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INVESTIGATING THE EFFECTIVENESS OF PREDICT-OBSERVE-EXPLAIN STRATEGY ON TEACHING PHOTO ELECTRICITY TOPIC

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Abstract. *In this study, Predict-Observe-Explain (POE) strategy was introduced and its effectiveness was investigated with respect to prospective science teacher opinions on an experimental activity, during the implementation and at the end of the process. The study was implemented to a group of 16 science and technology education program prospective science teachers. The research data was obtained with the analysis of worksheet and the results of experimental discussions with prospective science teachers. The developed experimental activities were conducted over the "Experimental Worksheet" including the stages of pre-experiment (prediction), experiment (observation), and post-experiment (explain) according to the POE strategy. Finally, between 10-12 min time discussion environment was prepared for 4 different groups. At the end of the study, evaluations were realized on applicability of POE and it was concluded that the developed activity according to the POE was effective and attractive in learning the science concepts.*

Key words: *conceptual change, experiment design, misconceptions, predict-observe-explain strategy, photo electricity.*

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Introduction

The science teaching has been included almost in all school curriculums since enables to raise scientifically literate individuals who are able to search, experiment, observe, and develop positive attitudes through scientific processes (Çilenti, 1985; Ayas et al., 1997; Legendre, 1997; Akdeniz & Devecioğlu, 2001). According to Topsakal (1999), the science is scientific thinking and practicing those scientific thoughts. For this reason, objects and events in nature have been investigated in science classes (Turgut et al., 1997). In order to comprehend science lessons permanently and practice them in daily life, students should learn in laboratories through practicing and ensure information integrity through adding new information on daily life.

Laboratories provides students to learn, develop motor skills besides forming images and experiences in order to comprehend known or to be known information (Gunstone & Champagne, 1990; Özdemir, 2011). Any branches of science could not be taught without placing any experiments. The cognitive overload to convert abstract concepts into concrete concepts and lack of connection with the real life situations for the theoretically transferred issues affect the efficacy of science teaching. Learning of students how to use theoretical information into practice is possible through laboratory approaches. The quotation of "I hear and I forget, I see and I remember, I do and I understand" which makes this situation a slogan summarizes the situation in a very effective way. In order to realize this, students need to find themselves in a fun and exciting learning environment. That kind of environment nevertheless can be laboratories. In these days, laboratory approaches have been used during the transfer of theoretical backgrounds into the laboratory environment.

Both included overloaded issues into the physics curriculum and insufficient time predictions to teach the chapters, activities become harder to connect with real life situations in science classes and students may lead to memorize the concepts (Tunçer & Eryılmaz, 1997; Golin, 2002; Oh, 2010). In the current education system, at 12th grade level, the issue of photo-electricity in the content of light theories is one of the issues that the students could not be able to imagine in their minds easily. The necessity of placing more emphasizes on practical works which enable to convert those kinds of abstract concepts included issues into the concrete issues and to exhibit real situations are stand out (Foong et al., 2009; Gemici et al., 2000; Guo et al., 2009; Azarov et al., 2008). It has seen that the inadequacy of studies on abstract concepts which could be hard to learn, imagine in mind, enable students to develop scientific process skills, and solve the problems that they have faced and the necessity of those kinds of studies.

On the other hand, photo electricity is one of the issues that require cognitive thinking and comprehension activities because of including abstract concepts. If students percept that the information about the photo electricity is not abstract on the contrary it is directly related with their own life, students learn the issue more meaningfully since they give more importance. Even, this relation makes easy to learn (Kearney et al., 2001; Çepni, 2005). For example, all of the elements that photo electric events happen are known as "photocell". They are used for different purposes with respect to their features. The control of street lamps according to day light, door automats, color difference in printing, control systems to stop the elevators, measurement of chimney smog density and blurt of liquids, counters which are used to count huge number of subjects, automated stop when the hands entered to the inside of the machine in press for the sheet cutting guillotines etc. are the most majority of the areas that the photocells have been used. For this reason, the interests and attitudes of the students positively change since they see photo electricity has been used in daily life.

However, the teaching of photo electricity event has usually been explained through traditional methods in schools. In traditional methods, teacher prompts the word explaining concept, the verbal identification of the concept, distinctive and similar features of the concept in order to enable the comprehension of the identification for the students and require students to find samples compromising the conception or out of concept scope. This method is also known as the deductive approach. The obtained results of findings from the studies conducted on conceptions indicated that teachers have used the traditional method incomplete and mistakenly however the most majority of teachers prefer to use for concept teaching (Coştu, 2002; Çalık, 2003; Coştu et al., 2002; Kearney, 2004; Kurt & Akdeniz, 2003; Köseoğlu & Kavak, 2001). On the other hand, there are different teaching methods in order to make effective concept teaching, remove misconceptions, and obstruct the formation of misconceptions. There are a lot of methods such as conceptual change text, concept maps, concept cartoons and Predict-Observe-Explain (POE).

In recent times, the method of POE has been widely used in order to identify misconceptions (Boo & Watson, 2001) and perform effective concept teaching (Liew & Treagust, 1995). The method of POE requires students predicting the result of the events in the science activities prepared by the researcher with its reasons, observe the event, and make explanations to remove the contradictions between predictions and observations (White & Gunstone, 1992). The most important feature of the POE method is providing the use for students to support their predictions through benefiting their existing knowledge and experiences of similar events that they encountered in their daily life. Also, POE is more powerful from the point of science training with respect to other general approaches since providing opportunities to inquire the nature of scientific events (Gunstone et al., 1988).

With this aim, it has been believed in the necessity of formation of learning environments in which students have access to the information by themselves and design of teaching situations that enable to realize meaningful learning in order to convert the abstract concepts of photo electricity issue into the concrete concepts and remove students existing misconceptions. On the other hand, the researches propounded that the laboratory lessons conducted through traditional methods were not effective enough to teach science conceptions (Ayas et al., 2005) and offered to take the benefit of modern laboratory approaches in the teaching of science conceptions (Yeşilyurt, 2003; Kurt & Akdeniz, 2004; Ayvacı & Devecioğlu, 2006). In this meaning, there is a strong need for the researches that investigate whether or not the POE method is effective for the teaching of photo electricity issue. From this point, this study taught as an original study.

The Implementation Process of Predict- Observe- Explain Strategy

Prospective science teachers are required to predict for some kinds of relevant events, test these predictions, and construct their information through focusing on fundamental conceptions (Moss & Cornely, 2001). From this point, the approach is based on the technique of Predict-Observe-Explain offered by the Gunstone and Champangne (1990) (White & Gunstone, 1992; Bodner et al., 1998). The implementation of POE performed in three stages. Those stages briefly explained in below.

*i) The stage of prediction***:** Before the experiment, prospective science teachers are asked questions in order to attract their attention and identify their prior knowledge. Prospective science teachers try to predict unknown by using their known knowledge through performed group discussions in order to suggest a hypothesis. If there are some contradictory hypothesis arising from one group, prospective science teachers go to the next step, which is experimental study, more curious and enthusiastic. In addition, prospective science teachers try to find evidences to support their hypothesis.

*ii) The stage of observation***:** At this stage, prospective science teachers are expected to construct their experimental settings by using materials in laboratory environment and helping to other group members in order to verify the hypothesis that suggested by the prospective science teachers at first stage. The method of POE enables to make relation between the experiment and hypothesis suggested by prospective science teachers. In this process, prospective science teachers should study in small groups and those small groups frequently should check their hypothesis through discussing in each other. In this way, prospective science teachers have the opportunity to work together and to be more achievable by making collaboration. At the end of this stage, prospective science teachers in each group are expected to write down their own individual hypothesis to the related field on their worksheets.

*iii) The stage of explanation***:** At this stage, prospective science teachers need to make explanations in order to remove the contradictions between the observations and predictions in the activity prepared by the researcher. Thus, prospective science teachers become aware of their misconceptions related to the issue. Prospective science teachers take an active role in all stages of the POE. Since the approach addresses to senses and enables to use more than one sense, learning could be easier. In each stages of POE, high level skills could be developed (Gunstone & Champangne, 1990). The method of POE requires prospective science teachers predicting the result of the events in the science activities prepared by the researcher with its reasons, observe the event, and make explanations to remove the contradictions between predictions and observations.

For this reason, seven experiments included worksheets were designed according to POE for the understanding of photo electricity event. Each experiment was included the stages of predict, observe and explain. At predict stage, engaging to issue, remarkable, and intriguing questions asked to prospective science teachers about the photo electricity. Then, observe stage was followed. At this stage, prospective science teachers were required to write their observations by doing experiments. After this stage, explain stage was followed. At the stage of explain, prospective science teachers were required to write contradictions through comparing the results of predict and observe. Thus, prospective science teachers become aware of their misconceptions.

The Aim of the Study

The aim of this study was to explore the implementation of POE technique into an experimental activity developed for the photo electricity issue and determine how experimental activities changed the knowledge level of prospective science teachers on the issue of photo electricity.

Methodology of Research

Research Design

The case study approach was adopted for this study. The case studies are the researches that enlighten the phenomena through deeply investigating only one sample (case situation) belongs to

definite phenomenon. On the other hand, this method was adopted since providing the opportunity to explain very little details for the researcher through linking cause-effects and variables mutually (Çepni, 2011; Ekiz, 2003).

Sample of Research

The study was implemented to sixteen second grade science and technology education program prospective science teachers at the Fatih Faculty of Education, Karadeniz Technical University, Trabzon in the spring semester of 2010-2011 education and training years. The research sample of this research was identified by using the easily accessible sampling method. This sampling method gives speed and practicality since in this method researcher selects easily accessible situation (Yıldırım & Şimşek, 2006). All the participants were taught photo electricity in high school level. At university grade 2 in spring semester, prospective science teachers have a course titled as Introduction to Modern Physics which enables for prospective science teachers to learn about fundamental subjects of modern physics.

Instrument and Procedures

The research data was obtained through the investigations of worksheets and discussions of preservice teachers on the results of the activities.

Implementation Stage: The study was conducted in those steps.

1. Both including overloaded issues into the physics curriculum and insufficient time predictions to teach the chapters, activities become harder to connect with real life situations in science classes and students may lead to memorize the concepts (Tunçer & Eryılmaz, 1997). First, the secondary education physics curriculum was investigated and the photo electricity issue was selected since including abstract concepts which are hard to understand almost by every preservice teachers.
2. The fundamental features of the method were investigated with the aim of teaching the concepts of photo electricity issue through POE method. According to this "*A student worksheet*" was developed in the form of activity page including the stages to conduct and questions to respond for prospective science teachers. The questions in the worksheet were responded with respect to the stages of POE. At this stage, worksheet was developed to provide the written information record with the idea of prospective science teachers were not able to provide enough information from the classroom discussions during the implementation process of the approach. The worksheet was used to get the responses in the written form.
3. The study was conducted by the guidance of a teacher. The theoretical information on photo electricty was written in the worksheet and presented by the teacher. During the teaching of photo electricity issue, the necessary information were given such as loading the electroscope with positive (+) and negative (-) charge before the activities to implement the POE method. Before the activity, a small presentation on photo electricity was done to provide necessary theoretical information. Thus, prospective science teachers were acquired the necessary cognitive and psychomotor skills before the activity.
4. Four different groups were identified with 4 persons in each.
5. Prospective science teachers were explained on the content of the implementation and the importance of the group discussions. The groups were required to write their common ideas at the end of the study.
6. At the end of the implementation, it was aimed to obtain the data about prospective science teacher learning on cognitive field through investigating the worksheet used by the prospective science teachers. The worksheet was categorized according to the stages of POE. In findings part of the worksheet, the general statements of prospective science teachers were presented in quotes. According to Marriam, the presentation of the statements which are directly related to research problem could enable the reader to interpret the meaning of

data (Merriam, 1988). In tables created for some questions, some of the prospective science teacher quotas categorized and presented in frequencies.

7. Finally, a short period (10-12 minutes) discussion environment was prepared for 4 different groups. It was enabled to reach to the common idea for each activity in separate. Thus, the ideas and opinions of the prospective science teachers were tried to be identified on implementation.

Results of Research

Actions during the Process of Data Obtaining

In this section, the findings obtained from prospective science teacher responses and questions asked were presented by considering similar aspects of prospective science teacher responses.

Before the activity, prospective science teachers were aware of the taken actions by asking questions such as "What is photo electricity?" and "Where do we encounter with photo electricity in our life" to attract the prospective science teacher attention and investigate their previous knowledge. Each section was included the stages of predict, observe, and explain in itself. In the first questions of each activity, prospective science teachers were required to make hypotheses about the activities that they are going to make, then discuss this hypothesis in groups, and note their personal decisions that they reached at the end of the discussions. In general, it was observed that the prospective science teachers participated to group discussions, effective group discussions are preformed and prospective science teachers tried to discuss their opinions. At the end of the group discussions, prospective science teachers were required to present their opinions to the class. For this aim, it was expected to announce one of the prospective science teachers to talk from each group on behalf of the group and present the predictions. The participant prospective science teachers were coded as T1, T2, T3, …, and T16.

Activity-1

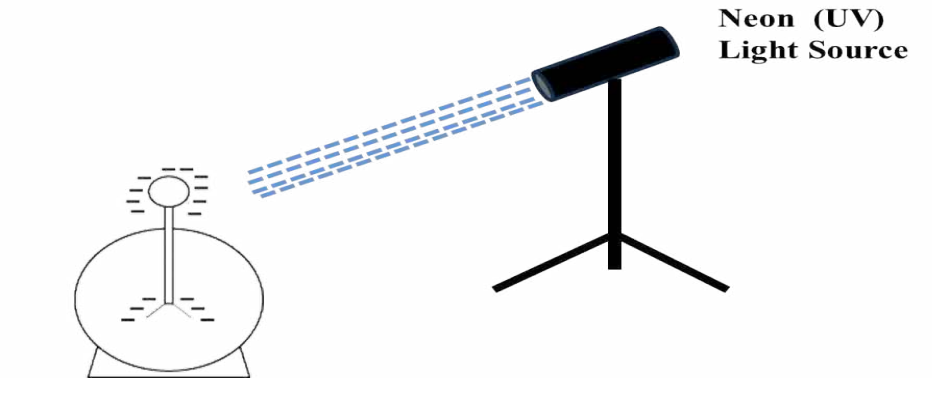

Figure 1: Negative charged electroscope and light source.

Findings for Prediction Stage

Please, think that you charged the electroscope with negative (-) charge and send neon (UV) light to the sanded surface of metal knob. What kinds of change do you expect for the metal leaves of the electroscope? Explain your predictions by drawing. The predictions of prospective science teachers were as below.

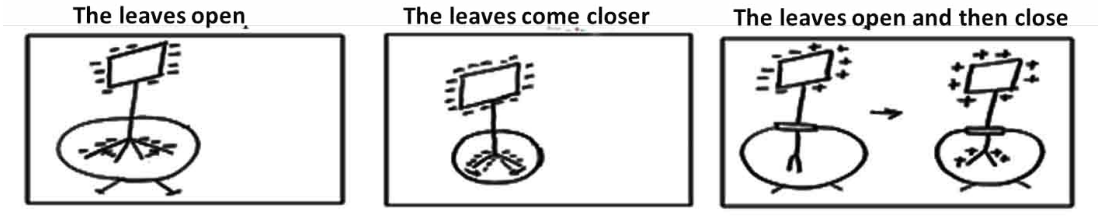

Figure 2: Student drawings for the prediction of Activity-I.

Table 1. Hypothesis of groups belongs to the question.

Activity-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
The electron charged lights pass to the metal knob from the light source directed to electroscope, then the metal leaves of the electroscope open.		X		X		X	X	X	X							X
When the lights come from the light source to the charged electroscope, the protons that these lights possesed made a move of the positive (+) charges from the metal knob to the leaves. The leaves closed a little bit more.	X		X		X					X	X		X		X	
When the UV light sends to the negative (-) charged electroscope it is going to be charged positive (+). At first it is going to close, then open again since charged positive (+).												X		X		

According to Table 1, three different predictions were made by the 16 prospective science teachers. With respect to those predictions, it was seen that the most majority of the prospective science teachers asserted the hypothesis of "The electron charged lights pass to the metal knob from the light source directed to electroscope, then the metal leaves of the electroscope open". For example, the prospective science teacher coded as T16 stated that: "The light source which has electric was brought kinetic energy to the sanded surface and leaves open". On the other hand, T4 coded prospective science teacher stated that "The electrons coming from the UV light source charges with negative (-) charge by hitting to the knob. For this reason, metallic leaves open much more". The other prospective science teachers asserted against the situation for the activity. For example, T10 coded prospective science teacher mentioned that "When the lights come to the charged electroscope, the protons carried by this light make the positive (+) charges move from the knob to the leaves and leaves close much more".

Findings for Observation Stage

Please, send (UV) light to the sanded surface of negatively (-) charged electroscope such in figure 1. Then, observe the changes of the metal leaves of the electroscope. Write down your observations with your reasons.

It was expected from the prospective science teachers to write down as their observations after the activity completed: "the leaves of the electroscope close since the UV lights send to the (-) charged electroscope". According to this, it was observed that the most of the groups responded correctly however write their opinions through different explanations and details. For instance, T6 coded prospective science teacher mentioned that "We charged the electroscope with (-) charge and the open leaves totally closed so, electrons went away" and T14 coded prospective science teacher wrote that "we send UV light

to the (-) charged electroscope and then I saw the leaves of the electroscope closed".

Findings for Explanation Stage

In Activity-1, prospective science teachers wrote down their predictions before the activity, observations during the activity, and the relations between prediction and observation to the explain stage. It was understood that most of the predictions and observations of the prospective science teachers (13 prospective science teachers) were not convenient with each other. For instance, T5 coded prospective science teacher stated that "I thought that the Neon lights pull off the protons on the plate. However, I could not find this result in my observations". On the other hand, T6 coded prospective science teacher mentioned that "I predicted that the leaves were going to be more charged with the electrons and open because of pushing each other. However in my observations, electrons went away and the leaves totally closed". The predictions of other 3 prospective science teachers were found convenient with their observations. As an example to this, T13 coded prospective science teacher stated that "I thought that the leaves of the electroscope were going to be closed when the UV light hits. I found the same results from my observations Activity-II".

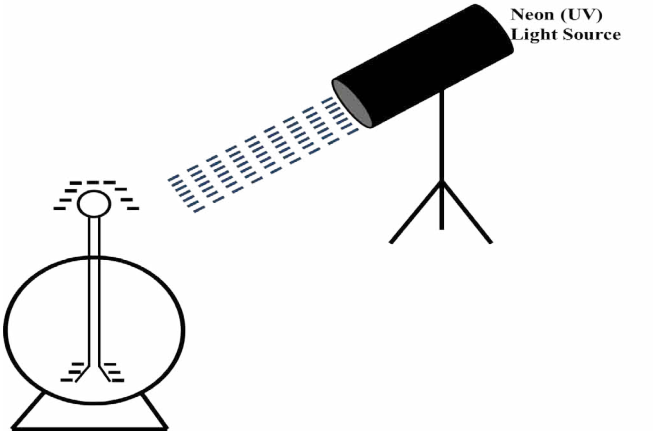

Figure 3: Positive charged electroscope and light source.

Findings for Prediction Stage

What kinds of change do you expect for the metal leaves of the electroscope when the electroscope charged with positive (+) charge and send neon (UV) light to the surface of metal knob? Write and draw your predictions. The predictions of prospective science teachers were as below.

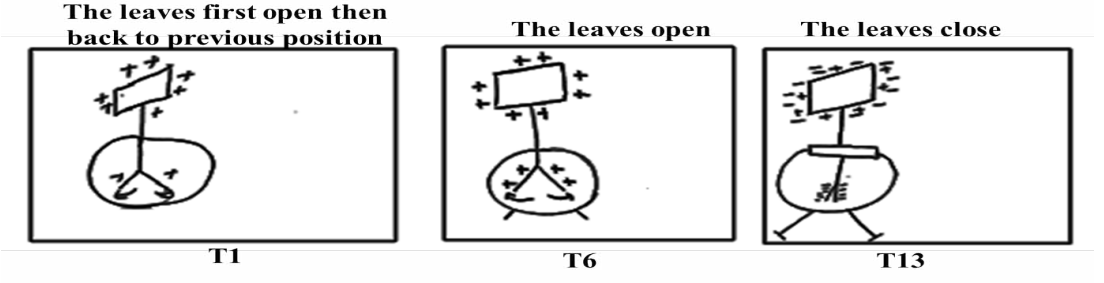

Figure 4: `Prospective science teacher drawings for the prediction of Activity-II.

Table 2. Hypothesis of groups belongs to the question II.

Activity-II	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
First open a little bit then back to previous position.	X															
The leaves open more since (+) charges were pushed to the leaves when light send to (+) charged electroscope.		X	X	X	X	X	X	X	X	X	X	X		X	X	X
The leaves get closer since the sent UV lights transmit the negative charges to the positive charges and pulling the charges.													X			

According to Table 2, it was seen that groups made 3 different predictions and in general the prospective science teachers were focused on the prediction of "The positive (+) charges push to the leaves when the lights send to the positive (+) charged electroscope, and the leaves open wider". While the T11 coded prospective science teacher responded as "the leaves are going to open by saving the (+) charges up to its capacity since the (+) charged lights come to (+) charged electroscope", T16 coded prospective science teacher provided feedback as "according to the information which I inferred from the previous activity that I observed, the UV light has (+) charge and the leaves are going to open more if we send UV to the (+) charged electroscope". The other 2 prospective science teachers suggested different hypothesis.

Findings for Observation Stage

Please, charge the electroscope with (+) charge through sanding the front surface of the knob such in figure 3. Send neon light to the knob of the electroscope. Then, observe the changes of the leaves of the electroscope. Write down your observations with your reasons.

After describing the activity, for this question, prospective science teachers were expected to write their observations such as "there is going to be no change about the leaves of the electroscope since the UV lights send to (+) charged electroscope". According to this, in general it was observed that the groups gave true responses, however they wrote their opinions with different expressions and details. For example, while the T9 coded prospective science teacher stated that "we charged the electroscope with (+) charge. We put neon light to the electroscope plate and observed that the leaves of the electroscope opened more", the other prospective science teacher coded as T15 mentioned that "leaves tried to be more open when the light projected to the (+) charged electroscope, since the broken electrons through light enabled the (+) charges become more dominant in system".

Findings for Explanation Stage

In Activity-II, it was inferred that predictions of the most majority of prospective science teachers (14 people) were convenient with their observations. For example, T5 coded prospective science teacher responded as "I thought that the leaves become more open since the UV light broke electrons and (+) charges become more dominant. And the result was the same". One of the two prospective science teachers whose predictions were inconvenient with their predictions (T13) was stated as "I said the leaves close in my prediction, but contrarily I observed that the leaves were opened a little bit".

Activity III

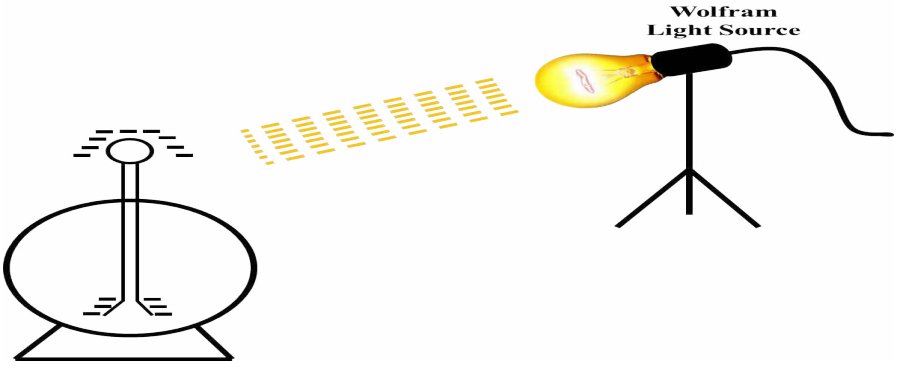

Figure 5: Negative charged electroscope and wolfram light source.

Findings for Prediction Stage

Please, think that you charged the electroscope with negative (-) charge and send wolfram (lamp) light to the sanded surface of metal knob. What kinds of change do you expect for the metal leaves of the electroscope? The predictions of prospective science teachers were as below.

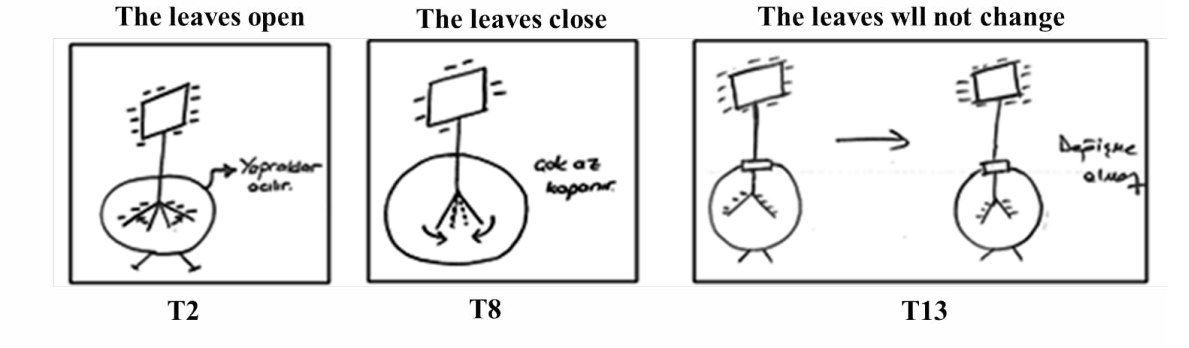

Figure 6: Prospective science teacher drawings for the prediction of Activity-III.

Table 3. Hypothesis of groups belongs to the question III.

Activity-III	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
The leaves of the electroscope more open.	X	X			X									X		X
If tungsten light send to (-) charged electroscope, the leaves close.			X	X		X	X	X	X	X	X	X			X	
The leaves will not changes													X			

According to Table 3, it was seen that prospective science teachers made 3 different predictions and they focused on the idea of "the leaves close if wolfram light send to negative charged electroscope". For example, while T10 responded as "t", T15 coded prospective science teacher answered as "since the energy of light is less it could not able to break enough electron and the leaves get closer". For example, T16 coded prospective science teacher came up with the hypothesis of "instead of UV light source, the wolfram light source send ultra-red lights and it has (-) charge in here. The leaves of the electroscope become more open".

Findings for Observation Stage

Please, charge the electroscope with (-) charge through sanding the front surface of the knob such in figure 5. Send wolfram light to the knob of the electroscope. Then, observe the changes of the leaves of the electroscope. Write down your observations with your reasons.

After describing the activity, for this question, prospective science teachers were expected to write their observations such as "the leaves of the electroscope close when the wolfram lights send to (-) charged electroscope". According to this, in general it was observed that the groups gave true responses, however they wrote their opinions with different expressions and details. For example, T6 coded prospective science teacher stated his opinion as "I did not see any important change at the leaves of the electroscope when the normal light source exposed to the (-) charged electroscope". On the other hand, T11 coded prospective science teacher stated the result of his observation as "I did not see any change at the leaves of electroscope when the wolfram light send to (-) charged electroscope".

Findings for Explanation Stage

In Activity-III, it was seen that almost all of the prospective science teachers (15 people) predicted in the wrong way before the activities. T1 coded prospective science teacher responded as "I thought that regular light is going to open the leaves of the electroscope a little bit more. But, any chance was not observed". In the same vein, T2 coded prospective science teacher stated as "I predicted that the leaves of electroscope become more open. But, no change was observed at the end of the activity". T16 coded prospective science teacher responded as "in my prediction, I said the leaves of the electroscope open more but no change was observed. I think it is because of the ultra-red light sent from the regular lamp was weak". Only, T13 coded prospective science teacher made the true predictions by stating that "I said there is nothing going to change at the leaves. I found the same result in my observations".

Activity IV

Findings for Prediction Stage

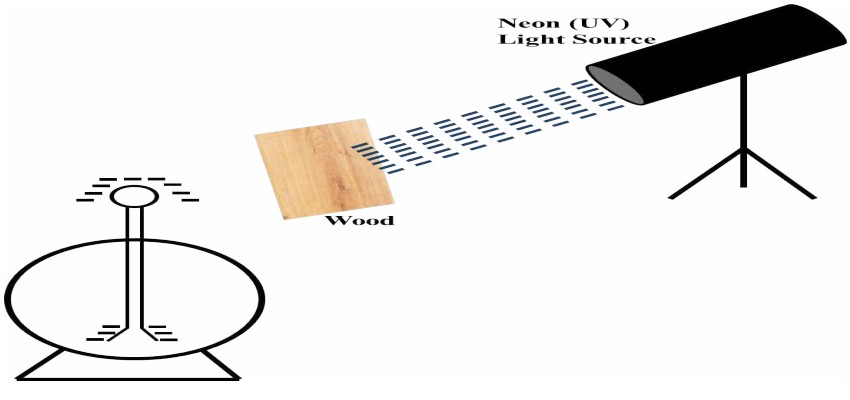

Figure 7: Negative charged electroscope, neon light source, and wood in between them.

Please, think that you charged the electroscope with negative (-) charge and send neon (UV) light to the sanded surface of metal knob when there is wood between electroscope and the light source. What kinds of change do you expect for the metal leaves of the electroscope? The predictions of prospective science teachers were as below.

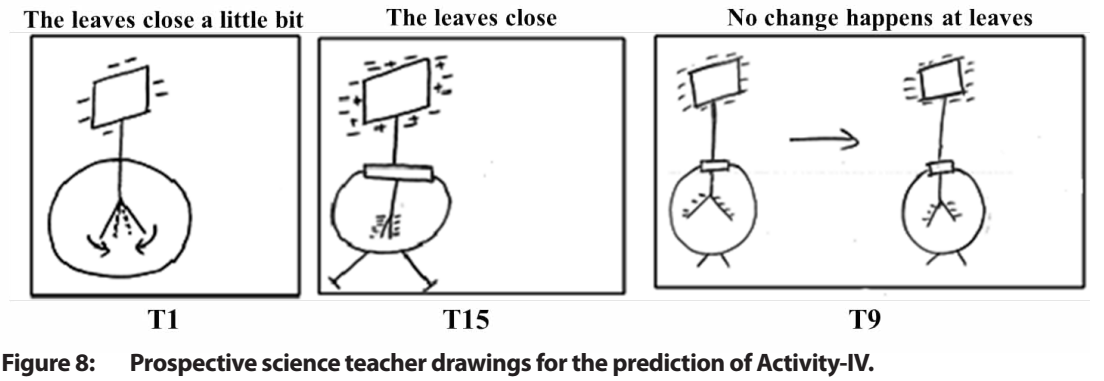

Figure 8: Prospective science teacher drawings for the prediction of Activity-IV.

Table 4. Hypothesis of groups belongs to the question IV.

Activity-IV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
The (+) charges increase on the wood, (-) charges are expected to come closer to the plate and the leaves close more.					X		X			X			X			
The leaves close since the neon lights pass from the wood.	X		X												X	
Since the neon lights cannot pass from the wood, no charge pass to electroscope and nothing happens at the leaves.		X		X		X		X	X		X	X		X		X

According to Table 4, it was seen that prospective science teachers made 3 different predictions and they focused on the idea of "no charge pass to the electroscope since the neon light cannot pass from the wood, and no change happens at the leaves". For example, it was observed that the T14 coded prospective science teacher stated his hypothesis as "It is not going to change if we put wood since no lights can pass from wood to electroscope". As an example, T1 coded prospective science teacher mentioned that "positive charged UV lights make the electroscope neuter". The third different prediction was "The number of (+) charges increases and the charges expected to come closer. So, the leaves close more". In the same vein, T10 coded prospective science teacher stated that "the (+) charges accumulated around the wood and the leaves close a little bit more as a result of effective electrification".

Findings for Observation Stage

Please, charge the electroscope with (-) charge through sanding the front surface of the knob such in figure 7. Put wood block between the knob and neon (UV) light source, then send neon light to the knob of the electroscope. Then, observe the changes of the leaves of the electroscope. Write down your observations with your reasons.

After describing the activity, for this question, prospective science teachers were expected to write their observations such as "There is no change going to be at the leaves of the electroscope when the wooden block placed in between and the UV lights send to the (-) charged electroscope". According to this, in general it was observed that the groups gave true responses, however they wrote their opinions with different expressions and details. While the T6 coded prospective science teacher identified his opinion as "The lights did not pass through and no change happened when we put a wooden block near to the (-) charged electroscope and send the neon lights", T12 coded prospective science teacher explained his opinions as "We charged the electroscope with (-) charge. No change happened at the leaves of electroscope".

Findings for Explanation Stage

In Activity-IV, it was seen that the 9 of the prospective science teachers made true predictions. For example, T9 predicted as "I thought the lights cannot pass through and nothing going to change since there is a wooden block in between and no change happened". The explanation of the prospective science teacher coded as T15 explains the opinions of false predictions: "I thought that the neon lights can pass through the wooden block. However, if there is no change happened, the neon lights cannot reach to the electroscope".

Activity V

Findings for Prediction Stage

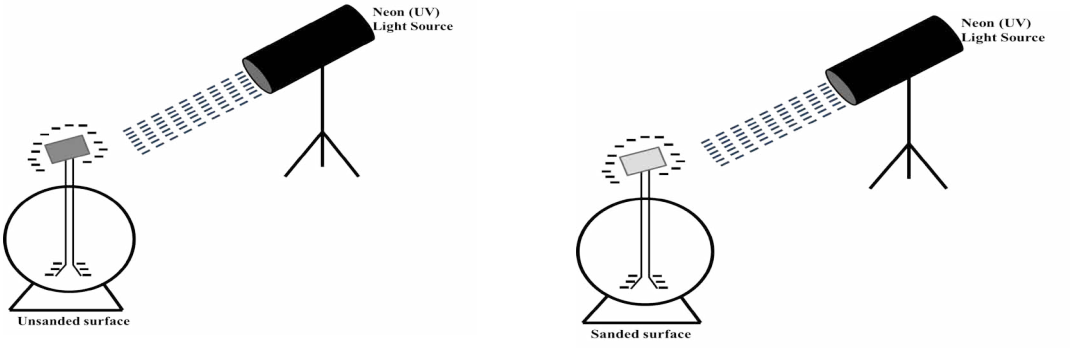

Figure 9: Sanded and non-sanded negative charged electroscope, neon light source.

Please, think that you charged the electroscope with negative (-) charge and send neon (UV) light to the surface of metal knob which did not sanded. What kinds of change do you expect for the metal leaves of the electroscope? The predictions of prospective science teachers were as below.

Figure 10: Prospective science teacher drawings for the prediction of Activity-V.

Table 5. Hypothesis of groups belongs to the question VII.

Activity-V	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
No charge passes to the leaves and no change occurs since the charged side of the (-) charge charged electroscope is not sanded		x	x	x		x	x	x	x			x	x	x		
The leaves close a little bit if neon light exposed to the (-) charged surface of the electroscope which is not sanded	x				x					x	x				x	x

It was observed that prospective science teachers made two different hypotheses which are closest in meaning of the activity. It was seen that one of those hypotheses is "No charge passes to the leaves and no change occurs since the charged side of the negative charge charged electroscope is not sanded". As an example to this hypothesis, T2 coded prospective science teacher made his hypothesis as "no change could be observed at the leaves of the electroscope since the shiny surface reflects the light". It was seen that the participant prospective science teachers made the second hypothesis as "The leaves close a little bit if neon light exposed to the (-) charged surface of the electroscope which is not sanded". As an example to this hypothesis, T16 coded prospective science teacher made his hypothesis as "when exposed to the surface which is not sanded the leaves of the electroscope close a little bit".

Findings for Observation Stage

Please, send UV light to the sanded surface of the (-) charged electroscope such in figure 9. Then, observe the changes at the leaves of the electroscope and send UV light to the surface of the plate which is not sanded. Write down your observations with your reasons.

After describing the activity, for this question, prospective science teachers were expected to write their observations such as "No change occurs at the leaves of the electroscope since the UV lights send to the surface of (-) charged electroscope which is not sanded". According to this, in general it was observed that the groups gave true responses, however they wrote their opinions with different expressions and details. For example, T3 coded prospective science teacher responded as "No change occurred in the conducted activity and observed that the leaves of the electroscope remain the same". In the same vein, T9 coded prospective science teacher has observation responses such as "we exposed neon light to the surface of (-) charged knob of the electroscope which is not sanded and observed the leaves of the electroscope close a little bit".

Findings for Explanation Stage

In Activity-V, it was seen that less than half of the prospective science teachers (5) made false predictions. T6 coded prospective science teacher explained such as "I realized that there is no change going to happen. But, we saw that the leaves closed a little bit. We saw that the surface which is not sanded had less effect". On the other hand, T12 coded prospective science teacher responded as "I predicted no change going to happen but closed a little bit".

Discussion and Conclusion

It was investigated that the POE based activities prepared to teach photo electricity event was successful according to the findings obtained from the study. The use of POE in teaching other science concepts was found in parallel with the results of many studies (e.g. Ayvacı & Devecioğlu, 2006; Costu et al., 2012; Köseoğlu et al. 2005; Özdemir, 2011).

In the study, it was observed that limited number of prospective science teachers made true hypotheses at the predict stage at the beginning of each activity. It was also found that the prospective science teachers had misconceptions on photo electricity event which is one of the hard issues of physics. When the literature is reviewed similar misconceptions are identified in many abstract science concepts (Demircioğlu et al., 2004; Golin, 2002; Kearney, 2004). The removal of this alternative prospective science teacher concepts in large extend at the end of the study was a concrete sign that the POE method is predominant than the traditional approaches. Atasoy and Akdeniz (2006) stated that prospective science teachers can learn easier and in an effective way in worksheets used classes. The use of inquiry based methods such as POE in physics teaching make a contribution to the permanent and effective learning. According to the data obtained from worksheets and observations of researcher during the activities, it was seen that the prospective science teachers listened to the explanations made by teacher, followed the given instruction in order, and made predictions. At the same time, there can be said that the prospective science teachers participated to the activities, listened to the different ideas, and interested in

activities. As a result, it was seen that prospective science teachers were able to explain the features of the photo electricity even after the discussions done after the activities.

In Activity-II, it was seen that at the prediction stage most of the prospective science teachers gave false response to the question of "What kinds of change do you expect for the metal leaves of the electroscope when the electroscope charged with positive (-) charge and send neon (UV) light to the surface of metal knob?". For example, While the T11 coded prospective science teacher responded as "the leaves are going to open by saving the (+) charges up to its capacity since the (+) charged lights come to (+) charged electroscope", T16 coded prospective science teacher provided feedback as "according to the information which I inferred from the previous activity that I observed, the UV light has (+) charge and the leaves are going to open more if we send UV to the (+) charged electroscope". After describing the activity, for this question, prospective science teachers were expected to write their observations such as "there is going to be no change about the leaves of the electroscope since the UV lights send to (+) charged electroscope".

The method of POE is one of the methods that are successful to uncover the ideas on an issue, realizes the meaningful learning through enabling to construct these concepts in their minds, entails the prospective science teachers to develop positive attitudes towards lessons, and increases the motivation, effective and easy to implement (Gunstone & Champagne, 1990; White & Gunstone, 1992). In this context, it was found that the prospective science teachers were effective in abstract concepts such as photo electricity. There can be said that one of the variables enable us to reach this result is the prospective science teacher responses. Thus, while the T5 coded prospective science teacher responded as "I thought that the leaves become more open since the UV light broke electrons and (+) charges become more dominant. And the result was the same", T13 coded prospective science teacher stated as "I said the leaves close in my prediction, but contrarily I observed that the leaves were opened a little bit". This situation is the sign of prospective science teachers learned that the particles pulled out from the metal are the electrons in photo electricity event.

In order to understand some of the abstract concepts, a concept related activity need to be conducted which is evidence based. In most times, prospective science teachers are convinced in the issues which they feel by their 5 sensory organs. When this situation considered, it has been seen that the POE method contributed to conceptual learning in a positive way and could be useful for the teachers in the teaching process designed with respect to the constructivist approach. This advantage of the POE found convenient with the results of many studies when the conducted studies reviewed (Kearney et al. 2001; Liew & Treagust, 1998; Kearney, 2004; Bilen & Aydoğdu, 2012).

In general, science students remain passive receivers of the information even in laboratory activities, since they are not able to do interpretation during the class. Thus, the information only forms theoretically in the minds of prospective science teachers. In this context, the studies in the literature and the results obtained in those studies are convenient in many points. One of these points is that if prospective science teachers learn the abstract concepts theoretically through traditional experimental methods, they are going to have difficulties to explain when they encounter in daily life (Biernacka, 2006). For this reason, there can be said that learning of abstract concepts, understanding of hard concepts and issues in physics experiments, cause the prospective science teachers learn more effectively and know better the use of physics issues in real life situations.

At the end of the study, it was seen that almost all of the prospective science teachers comprehended the fundamental principles of the photo electricity issue and related the principles with each other. POE was effective in teaching of abstract physics concepts in which both experiment and inquiry implemented together. Aycan and Yumusak (2003) stated that prospective science teachers mostly complaining about the issues including abstract concepts and rather prefer memorizing without learning. For this reason, in order to remove the learning difficulties in physics issues, prospective science teachers need to be provided the way to associate their learning with real life situations through practicing by using laboratory opportunities and need to embody the abstract concepts. Some of the previous studies (Liew & Treagust, 1995; Palmer, 1995; Kearney et al., 2001; Coştu, 2008; Foong et al., 2009) and the findings obtained during this study are verifying each other in order to indicate the use of POE method enable the prospective science teachers to make the information permanent.

In activity 4, it was seen that the prospective science teachers made different predictions by phrasing three different hypotheses as seen in Table 4 to the asked question phrased as "Please, think that you charged the electroscope with negative (-) charge and send neon (UV) light to the sanded surface of metal knob. What kinds of change do you expect for the metal leaves of the electroscope". Indeed, it is the sign of prospective science teachers can hold more than one misinformation in their minds in the issues that prospective science teachers believe in that they know the issue. Similar results were found in the previously conducted studies (Huppert and Lazarowitz, 2002; Çepni et al., 2002). Against to many false hypotheses made by the prospective science teachers at the predict stage, almost all of the prospective science teachers stated only one opinion at the observe stage, and reached to the result of UV lights pulled out electrons from the metal at the explain stage. Thus, it was seen that the POE was successful at teaching the abstract concepts such as photo electricity. The electroscope used in this process was the concrete proof of the pull out of the electrons from the metal.

Also, it was seen that prospective science teachers had misconceptions when they were presenting their individual opinions (Aycan & Yumuşak, 2003; Foong et al., 2009; Abdelhady, 2011; Niaz et al., 2010). Before the study, most of the prospective science teachers were holding false opinions as (+) charges moves. For example, T10 coded prospective science teacher stated that as "the leaves will close a little bit when we send light from the wolfram source to the (-) charged electroscope because (+) charge passes to the leaves". Indeed, those ideas were identified as misconceptions in the literature. It was seen that this misconceptions were removed with the group discussions performed at the end of the activities. The prospective science teacher holding this opinion changed his opinion at the explain stage to the "no change occurs at the leaves when light send to the (-) charged electroscope from the wolfram light source, because wolfram source cannot pull out electron from the metal and (+) charges cannot pass to the leaves since they are at the atomic nucleus and don't move. It was concluded that POE is the effective and useful method that can enable learning through performing and experiencing (Liew & Treagust, 1995; Palmer, 1995; Bilen & Aydoğdu, 2012; Özdemir, 2011; Coştu, 2008; Kearney, 2004), give opportunity to active participation, realizes permanent learning through promoting to make hypotheses, find results through their experiences, and in group discussions in teaching the photo electric concept.

The pull out of the electron from the metal is not an event that can be seen with the naked eye or sensory organs. Observation of these events in activities can be exciting to some extend and easy sometimes. Such as in the study, complex and confusing event can become observable directly when pulling out the electron from the metal related with the discharge of (-) charge from the charged electroscope. In this study, prospective science teachers comprehended the relation between the energy of light and pulling out the electron about the photo electricity concept. But, they could not construct a relation between the amounts of light and pulled out an electron. This situation could not be considered as the limitation of the POE, since this kind of relation was not aimed in the organization of experiment. The activities can be designed in order to analyze the different variables of the photo electricity event when designing the experiment.

Many concepts in photo electricity event such as stopping voltage, light energy, and photo electricity currently placed in the activity in the implemented study. These concepts could be taught with the worksheets after teaching the fundamental concepts related to photo electricity event. The studies can be designed in a more comprehensive way. Those kinds of studies should be planned for couples of lessons. During the study, electroscope was used as the instrument for measurement. For this reason, activities related to the use of electroscope placed at the activity at first. After the prospective science teachers were convinced that the electroscope (+) or (-) charged, the POE implementations were followed in teaching of photo electricity. The anxieties hold by the researcher at the beginning of the study caused to beginning activities. The development of cognitive and psychomotor skills with different activities in electroscope issue provides an opportunity to focus on the event of photoelectric. In addition to cognitive learning, there should be studies reflecting to prospective science teachers' ideas effectively on implementations conducted through POE. There is a strong need to conduct studies on teaching many abstract concepts such as photo electricity by implementing POE method.

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