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The Effect of POE Activities Supported by Concept Networks on Laboratory Attitudes, Anxieties and Scientific Process Skills of Pre-Service Science Teachers*

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ABSTRACT

The purpose of this study was to see if the Concept Network Supported Prediction-Observation-Explanation (POE) method had a meaningful impact on 1st grade pre-service science teachers' attitudes, anxiety, and scientific process skills toward the physics laboratory when compared to the traditional laboratory method. The current research was performed in the autumn term of the 2018-2019 academic year at a state university in Ankara province, using a quasi-experimental design with a pretest and posttest control group. A total of 35 pre-service teachers were comprised in this research. In the experimental group, Concept Network Supported POE activities were employed, whereas in the control group, the "Mechanics Laboratory-I" experiment sheet from the present program was used. The research took ten weeks to complete. The Scientific Process Skill Test, the Attitude Scale towards the Physics Laboratory, and the Anxiety Scale towards the Physics Laboratory were used as "pre-test and post-test" throughout the study. The data gathered within this research was analyzed by making use of "Independent groups t-test", "Dependent groups t-test" and "Mann Whitney-U test". In addition, at the end of the semester, a Preservice Science Teacher Opinion Form for Prediction-Observation-Explanation Method was employed to obtain the results. While POE method exercises resulted in a significant difference (p<,05) in pre-service science teachers' anxieties about the laboratory and scientific process skills in favor of experiment group, there was no meaningful difference in their attitudes toward the laboratory. The experiment group's pre-service teachers found the method useful, memorable, and encouraging of scientific thinking, and they desired to employ it in their professions in the future, among other outcomes.

Keywords: Concept network, Prediction-Observation-Explanation (POE) method, attitude, anxiety, scientific process skills

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1. INTRODUCTION

The prevalent name of positive sciences like physics, chemistry, and biology are known as "Science and Natural Knowledge" or "Natural Sciences". Natural science advancement has a significant impact not only on individual senses but also on the social and financial life of the country as a whole. The impact of the natural sciences is demonstrated in almost every area, from agriculture to medicine, from economics to instruments. Therefore, based on the importance of natural sciences, teachers and prospective teachers should strive to develop them by taking into account the "theories, principles, methods, and generalizations" that are exhibited by natural sciences (Akgün, 2001, pp.5-7). The fact that the considered topics of the natural sciences are frequently composed of abstract concepts and are complex leads to the natural sciences being defined as difficult-to-understand courses. This explains the necessity of using auxiliary and supportive methods and techniques besides concrete and visual materials to teach science courses containing a large number of abstract concepts as desired (Çepni, Ayas, Johnson & Turgut, 1997). The experimental method is one of the methods-techniques that could be used in the natural sciences. The experimental method, according to Büyükkaragöz and Çivi (1999), is a planned application whose purpose is to demonstrate a natural event to students in a classroom or laboratory environment while keeping the variables under control (p.94). Unquestionably, one of the environments where the experimental method would be used most effectively is a laboratory.

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Laboratories are of crucial importance for students to learn natural science subjects more effectively and conscioulsy. Laboratories are properly used to teach complex and abstract concepts in natural science subjects. In the laboratory environment, students primarily gain tangible experience. This learning-by-doing learning environment provides long-lasting learning. Laboratories allow students not only to become part of science-related activities but also contribute to the development of various capabilities like observation, thinking, constructing ideas, and commenting. Laboratory studies are an inseperable part of science teaching and learning, which provides students with methods such as critical thinking, reasoning, and generating information (Ayas, Çepni, Akdeniz, Özmen, Yiğit & Ayvacı, 2005). In the light of these explanations, it can be mentioned that in laboratories, a variety of methodologies are employed. These can be listed as: 1) Technical Skills Laboratory Approach, 2) Scientific Process Skills Laboratory Approach, 3) Confirmatory (Deductive) Approach, and 4) Inductive Approach (Çepni & Ayvacı, 2011).

The confirmatory laboratory approach is one of the most popular approaches for providing students with benefits in natural science laboratory applications (Çepni & Ayvacı, 2011). In the confirmatory laboratory approach, the subjects are determined by the laboratory guide or the teacher. Elaborate information is supplied about the theory related to the experiment, the structure of the experiment, how the data has been collected, and information about the analysis of the experiment, besides how the data obtained should be. First, the research is linked to the previous studies and then the actions of the students are directed in this direction. In this approach, students learn applications to be done from the experiment guidebook or from the instructor responsible for the course. In general, collected results are compared with only the expected results. In this kind of approach, students' independent thinking does not need to build meaning from the work they do (Kanlı, 2007). One of the methods that are used in universities is the conformity laboratory approach, which is also known as the traditional approach.

In the confirmatory (deductive) laboratory approach, in the laboratory environment, the student is given information about what to do, how to do it, and what he will eventually find, and then the student is expected to experiment by adhering to them (Köse, 2008). For effective science teaching, teachers who are expected to prepare stimulating learning environments need to possess adequate knowledge, skills, and attitude about the laboratory of science and practice. For this reason, the basic skills that a teacher needs to acquire are significant not only in pre-service education but also in the skills that they apply in service and help students develop meaningful learning and adopt a positive attitude toward science (Hegarty-Hazel, 1990).

By using the laboratory method during the teaching of Science and Physics courses, students can actively participate in, take part in research with their effort, opinion and with their personal experiences, generate new ideas about the topics that they are curious about, make connections between concepts, grasp and apply the methods of obtaining scientific facts, put their theoretical knowledge in practice, obtaining actual information, and cultivating a good attitude toward science (Ayas, Akdeniz & Çepni, 1994). Attitude, which is one of the characteristics of affective properties, is described as an internal condition that influences a person's decision-making in his own actions in reaction to events and situations. (Senemoğlu, 2000). Teachers who are expected to prepare stimulating learning environments must have adequate expertise and skills in science and laboratory to improve affective science learning. Therefore, the basic laboratory abilities that are expected to be gained by teachers, are significant skills that they will use in the future, make use of in the learning environment, assist students in developing a favorable attitude toward science and learning in a meaningful way (Kurt, Devecioğlu & Akdeniz, 2002). According to Tao and Gunstone (1999), the method of POE helps students develop many positive attitudes, such as enhancing self-esteem, taking responsibilities in group and individual work, taking responsibility for their own learning, expressing themselves well, possessing motivation, making a written estimate and describing the reasons for their estimations, forcing themselves to find and answer, and being active. Based on all these attitude characteristics mentioned and the contribution and effects of the POE method on attitude, it has been seen that it is necessary to examine the attitude variable in this study.

Scientific process skills are fundamental skills that empower students to become more active on their own learning, develop feelings of responsibility for their own learning, and increase persistence in their science learning (Taşar, Temiz & Tan, 2001). Scientific process skills are the basic skills needed for experimental activities to achieve their goals, and experimental processes ensure the development of all these skills. The growth of these skills gives rise to the ability to relate the experiments to the subject and to structure the concepts in the mind (Tan & Temiz, 2003). Considering that students who have acquired scientific process skills have an idea of how scientific research is conducted and are able to overcome the problems they encounter using scientific methods, these skills seems to form the backbone of science teaching (Çepni & Çil, 2011, p.46). One of the main approaches that helps in the effective use of scientific process skills is the constructivist approach.

The growing attention in the constructivist learning approach's core theoretical ideas and applications has resulted in its implementation in the educational process, participation in educational programs, and the development of learning techniques (Köseoğlu, Tumay & Kavak, 2002). Predict-Observe-Explain (POE) method is among the alternative learning strategies and methods based on the constructivist approach, which encourages the use of all these scientific process skills. The POE approach allows students to create and apply their scientific knowledge based on their scientific process skills in science education (Tokur, 2011). The first laboratory studies on POE have been conducted by White and Gunstone. The POE method is constructed into 3 basic phases.

Prediction Phase
In this phase, students are provided with information about a case or demonstration experiment. After that, students are invited to make predictions regarding an upcoming event or the outcome of a demonstration experiment. At this stage, students should present their predictions with reasons. It should also be ensured that students fully understand the event they are going to predict. Next, students should write down the reasons for their predictions. In this way, the prior knowledge of the students becomes active and at the same time alternative concepts they have are revealed (White & Gunstone, 1992).

Observation Phase
In this phase, students are presented a case and a demonstration of the experiment that they have predicted. To be able to prevent students' answers from influencing each other and changing their observations, they are expected to record their observations. If it is necessary, this phase can be repeated. The differences and contradictions between the students' observations and predictions enhance learning, so discontent is ensured in the students, which provides motivation for learning. At the same time, the other important point here is that the whole event, which is directed by the guide, should be easily observed by all students (Tao & Gunstone, 1999; White & Gunstone, 1992).

Explanation Phase
At this point, the main purpose is for students to discuss and try to reconcile the inconsistencies between their predictions and observations. Debating their inspections in the class is of crucial importance for constructing concepts in their own way because their explanations supply information about their learning situation. At this stage, the teacher should not explain directly. He/She should supply an environment for students to develop alternative concepts and comments through guiding (White & Gunstone, 1992).

The rationale of this study is that the laboratory portion of the General Physics-1 curriculum taught in universities is based on the traditional methods of laboratory application (inductive and confirmatory), and the fact that POE supplies a more effective and constructive approach than the traditional one. The POE technique is used to compare the impact of typical laboratory practices on prospective teachers' attitudes and anxiety on physics laboratory, and scientific process skills with an alternative laboratory approach. At the same time, when we examine the literature, the studies conducted in the field of physics and physics laboratory are less in number when compared to other branches, which is important in terms of its contribution to the literature. Furthermore, while there are studies on attitude in the literature, the absence of a study in which attitude and anxiety are controlled together is important in terms of the contribution of these two affective variables to the literature in this study.

1.1. Purpose of the Study

This research aimed to see if the Concept Network Supported (CNS) Prediction-Observation-Explanation (POE) method had a substantial impact on 1st grade science teachers candidates' attitudes, anxiety, and scientific process skills toward the physics laboratory, which is used in the laboratory applications section of the General Physics-1 course and the Physics-1 Mechanics laboratory experiments utilized in the control group and performed in line with the curriculum in use. Meanwhile, it was also aimed define the views of the preservice teachers in the experiment group about the method applied.

In conformity with the purpose of the research, the response has been searched for the questions given as:

1) Is there a meaningul difference between the attitude pretest and posttest scores for the participants among the experiment and control groups?
2) Is there a meaningul difference between the anxiety pretest and posttest scores for the participants among the experiment and control groups?
3) Is there a meaningful difference between SPST pretest and posttest scores for the participants among the experiment and control groups?
4) Is there a meaningful difference between the attitude and anxiety towards the physics laboratory and SPST pretest and posttest scores for the preservice teachers among the group of experiment?
5) What are the thoughts of preservice teachers in the experiment group on the approach being used?

2. METHOD

2.1. Research Group

The experiment group of the study's sample comprises of 1st year science teacher candidates of a state university in Ankara province who are studying in the Department of Science Education. Two branches of 1st year preservice teachers are distributed randomly to the groups named as experiment and control groups. The study was conducted in the section "Laboratory (Mechanical Laboratory) applications of Physics-I course". Convenience sampling is preferred owing to lower cost, time-saving, practicality, and the ability to work with accessible samples (Yıldırım & Şimşek, 2016).

Table 1.
Distribution of Particiapants to the Groups According to Gender

Group	Female	Male	Total
Experiment Group	14	3	17
Control Group	16	2	18

2.2. Research Design

This study's quantitative dimension utilized a "pre-test and post-test semi-experimental model with control group" which is a well-known example of the experimental patterns. According to Büyüköztürk (2013), the unbiased assignment is not used in the "pre-test and post-test paired control group pattern". Two of the groups that are ready in the pattern are tried to be matched with certain variables. These paired groups are assigned via unselected assignment. It is a serious and the most useful alternative pattern in cases where an unselected assignment will not be made.

Table 2.
Demonstration of Research Design

Group		Pre-test	Treatment	Post-test
E (Experiment)	M	O1	X	O3
C (Control)	M	O2		O4

Experimental Group: The group which has been implemented with experiments prepared using the CNS POE method
Control Group: The group which has been implemented with traditional laboratory method

For the qualitative dimension, the views of preservice teachers in experiment group are asked with interviews.

2.3. Implementation of Application

Before starting the applications, "Attitude Scale towards Physics Laboratory (ASCTPL)", "Anxiety Scale towards Physics Laboratory (ASTPL)" and "Scientific Process Skill Test (SPST)" were applied to groups as pretests. According to the process of the study, the participants in the experiment group are treated in 3 phases of POE, which are Predict-Observe-Explain. Experiments were given to students with weekly work sheets. Firstly, students were expected to make predictions about the current prediction questions. After obtaining these answers, the experiment phase was conducted. Groups of three or four students completed the experiment as a group. Then, they carried out the explanation phase by noting the differences and similarities between their predictions and observations in accordance with their notes. Calculations and similar operations are still being made at the explanation phase. Lastly, the concept-network activity, which was done by the whole class, was meant to end the experiment. In the control group, students were treated by the traditional laboratory methods. The experiments were carried out by adhering to the experimental work sheet of the mechanical laboratory. The experimental work sheet is an experimental guide that contains all the experiments. The content of this experimental work sheet, which is being used in the current program, and the course of all experiments, consists of the main topics mentioned below:

a. Purpose of the experiment
b. Tools and equipment which is made use of
c. Necessary theoretical information
d. Conducting the experiment
e. Result and comment
f. Experiment errors
g. Answers of questions and calculations

The experiments in control groups are conducted in light of these steps. After mentioning the purpose of the study, students prepare the necessary tools. Then, the mandatory technical information is examined by the whole class together. The construction of the experiment is indicated in the experimental manual together with its stages. Students carry out the construction of the experiment according to these stages. Then, after the results obtained were noted in the necessary sections, each group compared their results in the experimental errors section, looked at where mistakes might have been made, and after making the necessary adjustments, answering the questions and making the graphical visualizations according to the calculations section, the experiments were terminated.

2.4. Tools of Collecting Data

Throuhout the research, "Attitude Scale towards Physics Laboratory (ASCTPL)" builded up by Tanrıverdi and Demirbaş (2012), "Anxiety Scale towards Physics Laboratory (ASTPL)" builded up by Berber (2013), "Scientific Process Skills Test (SPST)" which is builded up by Burns et al. (1985), adjusted by Ateş and Bahar (2002) into Turkish, with the original name "The Test of Integrated Process Skills-II (TIPS II)", are used as pretest and posttest. Furthermore, the "Preservice Science Teacher Opinion Form for Prediction-Observation-Explanation (POE) Method" developed by the researcher was used.

2.4.1. Attitude scale towards physics laboratory (ASCTPL)

ASCTPL is a Likert type scale of 5 points which consists of 27 items. There are 21 positive and 6 negative items. It was discovered through factor analysis that it was composed of six factors: "Methods and Techniques Applied during the Course", "Teacher's Attitude towards the Course", "Technical Opportunities in the Laboratories", "Associating the Course with Daily Life", "Students' Personal Attitudes towards the Course" and "Field Knowledge". When it is looked at the scales as a whole, the variance value is %59,143, and the Cronbach-Alpha internal consistency is (α=0,90). Based on these values, it can be said that the validity and reliability of the study are good (Tanrıverdi & Demirbaş, 2012). The Cronbach-Alpha internal consistency coefficient (α=0,79) was evaluated here as a result for the "ASCTPL" analysis applied to 74 preservice science teachers enrolled in the university's relevant department.

2.4.2. Anxiety scale towards physics laboratory (ASTPL)

Berber (2013) is the creator of ASTPL. The first application of this scale was implied to 245 undergraduate student at Necmettin Erbakan University. The scale, whose original version was composed of 42 items, has reached its final version of 16 items and 4 sub-factors after eleminating improper ones. The scale's Cronbach-Alpha internal consistency coefficient was evaluated as (α=0,87). For this study, which is applied to 74 prospective science teachers who were registered in the relevant department of the university, the coefficient of Cronbach-Alpha internal consistency of the test "ASTPL" was evaluated as (α=0,89).

2.4.3. Scientific process skills test (SPST)

SPST used in the study is composed of 36 multiple-choice questions, and 4 choices for each question. It consists of five sub-skills entitled "Recognizing and Controlling Variables", "Hypothesizing", "Defining Operations", "Visualazing and Analyzing Data", and "Conducting Experiments". The Cronbach-Alpha value of the original version of the test was evaluated as 0,86. The version of the test in Turkish language, developed by Ateş and Bahar (2002), was found to have a test reliability of 0.74. (Spearman-Brown).

2.4.4. Preservice science teacher opinion form for Prediction-Observation-Explanation (POE) method

"Preservice science teacher opinion form for Prediction-Observation-Explanation (POE) method" was prepared by the researcher in order to get an opinion on how effective the application was based on the main title and sub-titles of the study. Following preparation, the opinion form was finalized by soliciting expert opinions from a total of four faculty members, two of whom are specialists in the field of physics education and two of whom are experts in the area of science education, all of whom work at the same institution.This form consists of 7 items. In the form, there are items related to the effectiveness of the application, the effects of the method on the attitudes and concerns of the participants towards the physics laboratory. Before the main questions, the candidates were asked to mark one of the premises as "Yes, No, I am undecided" regarding whether they agreed with the opinion item they read, and then to describe the reasons for their ideas given in the premise in an open-ended style. In the last week of the study, the opinion form was delivered to 17 participants in the experimen group and was returned the very same day after the candidates submitted their replies.

2.5. Analysis of Data

2.5.1. Analysis of quantitative data

The collected quantitative data was analyzed using the SPSS 22 software package. In line with the research's sub-problems, "(ASCTPL)", "(ASTPL)" and "(SPST)" were used as pre and post tests. The normality distributions of the data were verified prior to analysis. Since the statistical hypotheses in the analyzes are established with the statement "the distribution of scores does not differ significantly from the normal distribution", the calculated p values being greater than (α=,05) is interpreted as there is no excessive deviation from the normal distribution at this significance level (Buyuköztürk, 2017, p.42).

According to these reasons, it was thought that data sets with "p values larger than 0,05" in the normality distributions demonstrated "normal distribution", and dependent and independent groups t-Test analyses were utilized. Mann-Whitney U test analysis, which is a well-known non-parametric test, was utilized in the "Shapiro-Wilk" test and in the light of "histogram graphs" and other information, assuming that the data is not normally distributed, in the analysis of the control group SPST post-test, which is the only data with a non-normal distribution. Table 3 contains information on the data's normal distribution.

Data collection tools' scoring

- ASCTPL scoring was done between 1 and 5 values. While the value of 1 expresses negative attitudes towards the laboratory, it is interpreted as an increase in positive attitude towards the laboratory as the value of 5 is approached. On the other hand, negative attitude items were scored exactly the opposite.
- ASTPL scoring was made between 1 and 5 point values. While a value of 1 indicates a low level of anxiety towards the laboratory, it is interpreted as increasing anxiety towards the laboratory as it approaches the value of 5.

- SPST is in the form of a multiple choice test consisting of 36 items. Correct responses receive one point, while incorrect and empty answers receive zero points here. Necessary interpretations were made based on the total number of correct answers.

2.5.2. Analysis of qualitative data

In order to discover what pre-service teachers believe about the implementation process, the "Preservice Science Teacher Opinion Form for Prediction-Observation-Explanation Method" was applied to the candidates at the term's closure. The answers given by the candidates to the premises were analyzed as frequency (f) and percentage (%). In addition, in the analysis of the answers given regarding the reasons for the students' opinions, after the answers given to the premises were interpreted separately, general interpretations were made based on these answers. The replies of participants are offered in the form of sample quotations.

3. FINDINGS AND INTERPRETATION

Table 3 shows the results of the Shapiro-Wilk test, which was used to evaluate whether the data had a normal distribution or not.

Table 3.
Normality Distributions of Groups and Other Data

GROUP	TESTS	Pre-test ASTPL	Pre-test ASCTPL	Pre-test SPST	Post-test ASTPL	Post-test ASCTPL	Post-test SPST
EXPERIMENT GROUP	N	17	17	17	17	17	17
	X	47,47	111,35	27,76	40,05	114,76	28,82
	Sd	9,08	10,28	4,603	7,58	9.12	3,414
	z skew.	-1,36	-1,40	-0,62	-0,29	-0,80	-0,89
	z kurtos.	0,28	1,43	1,10	-0,90	-0,86	0,37
	p	0,483	0,295	0,297	0,781	0,254	0,712
CONTROL GROUP	N	18	18	18	18	18	18
	X	49,00	111,16	26,61	49,33	108,72	24,11
	Sd	6,23	11,45	3,82	10,07	13,55	3,64
	z skew.	-0,45	-2,43	0,28	0,871	0,141	-1,16
	z kurtos.	-0,10	3,12	-1,12	-0,29	-0,33	-0,88
	p	0,973	0,065	0,348	0,247	0,883	0,039

The p values in Table 3 are Shapiro-Wilk normality test values, and it is assumed that data sets with pretest and posttest p scores greater than 0,05 are normally distributed, while data sets less than 0,05 do not show normal distribution. As a consequence, only in the control group's SPST posttest was the one with the p value less than 0,05 and the distribution was not normally distributed, as determined by the Shapiro-Wilk normality test.

Findings achieved from sup-problems of the study are offered below.

1) Table 4 shows the t-test findings for the solutions of the attitude participants' pretest and posttest results towards the physics laboratory in both groups.

Table 4.
Physics Laboratory Attitude Test Scores and t-Test Results of the Participants and Their Means

	Experiment Group			Control Group			t-test		
Measurement	N	X	Sd	N	X	Sd	t	df	p
Pre-test	17	111,35	10,28	18	111,16	11,45	0,50	33	0,960
Post-test	17	114,76	9,12	18	108,72	13,55	1,53		0,134

In Table 4, the pre-test mean attitude points of participants in the experiment group before the implementation were 111,35, and the control group's pre-test mean attitude points were 111,16. From this point of view, it is seen that the pre-test attitude values of the experimental and control groups are equivalent to each other and there is no significant difference between the experimental control group pre-test mean attitude scores [t=0,50; p>0,05]. On the other hand, whilst the average attitude point in experiment group was 114,76 when the experiments were carried out using the POE method supported by concept network activities after the implementation, it was 108,72 in the control group when the trials were performed in line with the curriculum in use. There is no significant difference between the experimental group's mean attitude scores and the control group's mean attitude scores toward the physics laboratory where the experiments were performed [t=1,53; p>0,05].

2) Table 5 displays the results for t-test and the solution of the anxiety pre and posttest scores of the both groups towards the physics laboratory.

Table 5.
Physics Laboratory Anxiety Test Scores and t-Test Results of the Participants and Their Means

	Experiment Group			Control Group			t-test		
Measurement	**N**	**X**	**Sd**	**N**	**X**	**Sd**	**t**	**df**	**p**
Pre-test	17	47,47	9,08	18	49,00	6,23	-0,584	33	0,563
Pre-test	17	40,05	7,58	18	49,33	10,07	-3,06		0,004*

*p<,05

Before the application, the pretest average anxiety ratings of the experiment group are 47,47, while the pretest mean anxiety points of the control group are 49,00, as depicted in Table 5. From this perspective, there is no significant difference between the two groups' pretest anxiety levels since the experiment and control groups' pretest anxiety scores are extremely near to each other and the p value is more than 0,05 [t=-0,584; p>0,05]. On the other hand, after the application, the anxiety score average in the experimental group was 40,05, while the anxiety score average in the control group was 49,33. According to these findings, the experimental group's pre-service teachers have considerably reduced anxiety levels [t=-3,06; p<0,05]. Here, the decrease in anxiety in the group that was applied with the POE method supported by the concept network activities can be associated with the fact that the applied method participated in the experiments more actively compared to the laboratory method carried out according to the current program, and they passed the experimental phase more effectively with their predictions and observations.

3) Table 6 displays the results of t-test for the solution of the SPST test scores of the both groups, while Table 7 displays the results of Mann Whitney-U test.

Table 6.
The Results of t-Test in Relation to the Pretest Points and Participants' Averages

Group	**Measurement**	**N**	**X**	**Sd**	**t**	**df**	**p**
Experiment	Pre-test	17	27,76	4,60	0,809	33	0,425
Control		18	26,61	3,82			

Table 6 shows that the pretest SPST averages of the experiment group's participants before the application are 27,76, whereas the control group's participants are 26,61 for the same averages. From this, it is possible to conclude that the averages of the pretest SPST scores of the groups are identical. Furthermore, when the p value was investigated, it was determined that there was no meaningful statistical difference between the two groups in terms of pre-test averages [t=0,809; p>0,05].

Table 7.
Results of the Mann Whitney-U Test on Posttest SPST Scores and Averages of Participants in Both Groups

Group	**Measurement**	**N**	**X**	**Sd**	**df**	**Z**	**p**
Experiment	Post-test	17	28,82	3,41	33	-3,48	0,000*
Control		18	24,11	3,64			

*p<,05

In Table 7, following the application, the posttest SPST mean score of the experiment group is 28,82, whereas it is 24,11 for the other group. The posttest mean scores of the groups display a meaningful difference in favor of the experiment groups' participants [Z=-3,48; p<0,05]. In comparison to the existing program, POE activities supplemented by concept network activities in the experiment group may be regarded to be more supportive of the scientific thinking process.

4) Table 8 shows the t-test results for experiment group in terms of attitude, anxiety, and SPST pre and post-test scores and averages.

Table 8.
Results of the t-Test for Experiment Group on Attitude, Anxiety, and SPST Pre and Posttest Scores and Averages

	Pre-test			Post-test			t-test		
Scales	**N**	**X**	**Sd**	**N**	**X**	**Sd**	**t**	**df**	**p**
ASCTPL	17	111,35	10,28	17	114,76	9,12	-1,54	16	0,142
ASTPL	17	47,47	9,08	17	40,05	7,58	3,24		0,005*
SPST	17	27,76	4,60	17	28,82	3,41	-0,917		0,373

*p<,05

Table 8 depicts the views of participants regarding the physics laboratory, their anxiety, and the mean SPST scores in the experiment group after and before the application stage. As a result, the pre-service teachers' pre-test attitude mean score is 111,35, while their post-test attitude mean score is 114,76. There is an increase in the attitude averages of participants in the

group that used the POE approach [t=-1,54; p>0,05]. Participants' average pretest anxiety level, on the other hand, is 47,47, while the average posttest attitude score is 40,05. Based on the notion that a rise in the mean score on the anxiety scale reflects an increase in the degree of anxiety, a significant decline in the anxiety level of participants was seen following the application [t=3,24; p<0,05]. Finally, the pre-test SPST mean score of the subjects was 27,76, whereas the post-test SPST mean score was 28,82. For the mean SPST scores, no meaningful statistical difference was observed [t=-0,917; p>0,05].

5) Participants opinions in the experiment group about the method applied.

The following are the findings and interpretations of the participants' viewpoints.

- Looking at the first question item, it was asked as "I think the POE (Prediction-Observation-Explanation) method is a useful method in the laboratory applications part of Physics-I course". Considering the distribution of answers given to the premises, 88,2% of the pre-service teachers, that is, 15 pre-service teacher, agree with the first opinion. While 5,9%, that is, 1 pre-service teacher, did not agree with this first item, 5,9%, that is, 1 again, expressed their opinion as undecided. 88.2% of those who participated in the application thought it was a beneficial technique. When the open-ended answers of participants' who found the method useful are analyzed, it is seen that the majority of them "think that what they have learned is permanent (N=7)". At the same time, they responded as "they think that the method is a method that enables to be active and makes it easier to establish connections between concepts (N=2)" and "they think it is a remarkable method (N=2)". Other participants (N=4) think that "it is a method that aims to think, provides detailed learning, provides a discussion environment and provides regular-planned learning". In addition, when the open-ended answers given by the pre-service teachers who expressed disagreement or undecided were examined, it was seen that "they thought the method took too much time (N=1)" and "they found the prediction phase unnecessary and the method long (N=1)". Some of the answers given are given below.

> *"...After thinking and reasoning about the given experiment, I think it is more memorable when I do the experiment...-B ", "...Because I like to be more active in the lesson and approve of it. It becomes more memorable...-D", "...It may be useful, but I think I lost a lot of time trying to fill it out, so I am not entirely sure...-A", "...I think it will be enough to do the experiment and evaluate the data obtained afterwards. I think the prediction part at the beginning is unnecessary...-H".*

- When one checks the second question item, it was asked as "I am more willing and willing to participate in every stage of the experiment during the whole experiment in the laboratory applications of the physics course". Considering the distribution of answers given to the premises, we can say that 82,4% of the pre-service teachers, that is, 14 pre-service teachers, agreed with the second opinion item. It is seen that 11,8% of the pre-service teachers, i.e. 2 pre-service teachers, chose the premise of "I am undecided" about the second item, and 5,9%, that is, 1 participant, did not agree with this question. 82,4% of the candidates who participated in the application stated that they were willing and willing to participate in every stage of the experiment during the entire experiment in the laboratory practices of physics course. When we look at the open-ended responses offered by those who took part in the second question, we see that "they are now more willing and willing to participate in experiments (N=5)", "they think that the experiments are fun (N=5)". Other participants (N=4) also stated that they thought that "theory turned into practice and they reinforced what they knew with formulas". From this point of view, we can say that this is one of the reasons why the POE method makes students more active and participates in the experiment. In addition, when the open-ended answers given by the pre-service teachers who expressed disagreement or undecided were examined, it was stated that "they were bored with the experiment because the experiments were too long (N=2)" and "that too much work being taken home and there were too many places to be filled (N=1)". It is seen that they express negative opinions. The following are some of the open-ended responses:

> *"...I think that I am the person who is willing and trying to reach the result in all experiments. Every experiment we have done has increased my curiosity and desire for the next experiment...-J", "...I am more willing to learn because applied courses, in other words, these laboratory courses are more interesting to me. For this reason, I am even more eager to attend the lesson...-L", "...I don't know. I can't decide because I don't like physics class. Some experiments interest me and some do not...-İ", "...We take a lot of work home and I think the gaps we need to fill are too much...-K".*

- For the third question item, it was asked as "I think that the POE method is more effective in my scientific predictions and observations during the experiment". When we look at the distribution of answers given to the premises, we see that 70,6% of the participants, ie 12 participant, agreed with the third item, while 29,4%, i.e. 5 pre-service teachers, stated "I am undecided". When the open-ended responses of 12 participants who believe that the POE approach allows them to make more effective observations in scientific predictions and during the experiment are taken into account, when the open-ended answers are examined, it is mentioned that "the gradual method makes the observations more effective (N=5)". At the same time, they stated that "by talking about the prediction, observation and explanation stages of the method, they revealed their preliminary knowledge with the prediction phase, they had information about the accuracy of their predictions together with the observation and explanation phases, and they reached the correct information with the explanation phase (N=2)". Other participants (N=5) who voiced favourable sentiments claimed that "the usefulness of the phases is stressed since the process is progressive and the experiments are observed more clearly."In addition, when the open-ended answers given by the pre-service

teachers who expressed as undecided were examined, it was seen that they thought that "they found the method to be long and the steps unnecessary (N=3), and their opinions also changed according to the experiment (N=1)". Some of the open-ended answers given are listed below.

> *"...Although it is difficult to predict, it is more effective when we do that experiment visually. The POE method, which consists of 3 stages, is actually like input-development-result. We tie that experiment to a conclusion during the explanation phase...-E ,"...We first thought about what might happen while our curiosity about the experiment increased during the estimation phase, and then realized that this thought was right or wrong during the experiment, and we made explanations...-J", "...Some of his questions seem like a waste of time. For example, I don't like the sentence "Which one caught your attention"...-İ", "...It varies according to the experiments we have done...-H".*

- Looking at the fourth question item, it was asked as "I will use the POE method in experiments in my lessons when I start my teaching profession in the future". When we look at the distribution of answers given to the premises, we see that 76,5% of the pre-service teachers, that is, 13 pre-service teachers, expressed a positive opinion. While 17.6% of the participants, or 3 pre-service teachers, responded that they did not agree, only one, or 5.9% of the participants, claimed that they were undecided. When the open-ended answers given by the participants who promised to use the POE method in my future career are examined, it is seen that "it is an effective method in learning (N=5)", "it is a useful method in transforming theoretical knowledge into practice (N=2)" and "that it will increase the interest in the course (N=3)" etc. As a result, we notice that they state that they want to employ this strategy in their professional lives in the future. Other (N=3) participants, on the other hand, appear to believe that "the technique arouses inquiry, promotes course modification, and delivers comprehensive learning." In addition, when the open-ended answers given by the pre-service teachers who expressed disagreement or undecided were examined, "they do not find this method suitable or they will not use it because they will turn to another profession in the future (N=3)" and "some parts of the method they want to apply and some parts they do not want to use (N=1)". The following are some of the open-ended responses.

> *"...I think to use it because I think it provides a complete learning...-G", "Everything that is not forgotten for me starts with curiosity. In my profession, Prediction (Curious phase)-Observation (Experimental phase)-Explanation is the binding place where we conclude from where we came to this conclusion and ensure that the information we learned is memorable...-J", "...I can apply some of it. For example, where can we see them in our lives? I apply the question...-İ", "...I get these stages done by speaking and active participation, using their imagination, instead of written and copy-written reports...-K".*

- For the fifth question item, it was directed as "The POE method contributed to my own interpretation and critical access to the concepts related to physics in physics laboratory applications". When we look at the distribution of answers given to the premises, we see that all of the participants, which is 100%, and 17 pre-service teachers stated that the POE method provides a critical perspective and improves their interpretation skills while reaching the concepts related to physics in laboratory applications in physics course. When the open-ended responses are investigated, we find that a lot of participants believe that "the POE technique enhances their interpretation abilities (N=5)". In addition, we see that "although the knowledge available in theory is permanent with the application phase, with the development of their ability to interpret how physics formulas can be used, they can think about the starting point of the formulas and find the method useful (N=8)". Some of the open-ended answers are listed below.

> *"...I think the prediction phase is very useful. Before I made a guess on this subject, my thinking improved with criticism and comment and it allowed me to be more active...-A", "...In the experiments, we reached real data by using the concepts we know in theory in physics in the experiment. This allowed us to bring new interpretations...-H", "...As this method makes the abstract issues in our minds more concrete, it also enables us to understand them in a real sense. It will be easier to make our own comments and criticisms about a subject that we understand...-L"*

- Looking at the sixth question item, it is stated that "Thanks to the POE method, I got rid of the negative concerns I used to have in the laboratory applications of physics lessons and I am no longer worried about the laboratory applications of the physics lesson". When we look at the distribution of answers given to the premises, we see that 52,9% of the participants, that is, 9 pre-service teachers, stated that they got rid of their negative anxieties in physics lesson laboratory applications with the POE method. While 41,2% of the participants, 7 pre-service teachers, expressed their opinion as "I am undecided", 1 pre-service teacher, that is, 5,9% of the participants, stated that they did not agree with this opinion. It was discovered that as one considers the participants with the answer "Yes", "some of the participants who stated that they got rid of their anxiety as they experimented in the laboratory over time, and that they were anxious at first, got rid of these anxieties with the POE method, the method was permanent, and this reduced their anxiety (N=7)". Some participants stated that "The POE method makes the physics laboratory lesson more enjoyable and provides permanent logical learning (N=2)". In addition, when the open-ended answers given by the candidates who expressed disagreement or undecided were examined, they stated that "they still had deficiencies in some subjects, had difficulties in some experiments or had difficulties in some areas that needed to be filled in the test sheet and reports (N=7)" and said that "he was not worried in the laboratory anyway, and therefore did not get rid of his anxiety (N=1)". Some of the open-ended answers are listed below.

"…I think it went much better than the theoretical classes. I think that the information is more permanent because laboratory lessons are formed as a result of observations…-B", "…It motivates me more to the lesson and I am not afraid to express my opinion…-C", "…I still have concerns, I could not understand some experiments. I'm trying to learn…-İ", "…In the past, I wasn't worried about physics lab classes. That's why I didn't get rid of the worries…-H", "…Some applications are lacking in the subject, my interest in the subject, etc. Sometimes I think that my negative concerns will continue because of things …-Ö".

- As one looks at the seventh question item, it was asked as "I can think more scientifically not only in the laboratory applications of physics lesson but also outside the laboratory thanks to the POE method and I am a better observer in every field". When we look at the distribution of answers given to the premises, we see that 64,7% of the participants, that is, 11 pre-service teachers, stated that thanks to this method, they now think more scientifically in daily life outside the laboratory. While the rate of participants who expressed their opinion as "I am undecided" was 29,4%, that is, 5 teacher candidates, 1 teacher candidate, 5,9%, stated that they did not agree with this item. Considering the open-ended answers given, participants who said "Yes" especially "emphasized the prediction phase, they thought that they got better in scientific thinking as they improved in prediction (N=3)", "The POE method is useful and that they are better in scientific thinking and observation. They think they are better now (N=4)", "they think they are better observers in daily life events and experiments (N=4)". In addition, when the open-ended answers given by the pre-service teachers who expressed disagreement or undecided were examined, "they thought that they were a good observer, but they were undecided as to whether the reason for this was the POE method (N=2)", and "they thought that they needed to improve themselves (N=2)". Some of the open-ended answers given are listed below.

"…I can make predictions when we do experiments not only in physics but also in chemistry. I can predict how the experiment will be done, I can say that I have become a good observer…-E", "…I can predict and observe events in daily life with the POE method, and then explain my knowledge…-M", "…I need to improve myself a little more…-I", "…Normally, I am already a very good observer. And I can have different opinions about things. I am undecided as to whether the reason for this is POE…-H", "…I am not interested in events in daily life…-K".

4. RESULT, DISCUSSION AND SUGGESTIONS

The findings of this research, which was conducted to determine the anxieties, attitudes, and scientific process skills of the experiment group, in which the experiments were carried out using the CNS POE method, and the control group, in which the experiments were carried out in the traditional way using the current program, as well as to obtain the opinions of the pre-service teachers in the experiment group, are summarized.

Considering the results of the study, first of all, the results of the POE method on the level of anxiety towards the physics laboratory, this study is important because of its contribution to the literature because it gives results related to two different affective variables, such as anxiety and attitude towards the physics laboratory, and also mentions the effects of the POE method on laboratory anxiety. Considering the post-test anxiety scores for the physics laboratory, the anxiety score averages of the experimental group were 40,05, while the anxiety score averages of the control group were 49,33. It is seen that the p significance value is ($p<0,05$). From this perspective, it is conferred that participants in the group where the experiments were handled using the POE approach experienced less anxiety in the physics laboratory, which was statistically significant compared to the ones in the control group. From this, it is concluded that the CNS POE method significantly reduces the anxiety levels of candidates towards physics lesson laboratory applications compared to the traditional laboratory method used in the current program. However, in the answers given about the anxiety in the opinion form, a lot of the candidates stated that they got rid of their anxiety about the laboratory, which also overlaps with the explanations above and supports this result.

Another variable explored in this study is if there is a difference in attitudes between the two groups regarding the physics laboratory. When the results are examined, it is discovered that there is no meaningful statistical difference in the posttest laboratory attitude averages of the experiment group compared to the posttest laboratory attitude averages of the control group, but there is a boost in the posttest attitude averages in the group where the experiments were conducted using the POE method compared to the pretest attitude averages. When we examine the research on the POE technique in the literature, we discover that the method utilized in many studies has a beneficial influence on attitude. Özcan (2019) discovered a significant difference in favor of the experimental group in terms of attitude, academic achievement, and retention scores as a result of his study, which was conducted using the prediction-observation-explanation strategy and examined the effect on the academic achievement and attitudes of 4th grade primary school students. Yavuz and Çelik (2013) discovered a substantial difference in attitudes about the lesson in favor of the experimental group as a consequence of their study with primary school instructors. Sünkür, Arbaş, İlhan and Sünkür (2012) discovered a difference in favor of the post attitude score between the scores obtained from the pre-attitude-post-attitude scales of the students in the experimental group as a result of their studies on the effect of POE method supported reflective thinking activities on the attitudes of 7th grade students towards science and technology lessons. This difference, however, was not statistically significant. Many additional research on the influence of the POE technique on attitude have indicated that its use has a favorable effect on students' attitudes. (Aydın, 2010; Bilen & Köse, 2012; Chew, 2008; Duit, Treagust, & Mansfield, 1996; Keeratiechomroen, Panijpan & Pahsah, 2007, Köseoğlu, Tümay & Kavak, 2002; Mtembu, 2001; Teerasong, Chantore, Ruenwongsa & Nacapricha, 2010). In addition to all these, the fact that the majority of the

participants expressed positive opinions about the attitude towards the laboratory in the answers given in the opinion form is supportive in terms of the positive contributions of this method to the attitude.

The experiment group's participants' comments on the applied approach and procedure were solicited for this study. Positive opinions generally indicate that "Concept Network Supported POE activities" are an enjoyable and entertaining method, a useful method, experiments attract more attention, enable effective observation, improve interpretation skills, etc. given in the form. Also, "Will you use this method in your future professional life?" Thirteen (76.5%) of the seventeen participants of the experiment group replied yes to the question. In the third question, which is about the method's gradualness and efficacy, 5 pre-service teachers (29,4%) believe it is long, time-consuming, and difficult. The results obtained are similar to the literature. Yurtyapan (2018) conducted his study titled "The Effect of Prediction-Observation-Explanation Practices Supported by Concept Cartoon towards Biology Subjects on Academic Success and Metacognitive Skills of Science Prospective Teachers" with 79 pre-service teachers enrolled in the "Science Teaching Laboratory Applications-II" course in the third grade. Following the 4 week application, the participants reported that they believed the lesson provided using this approach was more permanent than previous lessons, that it improved their psychomotor abilities, and that they may apply this method in their professional life in the future. Yıldırım and Maşeoğlu (2016) concluded that, as a result of their study titled "Predict-Observe-Explain-Based Activities in the Association of Chemistry with the Daily Life and Student Views", they thought that the pre-service teachers enjoyed the activities related to the POE method, had the opportunity to correct their incorrect knowledge, and contributed positively to interpersonal interaction. In their action research study, Bilen, Özel and Köse (2016) stated that the majority of students who expressed their opinions thought that the applied method was more enjoyable than other methods, and that the method was time-consuming and challenging. Tekin (2008) found in his study on the scientific laboratory that students like experimenting as a consequence of the experiments he did using the POE technique.

Based on this information, it is clear that the findings of this study and the findings of the literature are comparable to the findings of the studies conducted. The POE method is an alternative method based on the constructivist approach, and there were differences in lab practices of the course Physics-I of this study in favor of the experiment group in the students' laboratory anxiety and scientific process skills when compared to the traditional laboratory method used in the current program. In terms of attitude, there was no statistically significant difference. On the other hand, the anxiety levels of participants in the control group, in which the experiments were conducted traditionally, towards the physics laboratory were statistically considerably greater than those of the participants in the experimental group. As a result, the anxiety levels of the participants in the group where the trials were processed using the POE technique fell considerably.

Another element under consideration throughout this research is prospective science teachers' scientific process abilities. As a consequence of the study, there is a statistically significant difference in the experimental and control groups' scientific process skill test post-test scores in favor of the experimental group. Several studies have found that the POE technique has a good influence on scientific process abilities. In his study on the effect of the concept cartoon supported POE method on the inquiry skills, scientific process skills, and concept learning of secondary school 5th grade students, according to Özçelik (2019), there was a positive rise in the scientific process abilities of the students in the group taught using the POE technique. Güngör (2016) investigated the effects of the POE method on the success, permanence, and scientific process skills of pre-service science teachers in teaching biological subjects and concepts, and concluded that the laboratory approach based on the POE method activities had a substantial impact on the success, development of scientific process skills, and persistence of teacher candidates. Karatekin and Öztürk (2012) investigated the influence of the POE method on science teacher candidates' success and scientific process abilities while studying "Cells and Tissues". As a result of their research, they came to the conclusion that applying the POE technique in the lab environment had a positive impact on scientific process skills and success.

When the results of quantitative data on attitude, anxiety, and scientific process skills are examined, positive attitudes toward the laboratory were observed in the experiment group in which POE method for Physics-1 course laboratory applications were issued for experiments when compared to the control group in which the experiments were performed in line with the traditional method. It can be noticed that their anxiety levels have statistically lowered dramatically. Simultaneously, they are statistically substantially more effective than the control group in post-test scores of scientific process skills. In the qualitative element of the study, it was reported that the majority of the candidates found the approach beneficial, that they wished to utilize it in their future professional life, and that it lessened their concern about the laboratory. They are viewed to communicate their ideas in a way that is compatible with the quantitative facts.

In the light of all this information, it can be suggested that new studies to be carried out should be used together with the POE method and different auxiliary alternative methods. Because the POE method, by its nature, is applied gradually and supports the creation of a discussion environment in the lesson, the time planning of the lessons should be done well and the planning for the course of the lesson should be done carefully. In this method, since the information is not given to the students ready-made and students are asked to reach the information in an environment of guesses and discussion, it is important for the students to make a preliminary preparation before the lesson in terms of the effectiveness of the lesson and the method. At the same time, since there are very limited studies on physics and physics laboratory, it is seen that more studies should be done in physics course and physics laboratory applications.

Research and Publication Ethics Statement

This research was produced from a master's thesis. It was unanimously decided at the meeting of Gazi University Ethics Commission, dated 11.09.2018 and numbered 07, that there is no ethical objection to conducting this research, provided that permission is obtained from the planned places. Considering the basic issues regarding the conduct of the research, it is stated that the participants in the applications comply with the principles of research and publication ethics in the principles of volunteering, conducting the applications, collecting data, using and analyzing the data, as well as the source used in the study content, the citations made and the references cited. This research has not been published in any other journal. However, a portion of the thesis that is the source of this article was given orally at a conference in Ankara.

Contribution Rates of Authors to the Article

When we look at all the processes related to the preparation of this research, the determination of the study subject, the implementation and the collection of data, the analysis and reporting of the data, it is seen that the contributions made by both authors to the article are of the same level (50% contribution rate).

Declaration of Interest

There was not any conflict of interest between authors during preparation of study, collecting data, interpreting and the reporting results.

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