers (Koklu & Topcu, 2012). In the light of these data, in order to eliminate them, first of all, it is necessary to determine what causes to the misconceptions. Considering the related literature, many factors affect the students' misconceptions such as lack or insufficiency of prior knowledge, prior experiences and thoughts, the way teachers or textbooks are presented, insufficient concretization, lack of knowledge (Coştu, Ayas & Ünal, 2007). Due to the fact that students' daily lives and speeches are far from scientific, *the inability to interpret words, analogies and symbols correctly; insufficient pre-learnings; insufficient textbooks and materials in terms of content, shape and sampling; not using instructional strategies, methods and activities appropriate to the scientific development level of students* are also considered among the reasons for misconceptions (Aşçı, Özkan & Tekkaya, 2001).

Karaçam, & Gürsel, (2017) in their studies to determine how students mean "lifting force in liquids" in their minds, have found that the students copy the information about buoyancy as they are from sources such as textbooks and / or test books and have more stereotypical images with smooth geometric shapes. In this study, in order to correct the mental structures of the students towards lifting force in the direction of daily life based images, it has been proposed to take measures such as to include visuals based on daily life in materials like textbooks and test books and to organize training activities for teachers to deal with the issues of lifting force. Kurnaz, Tarakçı, Saydam, & Pektaş (2013) have examined the mental models of high school students related to electrification, lightning and lightning, and determined that they made non-scientific models. Researchers suggest using meaning analysis tables to reflect the differences between the three concepts and using conceptual change texts for possible misperceptions.

Many methods are used in both detecting and eliminating misconceptions that have various causes. The most frequently used ones are concept maps, concept networks, conceptual change texts, analogies, computer based learning methods (Atılğanlar, 2014). Apart from these, many methods such as information maps, concept puzzles, meaning analysis tables, word association tests, fishbone diagrams, structured grids, diagnostic branched trees, Vee diagrams, interview, drawings, multiple choice tests, educational games, open-ended success tests are also applied in both teaching concepts and eliminating misconceptions (Akyürek & Afacan, 2012; Başer & Çataloğlu, 2005; Çayan & Karslı, 2014; Tokcan, 2015).

One of the concept teaching process used not only to determine students' current prior knowledges and their scientific consistencies but also to eliminate misconceptions is Prediction-Observation-Explanation (POE) method (Tekin, 2006). As the name implies, POE is implemented in three stages as prediction, observation and explanation. Firstly, at prediction stage, students are requested to make predictions with their justifications regarding the possible outcome of the concept or event presented. By activating the pre-learnings in this way, misconceptions are detected by reaching their missing knowledge or wrong learnings, if any. Secondly, the observation stage which enables effective data collection on the relevant event or concept, is started. At this stage presentations, demonstrations or experiments are made about the event or concept presented to the students. Recording of the observations made before, during and after the experiment is also provided. Finally, at explanation stage the teacher explains the events or concepts according to the findings at the stage of prediction and observation. In other words, in which the lesson is taught, is started (Mpofu, 2006). The appropriate activities performed in the prediction, observation and explanation stages, also provide comprehensive information about students' concept structuring processes (Atasoy, 2002). This study was carried out on high school students and the effectiveness of the POE method was determined in terms of their learning of "work, energy and power" concepts. In this context, there is no study in the literature that is carried out with the POE method for the sample of this research and related concepts. Therefore, the results of the study are important for teaching these concepts. In addition, it is thought that it will be instructive physics and science teachers. This research will contribute to closing this gap in the literature by accompanying many studies on POE activities. It is also believed to be beneficial to scientists who will conduct research in this field.

This research is designed not only for teaching "work, energy and power" concepts and the relationships among them but also for investigating the effects of the teaching on students' achievements under the POE method. For this purpose, answers to the following research questions are sought:

1. What is the preliminary knowledge of the students about "work, energy and power" concepts at the beginning of the concept teaching process within the scope of POE?

2. What is the final knowledge of the students about "work, energy and power" concepts at the end of the concept teaching process within the scope of POE?
3. What are the effects of the POE method applied in teaching “work, energy and power” concepts?

2. METHOD

2.1. Research Model

In this study, the effectiveness of POE method in teaching 9th grade “work, energy, power” concepts was investigated. Unlike other studies, in this study interview about concepts, open-ended achievement test, concept map were used as measurement and evaluation tools in determining students' prior knowledge.

It was carried out within the scope of a single group pretest-posttest simple experimental study, a quantitative research method. This method was used because the 9th grade students in the school which was determined through an easily accessible sampling, had only one branch. In this context, the experimental group was created without the control group. In the cases where experimental and control groups can not be assigned randomly or there is no second group, it is stated that the application of single group research pattern does not constitute a problem for the validity of the research (Trochim, 2001). POE based materials properly developed for the research, were applied to the experimental group and its effects on the experimental group were investigated. In this way, it was aimed to observe the conceptual changes and developments of the students more clearly. In scientific researches, it is thought that the effects of simple experimental method applied on a single group will be high in observing the conceptual changes and developments in the participants (İpek Akbulut, Şahin & Çepni, 2013; Karslı & Çalık, 2012). In the framework of simple experimental method, *pre-tests* to determine students' prior knowledge, and *post-tests* to determine the achievement levels as a result of teaching, were applied. The aim of scientific researches is to examine the success development of the experimental group as a result of the concept teaching, however the obtained data can not be compared with a control group (Çepni, 2010).

2.2. Research Group (Participants)

The universe of this study aiming to teach “work, energy and power” concepts under POE method within the scope of "Energy" unit of 9th grade "Physics" course, contained all the high schools in Samsun province İlkadım district in 2019-2020 academic year. Among those, due to such factors as “easy access, being available at application time, having suitable conditions for the applicaitons” Anatolian High School was chosen through the easy sampling method, one of the purposeful sampling methods (Özmen & Karamustafaoğlu, 2019). Therefore, the study group of the research was formed with 6 students attending the 9th grade in this high school. Given the factors such as material, time and long efforts, purposeful sampling method can be used as the most appropriate method (Patton, 1990). Easily accessible sampling, which is a widely used method in scientific studies, is less costly than other methods. In addition, working with a recognized and known sample is effective in terms of bringing speed and feasibility to the research (Yıldırım & Şimşek, 2013). Taking into account the scientific research ethics, the names of the students participating in the study were not used. For this reason, the students were given such codes as *S*1, *S*2, *S*3, *S*4, *S*5 and *S*6 according to the interview order.

2.3. Process

After the sample was determined, the lesson plans were firstly prepared in order to express each stage of the concept teaching process under POE method in detail. Before the application, not only the achievement test consisting of open-ended questions but also the concept map developed by the researchers, were applied as pre-tests. In addition, a semi-structured interview

was conducted with the aim of determining their memory elements such as episodes, images, propositions and indexes in order to comprehend how the participants put "work, energy and power" concepts into their minds. After reviewing relevant literature, data collection preparations for the interviews were completed and Anatolian High School was visited. The students, teachers and administrators of the school were informed about many subjects such as the purpose of the study, its importance, its contribution to science. Following the necessary approvals and permissions were obtained, the school was visited again and the school administrators were consulted about the place and time for the interviews. As a result of the desired answers, the semi-structured interview form was applied in an empty classroom, suitable for such factors as heat, light, silence, suitability for using, from 14.^{00} to 18.^{00} on 6th January 2020. The questions in the interview form were asked clearly (not having uncertain terms) when the participants felt themselves ready. During the interview the using of the gestures, mimics and words which might direct the participants, were especially avoided. Voice recording was also taken during the interviews to prevent data loss. In order to obtain further and more detailed data interviews, within the bounds of possibility were desired to be kept long, took an average of 30 minutes. After the interviews not only the students for their participation but also the teachers and the school administrators for their sincere support to the research were thanked. The findings obtained from the voice recordings were written down and also checked by an expert lecturer in this field. Therefore, it was aimed to increase the validity and reliability of the research. Researcher diversity may increase validity and reliability of scientific researches (Yıldırım & Şimşek, 2013). The day after the interviews, 7th January 2020, the open-ended achievement test and concept map were applied in the same class from 16.^{00} to 18.^{00}. Students were given 30 minutes for the open-ended achievement test and 3 minutes for the concept map as a response time. Then, open-ended achievement test and concept map documents were taken back and the participants were thanked again. The data obtained through the pre-test interviews, open-ended success tests and concept maps were examined in detail by the researchers. They also played an important role in the preparation of the lesson plans under POE method together with the findings obtained in the light of the literature review. The lesson plans prepared within the framework of POE method for teaching “work, energy, power” concepts and the relationships among them, were applied meticulously by the physics teacher (practitioner teacher) during the teaching period. As stated in the phsics curriculum, concept teaching under POE method in which different activities and practices were carried out at each stage, was carried out in 4 lessons (4 x 40 minutes). The first and second lessons were taught from 10.^{00} to 11.^{30} on 8th January 2020; third and fourth lesson were from 13.^{40} to 15.^{10} on 9th January 2020.

At the prediction stage: At the beginning of the first lesson, the concept cartoon previously developed by researchers, was firstly used. The concept cartoon papers, prepared for the relationships among “work, energy and power” concepts, named as *"Which Button Tells the Truth?"*, were delivered to the students. Therefore, they were asked to find out which button was saying the truth with its explanation by giving 5 minutes as a response time as Figure 1. Thanks to this concept cartoon which highly attracted their attention, the students were both informed about the subject in the framework of the relevant curriculum and their motivation levels were also increased. At the same time, misconceptions of the students to the related concepts were determined.

Figure 1. *"Which Button Tells the Truth?" concept cartoon.*

At the observation stage: The animation video about "work, energy and power" concepts proposed by the Ministry of National Education, was watched at both the first and second lesson. The video paused when tought necessary, and some questions in the form of "What, How, Why, Which,…?" were directed. Therefore, the students' active participation to the observations and better understanding of the concepts and events were provided.

At the explanation stage: After evaluating the prediction and observation stages by comparing each other, instructional activities were carried out by emphasising on many issues such as definitions, uses and relationship of the relevant concepts. At this stage where the subject was taught, *the pendulum test* and *the slide experiment* were performed visually while *table-wall push experiment* was applied practically at second, third and fourth lessons. Through those experiments, the students' active participation in concept teaching process and realization of the subject were aimed. The next day, on 9th January 2020, the achievement test, concept map and concept cartoon used as pre-tests, were applied again in the same order as post-tests from 16.^{00} to 18.^{00}. In addition, a week later than concept teaching process, on 15th January 2020, the semi-structured interview form was applied again from 14.^{00} to 18.^{00}. A relevant transcript was also created. The data obtained as a result of those post-test applications were examined in detail by the researchers and expert opinion was again taken. The data obtained from both pre-test and post-test applications were analyzed with Mann Whitney U Test via an appropriate statistical program. Also, in the analysis of the interviews, appropriate programs headed for the qualitative data analysis were used and the findings were presented in tables.

2.4. Data Collection Tools

"Work, Energy and Power Achievement Test" consisting of open-ended questions, *"Work, Energy and Power Concept Map"*, *"Work, Energy and Power Concept Cartoon"* and *"Work-Energy and Power Semi-Structured Interview Form"* were used as data collection tools in this research where the effect of POE method on the teaching of "work, energy and power" concepts

were investigated. The reason for using more than one data collection tool in this study is to ensure triangulation and to determine how the relevant concepts are learned in depth.

In the light of the relevant literature review and the achievements in the "2018 Physics Teaching Program", expert opinion was also taken in creating of data collection tools and giving them their final shape. The whole concept teaching process under POE method and application of the data collection tools were applied in January 2020.

2.4.1. Semi-Structured Interviews on "Work-Energy-Power" Concepts

The semi-structured interview form, which was used both as a pre-application pre-test and as a post-application post-test, consisted of 12 questions and extra questions directed according to the flow of the interview. In reference to the study's aims, the interview questions included many items related to memory elements (proposition, image, episode etc.) for "work, energy and power" concepts, such as detection, information, explanation and giving examples related to daily life. Also, through the 12th question of the interview, the participants were requested to draw the relationship of the concepts on a blank paper. By considering the achievements in the curriculum, the opinions of a physics teacher, a physics educator and a science educator were taken in the development of the interview questions related to the concepts.

An appropriate qualitative analysis program was used to transcribe, evaluate and analyze the data obtained from the interviews. Findings from the interviews are presented in Table 1, 2, 3 and 4.

2.4.2. "Work-Energy-Power" Open-Ended Achievement Test

The open-ended achievement test used both as a pre-application pre-test and as a post-application post-test, consisted of 6 questions. Participants' responses to open-ended achievement test questions were scored as "full comprehension 5 points", "partial comprehension 4 points", "no comprehension 3 points", "miscomprehension 2 points", "no response 1 point" (Abraham, Gryzybowski, Renner, & Marek 1992). The miscomprehension mentioned above refers to the misconceptions of the students. The findings are presented in Table 5.

2.4.3. "Work-Energy-Power" Concept Map

The concept map used both as a pre-application pre-test and as a post-application post-test, consisted of 2 concept boxes and 1 relationship box. 1 minute, as response time, was given for each of these gaps in the concept map designed according to the relationships among "work, energy and power" concepts. In scoring of the concept map, each concept and relationship box that was answered correctly was given "1" point. Appropriate computer programs were used to create, analyze, evaluate the data obtained from the concept map. The findings are presented in Tables 6, 7 and 8.

2.4.4. Work-Energy-Power Concept Cartoon

Work-Energy-Power Concept Cartoon" was developed to be used in the prediction phase of the activity developed for the POE method. In line with the opinions of a physics educator, a science educator, and a physics teacher, its validity was achieved and therefore applied.

"Which Button Tells The Truth?" consisted of 4 buttons in different colors (red, green, yellow, blue) prepared to show the relationships among "work, energy and power" concepts. Each button contained of different related to these relationships. In the concept cartoon where the "red button" tells the truth, "green, yellow and blue buttons" were located as distractors. The response gap was also reserved at the bottom of the cartoon for students to write down the reasons for the button they chose and 5 minutes was given as response time.

The concept cartoon was used in the prediction stage during the application process as a pre-

test. After the concept teaching was completed, it was reapplied as a pos-test. Therefore, the relationships between the concepts were tried to be determined. Appropriate computer programs were used not only to create concept cartoons but also to analyze and evaluate the obtained data. The findings are presented in Table 9.

2.5. Data Analysis

In this research the obtained data were analyzed through both gap and content analysis methods (Yıldırım & Şimşek, 2013). The relevant findings were also shown in tables. The data obtained from the achievement test and the concept map were analyzed via an appropriate statistical package program. As the sample size was less than 30 participants, "Wilcoxon Signed Rank Test" one of the non-parametric tests, was used to determine whether there is a significant difference between the averages of the measurements made according to the pre-test and post-test results. When the assumptions of the parametric test are not met, "Wilcoxon Signed Rank Test" can be applied for multiple measurements for the relevant sample to determine if there is a significant difference between the averages (Büyüköztürk, 2012). Content analysis is used not only to gather data related to each other within certain concepts and themes but also to interpret them by organizing them in a way that the reader can understand more easily (Yıldırım & Şimşek, 2013).

3. FINDINGS

3.1. Findings Through Semi-Structured Interviews on "Work-Energy-Power" Concepts

Within the framework of the research aims, semi-structured interviews about "work, energy, power" concepts and the relationships among them, were applied to the participants both before and after the application. The students were requested to tell whether they had any experience related to these concepts and to declare them if any. They were also wanted to give examples for the relevant relationships. In that way, it was aimed to detect the misconceptions "already existing" and "after education", if any. These findings analyzed through content analysis method, are presented in Table 1, 2 and 3.

The participants were also wanted to draw relationships among the concepts on a blank paper. Thanks to those drawings, it was aimed to determine students' images related to these concepts. Obtained findings analyzed via content analysis method, are presented in Table 4.

Table 1. *Content analysis results of the interviews.*

Statements	1. Interview						2. Interview					
	Interviewers						Interviewers					
	S1	S2	S3	S4	S5	S6	S1	S2	S3	S4	S5	S6
Work is doing a business.	*	*	*									
Work is making an effort.				*	*							
Work is a profession.						*						
Work is the movement of an object in the direction of applied force.							*	*	*	*	*	*
I played very well in the match, so I did a very good work (Work-related memory).				*								
People in the series I watch, do no work but gossipping (Work-related memory).	*											
I did no work other than playing on the phone last night (Work related memory).					*							
The work done in the animation we watch in the classroom (Work-related memory).								*		*	*	
Pushing the table and pushing the wall experiment (Work-related memory)							*		*			*

Energy is the power needed to do something.	*		*	*		*							
Energy is the force needed to do something.		*			*								
Energy is the capacity of something to do work							*	*	*	*	*	*	
There are renewable and non-renewable energy types.	*	*	*	*		*							
There are nuclear energy types.					*								
There are types of energy as potential and kinetic.							*	*	*	*	*	*	
Potential and kinetic energy can transform into one another.							*	*	*	*	*	*	
They made wind energy tribunes to our district (Energy-related memory).			*										
We had solar panels installed in our house in the village last year (Energy-related memory).					*								
The pendulum experiment shown by the teacher (Energy types-related memory).							*		*			*	
Sliding down the slide experiment (Energy-related memory).								*		*	*		
Power is the force applied to something.	*			*									
Power is the energy spent on doing a work.		*	*			*							
Power is the capacity to do a work.					*								
Power is the work done or energy spent per unit time.							*	*		*	*	*	
Power is the energy spent to do a work.									*				
We won the match because we were more powerful (Power-related memory).				*									
Batuhan punched the door. His hand came from the opposite side because he is very powerful (Power-related moment).		*											
Last night I just played on the phone and slept, so I didn't waste any power (Power-related memory).						*							
Power experiment in animation watched in the classroom (Power-related moment).							*		*	*		*	
Pushing the table and pushing the wall experiment (Power-related memory)								*			*		
Energy and power are spent to do a job.	*			*	*	*							
To do a job, energy is consumed but power does not have to be wasted.		*	*										
There is a top model car. When you put gasoline, its energy is filled and it moves by spending power. The car's movement is a work (Example for the relationship between work, energy and power)	*												
We spend energy to push the table. The powerful one pushes it faster. Pushing the table is a work (Example for the relationship between work, energy and power)					*								
Pushing the table and pushing the wall experiment (Example for the relationship between work, energy and power)							*		*			*	
The animation watched and sliding down the slide experiment(Example for the relationship between work, energy and power)								*		*	*		

In the light of the findings shown in Table 1, it is seen that the participants had misconceptions about "work, energy and power" concepts and the relationships among them in the pre-test interviews. When looked at the post-test interviews, as a result of the teaching under POE, it is understood that misconceptions were largely eliminated. In addition, the images of the participants regarding these concepts are presented in Table 2, as both before and after application.

Table 2. *Participant images for "work, energy and power" concepts.*

Concept	Pre-Application Images	Post-Application Images
Work	Doing a business, making an effort, labouring somewhere, trying hard, profession.	The movement of an object in the direction of force.
Energy	Being energitic, the power used, the force used, chocolate.	The capacity of something to do work.
Power	Difficulty, trouble, force, being strong.	The work done or energy spent per unit time, the energy spent to do a work.

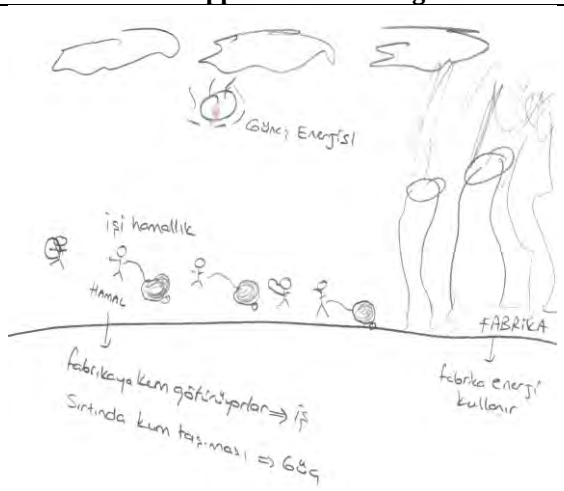
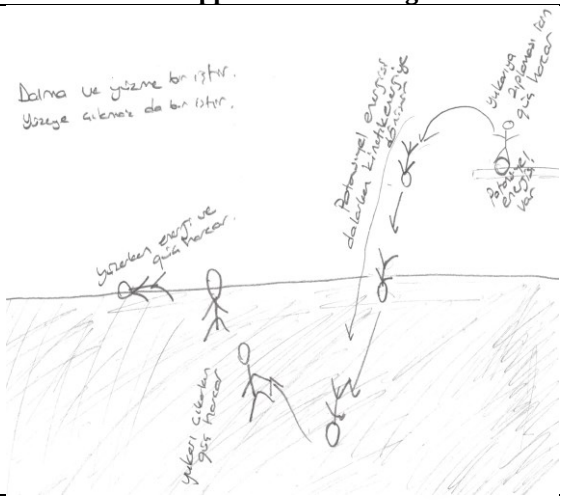
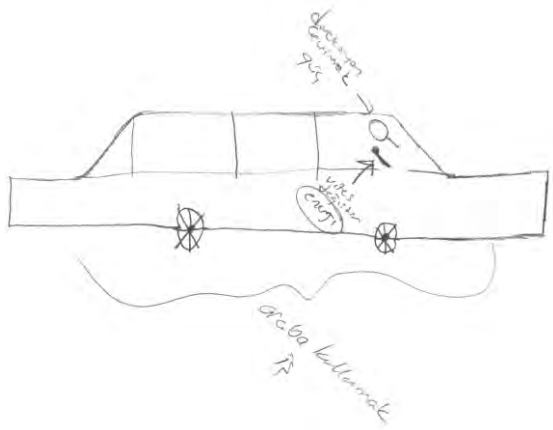
As seen in Table 2, it is understood that the students had misconceptions about "work, energy and power" concepts before the application. In the light of these data, the misconceptions were almost eliminated by turning them into scientific images. However, the statement of a participant (*S*3) on the concept of power as "*It is the energy spent to do a work*" revealed a new misconception. In addition, the episodes of the participants about these concepts are presented in Table 3, as both before and after the application.

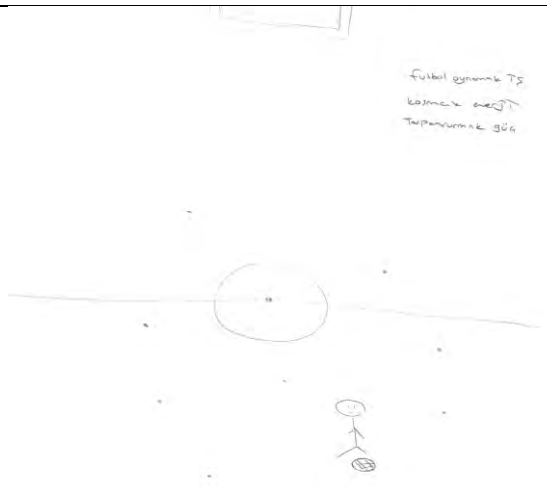
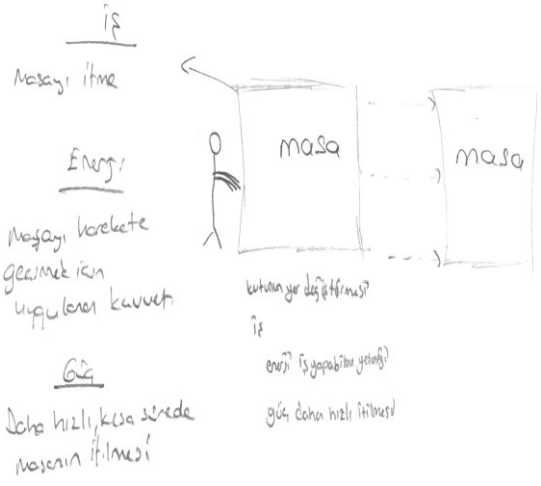
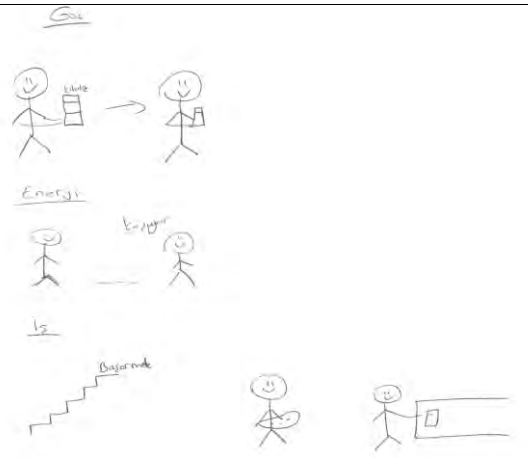
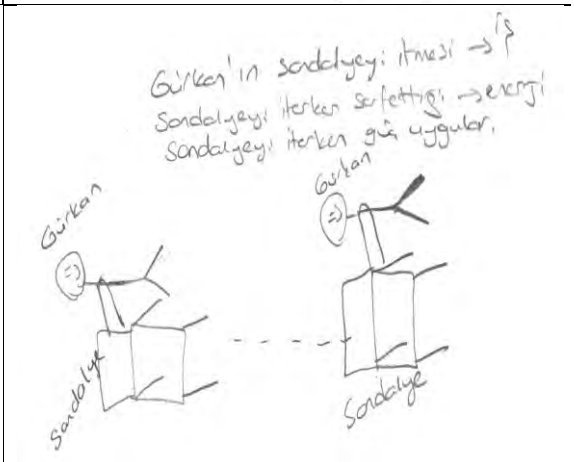
Table 3. *Participant episodes for "work, energy and power" concepts*.

Concept	Pre-Application Episodes	Post-Application Episodes
Work	I played very well in the match so I did a very good work, the people in the series I watch do no work but gossipping, I did no work other than playing on the phone last night, my father and I worked hard in the garden last Sunday, I work hard to be succesfull, I studied very hard to pass LGS exam last year.	The work done in the animation we watch in the classroom, pushing the table and pushing the wall experiment.
Energy	They made wind energy tribunes to our district, we had solar panels installed in our house in the village last year, I spent much energy to finish my homework yesterday, in a documantary I wacthed there a poisinous snake kills other beings via the huge energy in it, I was very tired yesterday and I didn't have a bit of energy.	The pendulum experiment shown by the teacher, sliding down the slide experiment.
Power	We won the match because we were more powerful, Batuhan punched the doo and his hand came from the opposite side because he is very powerful, last night I just played on the phone and slept, so I didn't waste any power, China lost its power because of Coronavirus, BMW is the best car because of its engine power, Ottoman Empire used its power to protect humanity.	Pushing the table and pushing the wall experiment, the animation watched and sliding down the slide experimen.

As stated in Table 3, according to the data obtained in the pre-test interviews, the participants had misconceptions about "work, energy and power" concepts. As a result of the concept teaching under POE, it is seen that the episodes related to these concepts before the application, were replaced by the episodes related to the experiments performed during the lesson and the activities in the relevant video. In addition, the drawings of the participants about the relationship of these concepts are presented in Table 4, as both before and after the application.

Table 4. *Participant drawings for the relationships among "work, energy and power" concepts.*

	Pre-Application Drawings	Post-Application Drawings
S1		
S2		
S3		

S4		
S5		
S6		

As seen in Table 4, only one participant (*S*5) did not draw anything in the pre-test interviews. On the other hand, in the post-test interviews, all the students made drawings about the relationships among "work, energy and power" concepts.

According to the drawings in the pre-test interviews, it is seen that participants had misconceptions about the relationships of "work, energy and power" concepts. As a result of the concept teaching under POE, it is observed that the drawnings related to these relationships before the application, were replaced by thescientifically-correct drawings related to the experiments performed during the lesson and the activities in the relevant video.

3.2. Findings Through the Open-Ended Achievement Test

Frequency tables related to the participants' comprehension levels of the concepts are created according to the pre-test and post-test data and presented in Table 5.

Table 5. *Participants' comprehension levels frequencies related to the pre-test / post-test results.*

Questions	Comp. Levels / Tests	N	FC f	PC f	NC f	MC f	NR f
What is work? Explain, please.	Pre-test	6	0	0	0	6	0
	Post-test	6	6	0	0	0	0
What is energy? Explain, please.	Pre-test	6	0	0	1	5	0
	Post-test	6	6	0	0	0	0
What are energy types? Explain, please.	Pre-test	6	0	5	0	1	0
	Post-test	6	5	1	0	0	0
What is power? Explain, please.	Pre-test	6	0	2	0	4	0
	Post-test	6	5	0	0	1	0
Is there a similarity or difference between work-energy-power concepts, if so, how is it? Explain, please.	Pre-test	6	0	1	0	5	0
	Post-test	6	3	3	0	0	0
Give examples for the relationship of work-energy-power concepts from daily life, please.	Pre-test	6	0	4	0	2	0
	Post-test	6	4	2	0	0	0
TOTAL	Pre-test	6	0	12	1	23	0
	Post-test	6	29	6	0	1	0

N: Sample number, *f:* Frequency, *FC:* Full comprehension, *PC:* Partial comprehension, *NC:* No comprehension, *MC:* miscomprehension, *NR*: No response (Abraham, Gryzybowski, Renner, & Marek 1992).

As can be seen in Table 5, there is an increase in post-test results compared to the pre-test results in all questions at full comprehension level. While the score of full comprehension level is 0 (zero) point in pre-application, it increases 29 x 5 = 145 points after application. This situation can be interpreted as a result of the success of the teaching in the elimination of the misconceptions. Although there isn't any change in the 1st and 2nd questions at the level of partial comprehension, a decrease in post-test results, from 12 to 6, is observed in the 3rd, 4th, 5th and 6th questions compared to the pretest results. While the pretest partial comprehension score was 12 x 4 = 48 points, the posttest score, declining 50%, was 6 x 4 = 24 points. This result can be interpreted as the concepts known as "partially" were largely learned "full" at the end of the application.

Merely in the 3rd question, only one student is at the level of no comprehension. 1 x 3 = 3 points obtained in the pre-test turned into 0 (zero) point in the post-test thanks to the elimination of the misconception after the application. In other questions, there aren't any students at "no comprehension" level both in the pre-test and post-test.

In all questions at the miscomprehension level, the frequency number was 23 and the score was 23 x 2 = 46 points before the application. This shows that students had many misconceptions within the frame of questions before the concept teaching under POE method was applied. As a result of the application, the frequency of the miscomprehensions decreased from 23 to 1 and the score also decreased to 2 points. These show that the concept teaching applied within the scope of POE was successful and so the misconceptions were largely eliminated. Since the students answered all questions, there isn't any participant at "no response" level in both the pre-test and post-test applications.

3.3. Findings Through the Concept Map

In the teaching process in order to eliminate misconceptions under POE method, the developed concept map was used as both a pre-test and a post-test. In the evaluation of concept maps, each concept and relationship box answered correctly, was given "1" point. The obtained results are presented in Table 6.

Table 6. *Concept map scoring table.*

Participants	PRE-TEST			POST-TEST		
	1. Concept Box "Potential energy"	2. Concept Box "Power"	Relationship Box "Because of the action of a substance"	1. Concept Box "Potential energy"	2. Concept Box "Power"	Relationship Box "Because of the action of a substance"
S1	0	0	0	1	1	0
S2	0	0	0	1	1	0
S3	0	0	0	1	1	1
S4	0	1	0	1	1	1
S5	0	0	0	1	1	1
S6	0	1	0	1	1	1
Total Points	0	2	0	6	6	4

As seen in Table 6, none of the 6 students could correctly answer the first concept box (potential energy) and the relationship box (because of the action of a substance) in the concept map used as pre-test. Except for two students (*S*4 and *S*6), the second concept box (power) was also replied incorrectly. Thanks to the concept teaching performed under POE method, both the first and second concept boxes were answered correctly by all the participants. Except two students (*S*1 and *S*2), they also answered the relationship box correctly. Considering the pre-test (2 points) and post-test (16 points) scores, it can be said that the concept teaching conducted within the scope of POE was successful and largely eliminated the misconceptions.

In order to determine whether there is a significant difference between pre-test and post-test results, "Wilcoxon Signed Rank Test" was conducted related to the achievement test and concept map scores. The test results are presented in Table 7.

Table 7. *The results of "Wilcoxon Signed Ranks Test" related to the pre-test and post-test scores of both academic achievement test and concept map.*

Test Type	Pre-test and Post-test Measurement	N	Rank Average	Rank Total	*z*	p^*	*r*
Achievement Test	Negative Ranks	0	0.00	0.00	-2.271	0.02	0.93
	Positive Ranks	6	3.50	21.00			
	No Difference	0					
Concept Map	Negative Ranks	0	0.00	0.00	-2.251	0.02	0.92
	Positive Ranks	6	3.50	21.00			
	No Difference	0					

$p<0.05$

When Table 7 is examined, a significant difference was found between the pre-test and post-test scores of the academic achievement test and concept map in favor of the post-test scores ($z = -2.271$, $p < 0.05$).

In addition, not only the pre-test and post-test mean but also standard deviations related to the open-ended achievement test and concept map were calculated. The relevant descriptive statistics are shown in Table 8.

Table 8. *The results of descriptive statistics related to the pre-test and post-test scores of both academic achievement test and concept map.*

Measurement	Test Type	N	$\bar{X}$	SD
Pre-test	Academic Achievement Test	6	16.17	2.23
	Concept Map	6	0.17	0.41
Post-test	Academic Achievement Test	6	27.83	2.48
	Concept Map	6	2.67	0.52

N: Participant Number

In the light of the findings in Table 8, in both pre-test and post-test applications, it is seen that there is a significant change in the academic achievement test consisting of open-ended questions, and concept map. This increase in favor of the post-test, shows that the concept teaching under POE was successful both in learning of the concepts and in eliminating the misconceptions.

3.4. Findings Through the Concept Cartoon

The concept cartoon with four buttons in different colors designed for the relationships among "work, energy and power" concepts, was used both as a pre-test and a post-test. The results obtained from the concept cartoon, "Which Button Tells th Truth?", are shown in Table 9.

Table 9. *The results of "Which Button Tells the Truth?" concept cartoon.*

Participants	PRE-TEST				POST-TEST			
	Red Button	Green Button	Yellow Button	Blue Button	Red Button	Green Button	Yellow Button	Blue Button
S1		*			*			
S2				*				*
S3	*				*			
S4		*			*			
S5		*				*		
S6	*				*			
Total	2	4	0	1	4	1	0	1

Red Button: The person who spends more power, does more work and spends more energy at the same unit time, Green Button: The person who spends more power, does more work but spends less energy at the same unit time, Yellow Button: The person who spends more power, does less work but produces more energy at the same unit time, Blue Button: The person who spends more power, does less work and produces less energy at the same unit time. "Red button tells the truth"

Looking at Table 9, only two students in the pre-test found the correct answer by marking the red button without explaining their reasons. On the other hand, 3 students answered as green button and one as blue incorrectly. No student chose the yellow button. Two students who answered correctly in the pre-test (*S*3 and *S*6) also chose the red button by explaining the correct reason in the post-test. Two students (*S*1 and *S*4) who chose the green button in the pre-test

gave the correct answer by explaining the red button in the post-test. Thus, the number of those who answered correctly in the pre-test increased at 50% in the post-test. Two students (*S*2 and *S*5) who gave the wrong answer by choosing the blue and green button in the pretest did not find the correct answer in the posttest by giving the same answers.

Increasing the correct answers in the pre-test from 2 to 4 in the posttest, with an 50% increase, and 4 students explaining their responses' reasons correctly (that was zero in pre-test) show that the concept teaching performed within the scope of POE was effective in eliminating misconceptions.

4. DISCUSSION, CONCLUSION

This study is designed to investigate the effect of POE method on teaching "work, energy and power" concepts in "Energy" unit of 9th grade Physics course. 4 data collection tools (semi-structured interview form, open-ended achievement test, concept map, concept cartoon) which were applied both as pre-test and post-test, were used to determine and eliminate misconceptions. According to the findings obtained from these data collection tools, this section is presented in 4 subtitles.

4.1. Discussion and Conclusion Related to the Findings Through Semi-Structured Interview Form

The semi-structured interview form involved many items related to "work, energy and power concepts" such as the describing, explaining of the participants' memory elements (proposition, image, episode etc.) and associating them with daily life. It consisted of 12 questions and extra questions directed according to the flow of the interview. Moreover, through 12th question of the interview, the participants were asked to draw about the relationship of "work, energy and power" concepts on a blank paper.

In the interviews applied as a pre-test, analyzes were made within the framework of the images at Table 2, episodes at Table 3 and the drawings on the relationships among these concepts at Table 4. In this context; it is determined that they had many misconceptions about these concepts such as:

- Related to "work" concept, *"Work is a profession."* and *"I didn't do any work other than playing on the phone last night.",*
- Related to "energy" concept, *"Energy is the force needed to do something."* and *"Energy is the force needed to do something.",*
- Related to "power" concept, *"Power is the capacity to do a work."*and *"We won in the match because we were more powerful."*

The same interview form was reapplied after the concept teaching under POE. While there are no students (zero) who can correctly define the concepts of work energy and power in the pre-test, as a result of the teaching, all the students (six) have correctly defined these concepts in the post-test. In addition, it is concluded from their expressions and drawings regarding these concepts' relationships that "there is a scientific change in students' images and episodes", "there is a significant increase in their comprehension of the concepts" and "the existing misconceptions have substantially been eliminated".

Concept teaching with the POE method reveals the deficient or incorrect prior knowledge of the students. This situation may arise from the fact that POE is a method that enables the structuring of the concept in the mind and increases motivation and so can achieve meaningful learning (Bilen, 2009; Özdemir, 2011). The high desire and motivation of the students during the application stages of the POE method and thereby getting very quick and successful results in correcting the misconceptions support this information.

4.2. Discussion and Results Related to the Findings Through Open-Ended Achievement Test

In the open-ended academic achievement test prepared for “work, energy and power” concepts and the relationship of them, contained 6 questions as “What is work? Explain, please.”, “What is energy? Explain, please.”, “What are energy types? Explain, please.”, “What is power? Explain, please.”, “Is there a similarity or difference among work-energy-power concepts, if so, how is it? Explain, please.”, and “Give examples for work-energy-power concepts from daily life, please.” were directed to the participants.

When the statements of 6 participants towards those 6 questions are analyzed, it is seen that none of the answers given is at the level of “full comprehension”. In addition, 12 of the 36 responses in total are at the level of “partial comprehension” and only 1 is at “no comprehension” level. The remaining 23 answers at the level of “miscomprehension” proves students’ misconceptions before the application. In this context, when we look at the answers given by students to the level of misunderstanding it is seen that they had many misconceptions such as;

- Related to “work” concept, “Work is an event related to energy and movement.” and “Taking a glass and put it from one place to another is a work”,
- Related to “energy” concept, “Energy is what is spent to do a work.” and “For example, we spend energy while running”,
- Related to “energy types”, “There are renewable and non-renewable energy types.” and “To illustrate, chocolate is a type of energy that cannot be renewed because it ends when you eat it”,
- Related to “power” concept, "Power is the force applied to do a work." and "For instance, for lifting this table, power is necessary",
- Related to the relationship of “work, energy and power” concepts, “There is a relationship between them. Because the person who does a work both spends energy and applies power”,
- To exemplify the relationship of “work, energy and power” concepts from daily life, “For example, lifting a desk is a work which both requires energy and cannot be done without power”.

There aren’t any students at “no response” level in both pre-test and post-test applications. After the concept teaching conducted within the scope of POE, the same success test was applied again. Looking at the answers given, it is seen that while no answer was given at "full comprehension" level in the pre-test, 29 of the 36 answers in total were at "full comprehension" level in the post-test. In the post-test not only the answers at "partial comprehension" level decreased from 12 to 6 but also the answers at the level of "miscomprehension" decreased from 23 to 1.

These answers were scored as "full comprehension 5 points”, “partial comprehension 4 points”, “no comprehension 3 points”, “miscomprehension 2 points”, “no respond 1 point". In this context, the pre-test score of the test was calculated as 85 and the post-test score as 171.

When the statements of 6 participants for these 6 questions are analyzed, it is seen that the number of correct answers, which was 0 (zero) at "full comprehension" level in the pre-test, increased to 29 in the post-test. The answers at "partial comprehension" level decreased to 6. The aimed concepts were taught at the level of "full comprehension" at 80.55%. Therefore the rate of the “partial comprehension” level in post test was decreased from 33.66% to 16.66%. These results show that the concept teaching under POE was successful. In addition, the fact that post-test scores’ rising 171 from 85 proves this result.

On the other hand, the answers’ at "miscomprehension" level decreasing from 23 to 1 in the

post-test shows that the current misconceptions regarding the concepts of work, energy and power were eliminated at 95.76%. These results show that the concept teaching was successful both in determining and eliminating misconceptions arising from students' incomplete or incorrect learning. It was also efficient in establishing close relations between the concepts.

Considering the academic success of the students in the literature review, it is seen that the applications carried out under POE method, have a more positive effect compared to the traditional teaching methods (Chew, 2008; Palmer, 1995; Özdemir, 2011). The fact that the scores in the achievement test used in this research, increased approximately twice in favor of the post-test and the fact that the misconceptions were eliminated at 95.76% support this information.

4.3. Discussion and Conclusion Related to the Findings Through Concept Map

In the concept map designed for this study, the students' were given 3 minutes as response time. In the case that the first concept box were replied as "Potential energy", the second concept box as "Power" and the relationship box as "Because of the action of a substance", 1 point was given to each concept box and relationship box. As a result of the answers given by 6 participants to these three boxes, the pre-test score of the concept map was calculated as 2 out of 18 full points, and the post-test score was 16 points.

In the concept map applied as a pre-test, two of the three boxes (the first concept box and the relationship box) could not be answered correctly by any student, while only two students (*S*4 and *S*6) could answer the second concept box correctly. In contrast, in the post-test, all students answered the first and second concept boxes correctly, while only two students (*S*1 and *S*2) answered the relationship box incorrectly. In line with these data, it is seen that the concept teaching within the scope of POE was successful and the existing misconceptions were eliminated at 88.88%. The post-test concept map test scores' increasing to 16 from 2 proves this result.

POE method makes the necessary environment suitable for students in realizing scientific process skills such as using knowledge, using mental skills in order to judge the problem and organizing the results achieved (Anagün & Yaşar, 2009). As it shows the importance of students' being related to daily life, this feature of POE is remarkable in terms of concept teaching. In addition, Ayvacı and Özbek (2015) draw attention to the importance of teaching features of science in terms of providing students with scientific thinking skills and creating a positive perspective towards science.

POE is a predictor for success because of its affective characteristics such as being enjoyable, fun, intriguing, motivational also increasing the desire to strive and act carefully (Mısır, 2009; Özyılmaz, 2008). In this study, it was observed that students were willing to eliminate existing misconceptions and to learn "work, energy and power" concepts during the concept teaching process conducted within the scope of POE. The fact that the scores in the concept map test applied in this research, increased eight times in favor of the post-test and the fact that the misconceptions were eliminated at 88.88% support those expressions in literature.

4.4. Discussion and Conclusion Related to the Findings Through Concept Cartoon

"Which Button Tells The Truth?" concept cartoon used both during and after the application, consists of 4 buttons in different colors (red, green, yellow, blue) prepared to show the relationships among "work, energy and power" concepts. The button in each color, consists of different sentences containing the relevant relationships. Also, the response gap is reserved at the bottom of the cartoon for students to write down the reasons for the button they chose. In the concept cartoon where the "red button" tells the truth, "green, yellow and blue buttons" are located as distractors. The statements in these buttons are presented below:

- *Red Button*: The person who spends more power, does more work and spends more energy at the same unit time,
- *Green Button*: The person who spends more power, does more work but spends less energy at the same unit time,
- *Yellow Button*: The person who spends more power, does less work but produces more energy at the same unit time,
- *Blue Button*: The person who spends more power, does less work and produces less energy at the same unit time.

Concept cartoon was used for the first time in the prediction stage at the beginning of the lesson. In pre-test, only two students wrote the red button which was the correct answer, but both of them failed to explain the reason. After the concept teaching under POE, two students (*S*4 and *S*6) who wrote green button in the pre-test changed their answer and chose the red button as the correct answer. Thus, a total of four students answered correctly and also explained the reason correctly. On the other hand, two students who chose blue button (*S*2) and green button (*S*5) in the pre-test gave the same answers in the post-test.

In this context, as a result of the concept teaching conducted under POE, although the misconceptions of the four students were eliminated, there was no change in the two students' answers. Considering the fact that there is an increase of fifty percent in the number of correct answerers according to pre-test and the explanation of the reasons for their answers correctly in post-test, the teaching can be considered successful.

Concept cartoons are visual tools that are prepared to view a scientific concept from a different wiewpoint in the form of discussion through their characters (Koch, 2010). When POE is used especially for the teaching of science concepts, it is important for students to question the nature of the concepts and to realize the changes in their own ideas. In this way, it increases learning and understanding of concepts (Kabapınar, Sapmaz & Bıkmaz, 2003; Köseoğlu, Tümay & Kavak, 2002, Liew, 2004). In the concept cartoon applied in this study, the number of those who chose the red button, where the relationships of "work, energy and power" is correctly expressed, increased from 2 to 4 in the post-test. Moreover the number of correct explanations of the reason for choosing the red button increased from 0 to 4 in the post-test. These results support the statements in literature.

On the other hand, the fact that students do not want to accept new information in some cases prevents correcting misconceptions (Torosluoğlu Çekiç, 2011). For this reason, replacing misconceptions with correct information is considered to be a very difficult task (Başer & Çataloğlu, 2005; Çaycı, 2007; Osborne & Freyberg, 1985; Özdemir, 2012). Two students who gave the wrong answer by choosing the green and blue buttons and could not explain the reasons in the pretest. They also chose the green and blue buttons in the posttest by not explaining the reasons correctly. This result which means that the existing misconceptions of the two students, unlike other four students, weren't eleminated is in parallel with these expressions in the literature.

Apart from these, observing after the prediction stage, was very effective on students' learning. During the observation stage, thanks to the demonstrations and experiments which increased both motivation and participation, the teaching process became conceptually rich. At explanation stage, not only the comparison of the predictions with the observations but also the active using of the predictions, information and findings, supported the conceptual meaning and learning while the concepts and their relationship were being taught.

As a result of the findings obtained through these tools used as pre-test and post-test, most of the misconceptions were eleminated by replacing them with the scientifically-correct concepts. In addition, it can be concluded that the concept teaching was successful in terms of memory

elements such as image, episode, and in this context, students were also positively affected in terms of perception, attitude and behavior.

Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the author(s).

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