

# Predict-Observe-Explain Tasks in Chemistry Laboratory: Pre-Service Elementary Teachers' Understanding and Attitudes

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## Abstract

This study was conducted to investigate the effects of laboratory activities based on predict-observe-explain tasks related to the subjects of "Mixtures, Physical and Chemical Changes, Acids and Bases" on pre-service elementary teachers' understanding and attitude toward chemistry lesson and chemistry laboratory. For this purpose, the pre-service elementary teachers were randomly assigned to experimental (N=26) and control (N=30) groups. The experimental group was instructed using laboratory activities based on predict-observe-explain task and the control group was taught using traditional cook-book design laboratory activities during ten weeks. For the data collection, a two-tier concept test, attitude toward chemistry lesson scale and attitude toward chemistry laboratory scale were applied before and after the instructions. The results indicated that the pre-service elementary teachers who were trained using laboratory activities based on predict-observe-explain task had significantly higher scores in terms of achievement and attitude toward chemistry lesson and laboratory than those taught by the traditional approach. It was also found that instruction for laboratory activities based on predict-observe-explain task was more successful in remediation of the predetermined alternative conceptions.

**Keywords:** Acids and bases, attitude toward chemistry lesson and chemistry laboratory, conceptual understanding, mixtures, physical and chemical changes, predict-observe-explain.

## Kimya Laboratuvarında Tahmin-Gözlem-Açıklama Uygulamaları: Sınıf Öğretmeni Adaylarının Anlamaları ve Tutumları

### Öz

Sunulan çalışmada "Karışımlar, Fiziksel ve Kimyasal Değişim, Asitler ve Bazlar" konularında tahmin gözlem açıklamaya dayalı laboratuvar etkinliklerinin sınıf öğretmeni adaylarının anlamalarına ve kimya dersine ve kimya laboratuvarına karşı tutumlarına etkisinin incelenmesi amaçlanmıştır. Bu amaçla sınıf öğretmeni adayları deney (N=26) ve kontrol (N=30) gruplarına ayrılmıştır. Laboratuvar etkinlikleri on hafta süresince deney grubunda tahmin gözlem açıklamaya dayalı olarak ger-

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çekleştirilirken, kontrol grubu geleneksel yaklaşıma dayalı yürütülmüştür. Veri toplama aracı olarak iki aşamalı kavram testi, kimya dersine karşı tutum ölçeği ve kimya laboratuvarına karşı tutum ölçeği kullanılmıştır. Sonuçlar tahmin gözlem açıklamaya dayalı laboratuvar etkinlikleri yapan sınıf öğretmeni adaylarının geleneksel yaklaşıma dayalı etkinlikler gerçekleştirenlere kıyasla başarı, kimya dersine ve kimya laboratuvarına karşı tutum açısından istatistiksel olarak anlamlı düzeyde daha yüksek puana sahip olduklarını göstermiştir. Ayrıca tahmin gözlem açıklamaya dayalı laboratuvar etkinliklerinin çalışmanın öncesinde belirlenen alternative kavramları gidermede oldukça başarılı olduğu bulunmuştur.

**Anahtar Kelimeler:** Asitler ve bazlar, fiziksel ve kimyasal değişim, kavramsal anlama, karışımlar, kimya dersine ve kimya laboratuvarına karşı tutum ölçeği, tahmin-gözlem-açıklama.

## 1. INTRODUCTION

Laboratory instruction has been a central part of science education from the early 20th century (Singer, Hilton & Schweingruber, 2006). A laboratory setting gives students a chance to work in small groups and to investigate scientific phenomena. By working in a laboratory, it is ensured that students - learn, clarify and validate scientific principles and theories. Hofstein and Lunetta (2004) have argued that laboratory has an important role for students' conceptual understanding. Costu, Ayas and Niaz (2010) have also indicated that chemistry laboratory provides students an opportunity to observe scientific events and it also enhances conceptual understanding and conceptual change. Furthermore, it has been emphasized that laboratory work is very important to promote positive attitudes, to increase interest, and to motivate students to learn science and especially chemistry (Freedman, 1997; Hofstein & Lunetta, 2004; Thompson & Soyibo, 2002). Students enjoy laboratory work; this is why laboratory experiences are important for developing positive attitudes and interest in science (Hofstein & Lunetta, 2004).

Besides students' having opportunities in laboratory an environment, it has been discussed that students can enhance their conceptual understanding and positive attitudes, if laboratory activities are carried out in an appropriate manner. In a traditionally cookbook laboratory setting, students only follow the directions

given and the experimental procedure. Students concentrate on following recipes, collecting and recording data in the laboratory guide which is including list of tasks for students in the environment. Therefore they aim only to complete their task and the purpose of their investigation is not understood in depth by them (Hofstein & Lunetta, 2004). In addition to these, excessive details given in the cook-book laboratory guides can distract students from the purpose of experiment (Johstone & Wham, 1982). Moreover, students rarely discuss scientific facts related to their investigation (Roth, 1994). They can only verify these facts to follow their tasks without any opportunities to reason about their observations. However, laboratory activities should involve students' active participation (Bradley, 2001). According to Milner, Ben-Zvi and Hofstein (1987), students wanted more advanced chemistry courses because they were able to gain experience with participation of these practical activities in the chemistry laboratory. While students experimenting, they should not only conduct laboratory activity step by step and collect data, but also they should discuss the observed data by correlating their conceptual learning. When the degree of active participation in the science laboratory improves, attitudes towards chemistry learning and chemistry laboratory increase (Okebukola, 1986).

Daily life application in the laboratory is also one of the most important factors which promote conceptual understanding and positive

attitudes. If laboratory activities do not associate with students' everyday life applications and social problems, they will not be able to make a connection between scientific facts and their experiences, so this situation will influence their achievements (Costu, Unal & Ayas, 2007), attitudes and interests (Hofstein & Mamlok-Naaman, 2011). Also, students' interests in the subject contribute to studying of science (Lindahl, 2003) and this can be provided by giving subjects from daily life examples. Because, when students are familiar with the subjects from their previous experience, they feel confident enough and this situation affects their motivation (Hofstein & Mamlok-Naaman, 2011).

Laboratory activities have been a substantial way for activity/performance-based science tasks (Acar-Sesen & Tarhan, 2013). A laboratory instruction based on active learning methods provides students an opportunity to analyze problems by using hands-on and inquiry-oriented activities in cooperative learning groups (Abdullah, Mohammed & Hj Ismail, 2009). Therefore, science educators have focused on sufficiency of cook-book laboratory settings for educational goals and they have highlighted the effectiveness of using active learning methods in laboratory instructions. In the previous research, different learning methods and techniques were used in the laboratory for increasing students' achievement, promoting students' understanding and improving their attitude toward chemistry lesson and chemistry laboratory. Predict-Observe-Explain (POE), which is used in the laboratory setting, is one of these active learning techniques.

### 1.1 Predict-Observe-Explain

POE has been used to provide students an opportunity to predict the result of the situation with its reasons and it also ensures students observe the situation and do explanations

to remove the conflict between prediction and observation (Kose, Costu & Keser, 2003). In the POE procedure, hypothesis are formulated, reasons are given to prove these hypothesis and then related data is collected and results are discussed (White, 1988). POE is an efficient strategy for encouraging students to discuss about their ideas (White & Gunstone, 1992). The POE technique is completed by requiring students to carry out three tasks.

In the *Predict (P)* step, information about an experiment or event is given to students and the students are supposed to predict the outcome of this event or situation. They have to justify, inquiry and give a reason for their prediction (White & Gunstone, 1992). In this step, the students' understanding and alternative conceptions are identified while they are discussing on their task in their cooperative groups. Moreover, the prediction stage provides students an opportunity to focus on observation and it promotes motivation.

The students describe what they see in the *Observe (O)* step. This may be an experiment, an event or a video related to the learning issue. These activities should be easy for observation and they should constitute a conflict (White & Gunstone, 1992).

In the *Explain (E)* step, the students inquire differences between their prediction and observation in order to reconcile any conflict between their prediction and observation. The students discuss and share their explanations. In this way, they do not repeat the knowledge in books; they can explain the phenomenon with their own sentences.

POE tasks have been reported extensively in the literature. Although POE tasks have been used in studies of conceptual change and learning achievement, there has been lack of studies that investigate the effect of POE on under-

graduates' attitudes towards chemistry lesson and chemistry laboratory. Also, elementary education has major importance for effective chemistry education in high school and undergraduate level. Therefore it should be provided that elementary teachers have positive attitude toward chemistry lesson and chemistry laboratory and they should understand meaningfully basic chemistry concepts such as mixtures, physical and chemical changes, acids and bases for providing effective learning to their students. Research which investigated understanding of aforementioned concept in elementary teacher training level has been limited.

Liew and Treagust (1998) aimed to explore the effectiveness POE in diagnosing students' understanding of science and in identifying their level of achievement. The POE tasks were concerned with expansion of water, solubility of salt, power and resistance of light globes. They collected data from 11<sup>th</sup> grade students included their written responses in POE task worksheet, interviews with individual students, and in-class discussion. The results implied that POE task can be used to design learning activities insightfully which starts with the students' viewpoints rather than teachers' or scientists'. They also reported that POE tasks are effective in facilitating the teacher and the students in documenting student achievement and profiling student progress.

Hsu (2004) explored students' alternative conceptions of combustibility by using the POE technique. Research participants were 96 6<sup>th</sup> graders, 86 8<sup>th</sup> graders and 121 11<sup>th</sup> graders. Research findings indicated that over half of the students in each grade predicted the hydraulic oil as a combustible substance. After the observation, over twenty percent of the students in each grade still thought that the hydraulic oil was combustible and about one third of the students considered the occurrence

of smoke as burning. At the explanation stage, most of the students could not explain that with scientific reasons and some of the students, who predicted that the hydraulic oil was combustible, thought either the temperature was not high enough or the boiling point of the hydraulic oil was too high to cause combustion.

Bilen and Aydogdu (2010) aimed to investigate the effects of a laboratory instruction, based on POE, on the pre-service science teachers' conceptual understanding of photosynthesis and respiration in plants. They also studied on the pre-service science teachers' attitudes towards general biology laboratory. The research was conducted with participation of 122 the pre-service elementary teachers who took the General Biology Laboratory course. A two-tier concept test related to photosynthesis and respiration in plants and an attitude scale toward biology laboratory were used for data collection. Their finding showed that laboratory instruction designed based on POE strategy was an effective way of promoting the conceptual understanding and improving attitudes toward biology laboratory positively.

Costu, Ayas and Niaz (2010) developed a POE based laboratory instruction described as Predict-Discuss-Explain-Observe-Discuss-Explain (PDEODE). They found that this technique was effective in achieving better conceptual understanding of evaporation concept. In their other study, they used the same procedure to teach condensation concepts and they found that PDEODE strategy was also effective in promoting the understanding of condensation concepts (Costu, Ayas & Niaz, 2012).

Acar-Sesen (2013) investigated that the pre-service science teachers' understanding of surface tension, cohesion and adhesion forces by using computer-mediated predict-observe-explain tasks. So, three computer-mediated predict-observe-explain tasks were devel-

oped. The pre-service science teachers' written POE task responses were analyzed to investigate their understanding. It was found that computer-mediated predict-observe-explain task was an effective method to diagnose students' understanding.

Bilen and Kose (2012) investigated the effects of activities, based on POE, about growth and development in plant on pre-service science teachers' attitudes toward science teaching. They studied with seventy-four second grade the pre-service science teachers and POE activities were conducted in the experimental group and a teacher centred traditional approach in the control group. The results showed that there were significant differences between the experimental and the control groups' attitudes toward science teaching in favour of the experimental group. Moreover, the pre-service science teachers said that POE activities were effective, they were happy, they felt themselves better, their self-confidence increased and they would use these activities in their lessons.

Koseoglu, Tumay and Kavak (2002) developed a POE activity named as "Water can be boiled with ice" This activity was applied to forty-four the pre-service chemistry teachers. They collected data from observations and interviews. According to the results, they found that POE activity was effective in promoting the pre-service science teachers' attitudes toward chemistry, their interest and motivation.

An extensive study has also been done by Yavuz and Celik (2013). They used POE tasks concerned with gases subject in the context of general chemistry lesson to remedy the pre-service elementary teachers' alternative concepts and to promote their attitude toward chemistry lesson. A gases concept test, an attitude scale toward chemistry and POE worksheets were used for data collection. Eight POE activities were applied during three weeks in

the experimental group and gases subject was taught with traditional approach in the control group. Researchers found that POE was an effective way of promoting the pre-service elementary teachers' achievement, conceptual understanding on gases subject and their attitude toward chemistry.

## 1.2 Purpose of the Research

The purpose of this study was to investigate the effects of the laboratory activities, which are based on predict-observe-explain tasks, on the pre-service elementary teachers' understanding some chemistry concepts, their attitudes toward chemistry lesson and attitudes toward chemistry laboratory. For this reason, the following research questions were investigated;

1. Do the laboratory activities based on predict-observe-explain task contribute to better conceptual understanding of chemistry concepts?
2. Do the laboratory activities based on predict-observe-explain task affect the pre-service elementary teachers' attitude toward chemistry lesson?
3. Do the laboratory activities based on predict-observe-explain task affect the pre-service elementary teachers' attitude toward chemistry laboratory?

## 2. METHOD

### 2.1 Participants

This study was conducted with participation of 56 the pre-service elementary teachers enrolled in Science and Technology Laboratory Applications-II lesson in an education faculty in Istanbul, Turkey. They were randomly assigned to experimental ( $N_E=26$ ) and control ( $N_C=30$ ) groups. All the pre-service elementary teachers in both groups were similar in socioeconomic

status; a great majority of the pre-service elementary teachers were from middle-class families. They all achieved Science and Technology Laboratory Applications-I lesson in previous semester. They had also learned laboratory rules, laboratory safety, and laboratory methods in advance.

## 2.2 Instruments

### 2.2.1 Two-tier concept test

In this study a two-tier concept test (TTCT), consisted of 23 items related to the concepts such as “*Mixtures, Physical and Chemical Changes, Acids and Bases*”, was developed based on following Treagust's methods (1988) by the researchers for data collection. Prior to the development of the tests items, the content boundaries had been defined by the researchers. Multiple-choice items with an open ended part included 23 items, in which the students were required to explain their reasons for their answers to the first part, were constructed. The test was validated by three chemistry educators and it was applied to 62 the pre-service elementary teachers. The responses of the open-ended part of each item were analyzed and alternative

conceptions were determined. Distracters were constructed by considering the students' responses to the open-ended part and alternative concepts identified in the literature (e.g. Ayvaci & Coruhlu, 2009; Calik & Ayas, 2005; Demirci et. al., 2005; Hesse & Anderson, 1992; Krause & Tasooji, 2007; Schmidt, 1991; Sheppard, 2006; Toplis, 1998). Later, the two-tier diagnostic test was developed in which the first tier was the conventional multiple choice step and the second tier was the part in which there were possible reasons for the answers given to the first tier. The second tier included two, three, four or five responses, one of them was the expected answer. The test was piloted with participation of 102 undergraduates, and then item analysis and reliability analysis were made. For analyzing data, the answer was considered to be correct if both tiers were correctly answered (Treagust, 1988). Therefore one point was given for the items only when both parts of the items were correctly answered, and zero point was given for the items when either part was incorrectly answered. The final version of the test included 23 items and reliability coefficients were found to be 0.72. An example item related to strength of acids is presented in Table 1.

**Table 1.** A sample question from the two-tier test

Strength of acids is determined by;
A. Indicators
B. pH meter
C. The percentage of dissociation in water
D. Melting proportion to metals
Because;
I. Acids turn indicators to red colour.
II. pH is less than 7.
III. Acids don't keep metal chemical storage box.
IV. Weak acids dissociate partially.

### 2.2.2 Attitude toward chemistry lesson scale

To determine the pre-service elementary teachers' attitudes toward the chemistry lesson be-

fore and after the instruction, 5-point Likert type Attitude toward Chemistry Lesson Scale (ATCS) developed by Acar (2008) in which twenty five items was used. Before develop-

ment of the items, the literature related to the attitude toward science and chemistry had been reviewed (Berberoglu & Calikoglu, 1992;

Freedman, 1997; Hofstein & Lunetta, 1982; Koballa, 1988; Koballa, Crawley & Shrigley, 1990; Salta & Tzougraki, 2004).

**Table 2.** ACTS' dimensions, items and cronbach's alpha reliability coefficient

Dimensions	Items	Cronbach Alpha reliability coefficients
Interest in chemistry lesson	1, 3, 8, 18, 20, 22.	0.78
Understanding and learning chemistry	2, 5, 7, 12 - 15, 17, 21, 23	0.84
The importance of chemistry in real life	4, 6, 11, 19, 25	0.83
Chemistry and occupational choice	9, 10, 16, 24	0.87

The items were constructed by considering the attitude scale developed by Salta and Tzougraki (2004). For the validity, the scale was reviewed by seven educators from different universities. After the corrections, the scale was applied to 195 undergraduates for the reliability. Cronbach's alpha reliability coefficient was found to be 0.82. The ATCS has four dimensions as it can be seen in Table 2.

#### Attitude toward chemistry laboratory scale

Students' attitudes toward the chemistry laboratory before and after the instruction were

**Table 3.** ACLTS' dimensions, items and cronbach's alpha reliability coefficient

Dimensions	Items	Cronbach Alpha reliability coefficients
Laboratory environment and using equipments	1, 6, 9, 13	0.82
Experimental process in the laboratory	2-8, 10, 12, 23, 25	0.90
Assessment in the laboratory	11, 15-21, 26	0.85
Cooperative learning in the laboratory	14, 22, 24, 27	0.87

### 2.3 Data Analysis

For the two tier diagnostic test's reliability analysis, SPSS data file was constructed. While analysing these data, the answer was considered to be correct if both tiers were correctly answered (Treagust, 1988) because of its decreasing students' obtaining a correct answer

determined by using 5-point Likert type Attitude toward Chemistry Laboratory Scale (ATCLS) developed by Tarhan (2008). Before development of the items, the literature reviews had been done (Carlo & Bodner, 2004; Freedman, 1997). For the validity, the scale was reviewed by seven educators from different universities. It was applied to 283 undergraduates; Cronbach's alpha reliability coefficient was found to be 0.87. The ATCLS has four dimensions (Table 3).

by chance (Tsui & Treagust, 2010) and evaluating meaningful understanding, deeply. Therefore, one point was given for items only when both parts of the item were correctly answered, and zero point was given for items when either part was incorrectly answered. Cronbach's alpha reliability coefficient was reported because coefficient alpha is equivalent to the

Kuder-Richardson 20 coefficient for dichotomous data (Green & Salkind, 2005).

For calculating the pre-and post TTCT total score, one point was given for items only when both parts of the item were correctly answered, and zero point was given for items when either part was incorrectly answered. For evaluating the pre-service elementary teachers' understanding, their responses to each item were analysed by following Treagust method (1988). Therefore, the percentage of the pre-service elementary teachers' choices for each option was calculated. Alternative conceptions that had percentage more than 20% related to aforementioned concepts were reported.

An example item related to acids-bases was presented to illustrate how the item worked and how the data was used by the pre-service elementary teachers.

When you examine a pH scale, you can see that pH is between 0-14. So, this pH value;

- It is the measure of acid strength.
- It is always 7 after the neutralization.
- It is the measure of concentration.

Because:

- pH and  $H_3O^+$  are inversely proportional.
- Acid strength increases when pH is close to 1.
- After all the neutralization, neutral solutions are always formed.
- Acid strength increases when pH increases.

This item assessed the pre-service elementary teachers' understanding of acids' strength and how determined to this conclusion. While analysing this item, the percentages of each option having been chosen in both tiers were calculated (Table 4).

In the pre-test, the minor part of the pre-service elementary teachers (19%) responded correctly that pH is the measure of concentration. Also, very few of the pre-service elementary teachers (13%) correctly responded to the second tier. However, only 8% of participants selected correct choice that was c in the first tier and A in the second tier, so only 8% correctly understood pH concept and the relationship between pH and concentration. The majority of the pre-service elementary teachers chose a and C, 64% and 40%, respectively.

**Table 4.** Analysing of an item related to acids-bases for identifying experimental group's understanding for pre-test

N	First Tier (%)	Second Tier (%)				
		A	B	C	D	No reason
151	a (64%)**	10%	17%	23%	14%	0%
	b (17%)	0%	2%	15%	0%	0%
	c (19%)	8%*	0%	2%	4%	5%
	No choice (0%)	-	-	-	-	-
Total		18%	19%	40%**	18%	5%

Note \* The correct choice and reason response

\*\* Reported alternative conceptions that had percentages more than 20%

- No responses in this category

According to the results, these the pre-service elementary teachers had following alternative conceptions;



- pH is the measure of acid strength (64%).
- Neutral solutions are always formed in all neutralization reactions (40%).

For statistical analysis of ATCS and ATCLS, positive items in both scales were assigned with a numeric value ranging between (5) strongly agree, (4) agree, (3) undecided, (2) disagree, (1) strongly disagree, and negative items were assigned with their reversed. The maximum scores which a student could obtain from the ATCS and ATCLS were 125 and 135 respectively.

While analysing the pre and post test scores of both two tier diagnostic test and attitude scales, firstly, Shapiro Wilk test was used to identify whether the data was normally distributed or not. According to the results, Mann Whitney U test and Wilcoxon Signed Ranks Test were conducted to compare pre-test mean scores and post- test mean scores of the pre-service elementary teachers in both groups.

## 2.4 Procedure

In this study, pre- and post- test design with control group was used. At the beginning of the study, TTCT, ATCS and ATCLS were applied to both groups. The same laboratory activities were conducted by using predict-observe-explain task in the experimental group and using a cook book traditional approach in the control group. After the instruction, TTCT, ATCS and ATCLS were applied.

### 2.4.1 Instructions in the experimental group

At the beginning of the study, the pre-service elementary teachers were informed about learning process. In this process, a brief orientation including group rules, student and instructor roles, and evaluation strategies in the POE process was held to prepare them for the laboratory activities. In the experimental group, 26

the pre-service elementary teachers were randomly stratified into six groups. Instruction was conducted with laboratory activities based on POE tasks. Ten POE tasks related to *mixtures, physical and chemical changes, acids and bases*, which are presented in Table 5, were developed, and worksheets were prepared for each task.

All of the POE tasks were started with a brief story about daily life. In the first stage, participants were required to read the story clearly, to discuss and inquiry the reason of the problem given in the story and to make a prediction. After they had conducted laboratory works in their cooperative groups, they discussed the conflict between their prediction and observation. The POE tasks were conducted during ten weeks in the experimental group in laboratory setting. All the laboratory activities were done by the pre-service elementary teachers in cooperative groups under the guidance of the instructor. An example worksheet for POE task is given in Figure 1.


In the first step of this task, an antacid was given to the pre-service elementary teachers. They were required to read the prospectus and to predict how the antacid affects heartburn in the stomach. Then, they justified their prediction and wrote their prediction on the worksheet. In the second step, they carried out the laboratory activity by using 0.1 M HCl solution, antacid for stomach and pH paper. They were steered to write their observations. In the last step, they were asked to amend and add their explanation to take account of the observation and to reconcile any conflict between their prediction and observation. During the POE tasks, the instructor encouraged the pre-service elementary teachers to discuss and share their knowledge with their peers in the groups. Finally, they shared their explanation with their classmates.

**Table 5.** POE task used in this study





POE Tasks	Purpose	Predict	Observe	Explain
While it is mixing, it is complicating	Students will be able to learn dissolution concept, homogeneous solutions, and classification of solution types.	Predict what will happen if you add salt, olive oil, paper clip, sand, match and flour to a cup of water. Discuss in your group and write down your prediction. State and explain the reasons of your prediction.	Carry out hands-on activity by using mentioned material and write down your observation.	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in your group and explain your reasons.
Lemonade	Students will be able to learn effects of stirring and heating on solubility	Predict how the sugar at the bottom of the beaker could be decomposed in the given scenario related to making lemonade. Discuss in your group and write down your prediction. State and explain the reasons of your prediction.	Carry out hands-on activity by using mentioned material and write down your observation.	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in your group and explain your reasons.
What happen to soft drink	Students will be able to learn factors affecting solubility of gases	Predict what will happen if you open a crown cap including soft drink after you shaken or put near stove. Discuss in your group and write down your prediction. State and explain the reasons of your prediction.	Carry out hands-on activity by using mentioned material and write down your observation.	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in your group and explain your reasons.
Let's produce electric	Students will be able to learn electrolyte and nonelectrolyte solutions' properties	Predict what will happen conducting wire with lamb is immersed to salt solution and sugar solution. Discuss in your group and write down your prediction. State and explain the reasons of your prediction.	Carry out hands-on activity by using battery, conducting wire with lamb, salt solution and sugar solution and write down your observation.	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in your group and explain your reasons.
Journey of Matters	Students will be able to learn physical and chemical changes some matter.	Predict what will happen sugar in the beaker and ice in the beaker are heated. Discuss in your group and write down your prediction. State and explain the reasons of your prediction.	Carry out hands-on activity by ice, sugar, two same beakers, a heater and write down their observation.	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in your group and explain your reasons.
Chemicals around us I	Students will be able to learn how some material in daily life effect litmus paper and its being classi-	Predict which material is acid and which one is base and then classify the material as acid or base which was given to you. Discuss	Carry out hands-on activity with lemon, soft drink, milk, dish soap, muruatic acid,	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in

	fied this material as acid or base.	in your group and write down your prediction. State and explain the reasons of your prediction	water, vinegar, drain opener and write down your observation.	your group and explain your reasons.
Chemicals around us II	Students will be able to learn the effects of acids and bases to different indicators.	Predict what changes will the acid and base solution's colour add to this different indicator. Discuss in your group and write down your prediction. State and explain the reasons of your prediction.	Carry out hands-on activity by using same materials in Task-6 and tea, red cabbage juice, bromcresol green and write down your observation.	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in your group and explain your reasons.
Chemicals around us III	Students will be able to learn how different concentration of acids and bases affect on indicators.	Predict how different concentration of acids and bases affect indicators. Discuss in your group and write down your prediction. State and explain the reasons of your prediction.	Carry out hands-on activity by using strength acid and strength base, bromcresol green indicator and write down your observation	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in your group and explain your reasons.
Heartburn	Students will be able to learn neutralization and how different concentration of acid and base effect neutralization and pH of a solution.	Read the prospectus of medicine for stomach and predict how the medicine affects heartburn in the stomach. Discuss in your group and write down your prediction. State and explain the reasons of your prediction.	Carry out hands-on activity by 0.1 M HCl solution, medicine for stomach and pH paper and write down your observation.	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in your group and explain your reasons.
How much does your necklace rost?	Students will be able to learn effect of acids to metals	Predict what will happen to metal material put into concentrated acid in the baker. Discuss in your group and write down your prediction. State and explain the reasons of your prediction.	Carry out hands-on activity by beaker, concentrated acid, different metal sample and write down your observation.	Compare your prediction and observation. Are they in agreement or disagreement? Discuss in your group and explain your reasons.










**HEARTBURN**  
 Heartburn is a discomfort - happening in the oesophagus and felt behind the breastbone area - that takes the form of a burning sensation, which tends to worsen when the person lies down or bends over. It can last for several hours and also tends to worsen after eating food. The burning pain moves up toward the neck and throat. The stomach fluid can reach the back of the throat for some, producing a bitter or sour taste. Doctors generally offer their patients, who have heartburn, to use antacids for a rapid relief.



**YOUR PREDICTION:** Can you predict the reason of using antacids for treatment of heartburn? Please read the prospectus of the antacid and discuss with your group mates.

YOUR MATERIALS	YOUR ACTIVITY
 <p>0.1 M HCl Solution</p>  <p>Antacid</p>  <p>pH paper</p>	 <p>Three Beakers</p>

**STEPS OF EXPERIMENT**

I	II	III	
			Add 100 ml HCl solution into all beakers.
			Add 2g, 4g and 6g of the antacid into the beakers respectively.
			Insert pH papers in to each solution.

**YOUR OBSERVATIONS:** Observe changes in pH papers for each solution.

**I. Solution:** .....

**II. Solution:** .....

**III. Solution:** .....

**YOUR EXPLANATIONS:** Explain the reason of changes in pH papers in each beaker.

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**COMPARE YOUR PREDICTION AND OBSERVATION:** Are there any differences between your prediction and observation? Inquire differences with your group mates and share your opinions with classmates.

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Figure 1. An example worksheet based on POE task

#### 2.4.2 Instructions in the control group

In the control group, same laboratory activities were conducted in traditional cook-book laboratory settings. The pre-service elementary teachers followed the experimental procedure

and directions in the worksheets. During this process, they were required to write the purpose of the activity, conduct laboratory activities, record their observations and discuss their results. An example worksheet used in the control group is given in the Figure 2.

NEUTRALIZATION OF ACID AND BASE	
<b>Purpose:</b>	
<b>Materials:</b> 0,1M HCl solution, antacid, 3 beakers, pH paper.	
<b>Procedure:</b>	
<ol style="list-style-type: none"> <li>1. Add 100 ml HCl solution into all beakers.</li> <li>2. Add 2g, 4g and 6 g of the antacid into the beakers respectively.</li> <li>3. Investigate the changes of pH using pH paper.</li> </ol>	
<b>Observations:</b>	
<b>Results and Discussion:</b>	

Figure 2. An example worksheet based on traditional approach.

### 3. RESULTS

whether the pre-test and post-test scores were normally distributed or not (Table 6).

#### 3.1. Results of Shapiro Wilk Test

Firstly, Shapiro Wilk test was used to identify

Table 6. Shapiro Wilk test results of the pre-test and post-test

		Group	Statistic	df	p
TTCT	Pre-test	Experimental	0.950	26	0.309
		Control	0.930	30	0.062
	Post-test	Experimental	0.886	26	0.010*
		Control	0.845	30	0.010*
ATCS	Pre-test	Experimental	0.957	26	0.395
		Control	0.926	30	0.048
	Post-test	Experimental	0.967	26	0.554
		Control	0.941	30	0.124
ATCLS	Pre-test	Experimental	0.686	26	0.010*
		Control	0.873	30	0.010*
	Post-test	Experimental	0.923	26	0.060
		Control	0.818	30	0.010*

The results showed that there was not a normal distribution for the all of the pre-test and post-test scores for both groups. For this reason,

nonparametric statistic tests were used for comparing the pre-test and post test scores.

#### 3.2. Results of Two-Tier Concept Test

Descriptive statistics of the pre-TTCT and post-TTCT were presented in Table 7.

**Table 7.** Descriptive statistics of the pre- and post-TTCT

Group	Test	Mean	Standart Deviation	Minimum Score	Maximum Score
Experimental	Pre-test	8.15	2.89	4.00	15.00
	Post-test	14.92	4.44	8.00	21.00
Control	Pre-test	8.13	2.21	5.00	14.00
	Post-test	9.93	1.91	5.00	12.00

Results showed that the pre-test and post-test mean scores of the experimental group were 8.15 and 14.92, and 8.13 and 9.93 for the control group respectively.

Mann Whitney U test was used for comparing the pre-test scores and the post-test scores of the groups before and after the instruction (Table 8).

**Table 8.** Mann Whitney U Test results of the pre-test and post-test TTCT

	Group	N	Mean Rank	Sum of Rank	U	p
Pre-test	Experimental	26	28.17	732.50	381.500	0.888
	Control	30	28.78	863.50		
Post-test	Experimental	26	37.83	983.50	147.500	0.000
	Control	30	20.42	612.50		

According to results, while there was no statistically significant difference between the experimental and control groups ( $U=381.500$ ,  $p>0.05$ ), there was statistically significant difference between the experimental and control groups' post test scores in favour of the experimental group ( $U=147.500$ ,  $p<0.05$ ,  $z=-4.018$ ,  $r=0.54$ ).

Wilcoxon Signed Ranks test was used to compare the pre and post-test scores of the groups (Table 9). According to results, there was statistically significant difference between the pre and post-test scores of both experimental ( $z=-4.031$ ,  $p<0.05$ ,  $r=0.56$ ) and control groups ( $z=-3.186$ ,  $p<0.05$ ,  $r=0.41$ ) in favour of the post test score.

**Table 9.** Wilcoxon Signed Ranks test results of the pre-test and post test TTCT

Grup	Post-Test-Pre-test	N	Mean Rank	Sum of Rank	Z	p
Experimental	Negative Ranks	3	3.00	9.00	-4.031*	0.000
	Positive Ranks	21	13.86	291.00		
	Ties	2				
Control	Negative Ranks	5	10.20	51.00	-3.186*	0.000
	Positive Ranks	21	14.29	300.00		
	Ties	4				

Note: \*Based on negative ranks

The pre-service elementary teachers' responses to the two-tier concept test before and after the instruction were also analyzed to determine their conceptions. Totally 19 alternative concepts related to properties of acids and bases, acids and bases in the daily life, pH, indicators,

neutralization, solutions, solubility and factors effecting solubility, physical and chemical changes were determined in the pre-test. As it can be seen from Table 10, percentage of these alternative conceptions decreased after the instruction.

**Table 10.** Percentages of alternative concepts determined in the pre test and post test

Pre-service elementary teachers Alternative Concepts	Experimental Group		Control Group	
	Pre Test (%)	Post Test (%)	Pre Test (%)	Post Test (%)
If stirring rate increases, solubility increases.	25	5	30	10
Solution is a maximum amount of a solute that can be dissolved in a solvent.	36	22	45	30
Solvent is always liquid.	29	7	20	10
If sugar is added to water in a beaker, it melts.	32	11	35	30
If sugar is added to water in a beaker, sugar ions are surrounded by water molecules.	43	30	50	40
If salt dissolves in water it disappears.	25	19	20	10
If a solute is added to a saturated solution, the solution becomes supersaturated.	50	19	40	30
If silver tarnished, physical change occurs owing the fact that the physical appearance has changed.	21	4	25	22
If a test tube including iron and sulphur is heated, physical change occurs.	46	37	50	45
When a test tube including iron and sulphur is heated, iron and sulphur melt.	21	4	22	20
All acids are poisonous.	43	22	30	15
Acids always turn indicators to red colour, bases turn them to blue colour	71	48	80	60
Acids melt everything.	43	26	50	40
pH is the measure of acid strength.	64	33	68	40
If acid and bases are not at the same amount, neutralization does not occur.	21	15	25	20
Water and salt are always formed after acid-base reactions.	32	15	30	25
Neutral solutions are always formed in all neutralization reactions.	40	19	25	10
Because acids burn everything, they can give combustion reactions.	43	33	30	15
Carbon and oxygen gases react with water and they neutralize during combustion reaction.	29	19	25	15

### 3.3. Results of Attitude toward Chemistry Lesson Scale

Descriptive statistics of the pre-test and post-test ATCS were presented in Table 11. The

results showed that the pre-test and post-test mean scores of experimental group were 76.65 and 89.85, and the pre-test and post-test mean scores of control group were 75.63 and 76.13 respectively.

**Table 11.** Descriptive statistics of the pre-test and post-test ATCS

Group	Test	Mean	Standart Deviation	Minimum Score	Maximum Score
Experimental	Pre-test	76.65	18.26	49.00	115.00
	Post-test	89.85	9.71	75.00	115.00
Control	Pre-test	75.63	12.28	55.00	99.00
	Post-test	76.13	8.45	57.00	100.00

Mann Whitney U test was used for comparing the pre-test and post test scores of the groups before and after the instruction (Table 12).

**Table 12.** Mann Whitney U test results of the pre-test and post-test ATCS

	Group	N	Mean Rank	Sum of Rank	U	p
Pre-test	Experimental	26	29.21	759.50	371.500	0.761
	Control	30	27.88	836.50		
Post-test	Experimental	26	39.46	1026.00	105.000	0.000
	Control	30	19.00	570.00		

Based on the results, while there was no statistically significant difference between the experimental and control groups ( $U=371.500$ ,  $p>0.05$ ), there was statistically significant difference between the experimental and control groups' post test score in favour of the experimental group ( $U=105.000$ ,  $p<0.05$ ,  $z=-4.690$ ,  $r=0.63$ ).

Wilcoxon Signed Ranks test was used to

compare the pre and post-test scores of the groups (Table 13). Based on the results, while there was statistically significant difference between the pre and post-test scores of the experimental group ( $z=-2.604$ ,  $p<0.05$ ,  $r=0.36$ ) in favour of the post test score, there was no statistically significant difference between the pre and post-test score of the control groups ( $z=-0.319$ ,  $p>0.05$ ).

**Table 13.** Wilcoxon Signed Ranks test results of the pre-test and post test ATCS

Grup	Post-Test-Pre-test	N	Mean Rank	Sum of Rank	Z	p
Experimental	Negative Ranks	8	9.13	73.00	-2.604*	0.009
	Positive Ranks	18	15.44	278.00		
	Ties	0				
Control	Negative Ranks	15	14.47	217.00	-0.319*	0.750
	Positive Ranks	15	16.53	248.00		
	Ties	0				

Note: \*Based on negative ranks

### 3.4. Results of Attitude toward Chemistry Laboratory Scale

Descriptive statistics of the pre-test and post-test ATCLS were presented in Table 14. The

results showed that the pre-test and post-test mean scores of experimental group were 99.50 and 109.15, and the pre-test and the post-test mean score of the control group were 98.90 and 100.77 respectively.



**Table 14.** Descriptive statistics of the pre-test and post-test ATCLS

Group	Test	Mean	Standart Deviation	Minimum Score	Maximum Score
Experimental	Pre-test	99.50	12.54	47.00	112.00
	Post-test	109.15	8.02	96.00	123.00
Control	Pre-test	98.90	13.41	78.00	120.00
	Post-test	100.77	12.66	88.00	125.00

Mann Whitney U test was used for comparing the pre-test and post test scores of the groups before and after the instruction (Table 15).

The results reflected that, while there was no statistically significant difference between the

experimental and control groups ( $U=343.500$ ,  $p>0.05$ ), there was statistically significant difference between the experimental and control groups' post test scores in favour of the experimental group ( $U=201.500$ ,  $p<0.05$ ,  $z=-3.106$ ,  $r=0.42$ ).

**Table 15.** Mann Whitney U test results of the pre-test and post-test ATCLS

	Group	N	Mean Rank	Sum of Rank	U	p
Pre-test	Experimental	26	30.29	787.50	343.500	0.444
	Control	30	26.95	808.50		
Post-test	Experimental	26	35.75	929.50	201.500	0.002
	Control	30	22.22	666.50		

Wilcoxon Signed Ranks test was used to compare the pre and post-test scores of the groups (Table 16). According to the results, while there was statistically significant difference between the pre and post-test scores of experimental

group ( $z=-2.999$ ,  $p<0.05$ ,  $r=0.42$ ) in favour of the post test scores, there was no statistically significant difference between the pre and post-test score of control groups ( $z=-1.470$ ,  $p>0.05$ ).

**Table 16.** Wilcoxon Signed Ranks test results of the pre-test and post test ATCLS

Grup	Post-Test-Pre-test	N	Mean Rank	Sum of Rank	Z	p
Experimental	Negative Ranks	7	8.21	57.50	-2.999	0.003
	Positive Ranks	19	15.45	293.50		
	Ties	0				
Control	Negative Ranks	6	23.08	138.50	-1.470	0.142
	Positive Ranks	22	12.16	267.50		
	Ties	2				

Note: \*Based on negative ranks

#### 4. DISCUSSION

In this study, the effects of POE task on the pre-service elementary teachers' understanding and their attitude toward chemistry lesson and chemistry laboratory were investigated. The results showed that laboratory activities based

on POE task were more effective than the traditional cook-book laboratory setting for promoting the pre-service elementary teachers' conceptual understanding. According to the results 19 alternative concepts were determined in this study. For example, it was found that the pre-service elementary teachers reflected alternative concepts related to solubility as; "If a solute

is added to a saturated solution, the solution becomes supersaturated" and "Solution is a maximum amount of a solute that can be dissolved in a solvent". The same alternative concepts were also identified by Karamustafaoglu et al (2002). These alternative concepts underlined that the pre-service elementary teachers confused saturated solution with supersaturated solutions, and solution with solubility concepts. After the instruction, the percentages of these alternative concepts in the experimental group decreased more than the percentages in the control group as it can be seen in Table 10. This situation can be explained by the second POE Task in which the pre-service elementary teachers had an opportunity to discuss about these concepts. In addition to this, it was determined that they had an alternative concept "If sugar is added water in a beaker, it melts". This shows that the pre-service elementary teachers had difficulties in determining melting and dissolution as described by Calik and Ayas (2005), Pinarbasi et al. (2007), Tsaparlis (2003). Moreover, the pre-service elementary teachers had alternative concepts such as "If stirring rate increases, solubility increases". This situation revealed that they confused the effective factors on solubility rate and solubility. Also, before the instruction while the pre-service elementary teachers percentage of having alternative conceptions was 25% and 30% in the experimental group and control group respectively, this value decreased to 5% in the experimental group and to %10 in the control group after the instruction. In the context of the second POE task named as Lemonade, the pre-service elementary teachers in the experimental group predicted that some factors were effective on solubility rate, so they observed their prediction and discussed the effective factors on solubility rate and the differences of these factors from effective factors on solubility under the guidance of instructor. The pre-service elementary teachers in the control group only followed directions; therefore the POE task was more effective than the laboratory activities based on traditional cook-

book laboratory setting in the control group for remedying this alternative concept.

Alternative concepts related to physical and chemical changes were also identified in this study. It was found that the percentages of these alternative concepts in the experimental group such as "When silver tarnished, physical change occurs owing to physical appearance changed", "When a test tube including iron and sulphur is heated, physical change occurs" were remedied better than the concepts in the control group after the instruction (Table 10). In the context of the fifth POE task named as Journey of Matter, the pre-service elementary teachers in the experimental group predicted what changes would occur in an experiment, so they conducted the experiment in which physical and chemical changes were created by using ice and sugar, and then they compared and discussed physical and chemical changes based on their observations and predictions. So they interpreted the new physical and chemical changes more easily than the control group and those alternative concepts were remedied better after the instruction.

According to the pre-service elementary teachers' answers, it is understood that they confused chemical and physical changes as it was identified by Ayvaci and Coruhlu (2009), Hesse and Anderson (1992). Moreover, before the instruction while 71% and %80 of the pre-service elementary teachers in the experimental group and control group respectively thought that "acids always turn indicators to red colour, bases turn them to blue colour", this value decreased to 48% in the experimental group and to %60 in the control group after the instruction. POE tasks named as Chemical around Us I, II and III were related to acid-base reaction and using indicators, the results showed that the tasks represented more positive conceptual change. The reason of this alternative concept is generally associated with giving a sample which describes the effects of acids and bases on litmus paper in books. This causes a conceptual conflict. Similarly, Morgil et al. (2002) de-

terminated alternative concepts related to the indicator. As it can be seen in Table 10, the percentage of alternative concepts related to neutralization decreased, and this situation showed that the POE task named as Heartburn in which the pre-service elementary teachers conducted an experiment related to neutralization by using antacid and HCL was effective for remedying the alternative concepts related to neutralization too.

During the POE instruction, the pre-service elementary teachers discussed their predictions about the story in prediction stage. These stories were derived from in daily life. The problems in daily life are meaningful and interesting for students (Jonassen, 1997), in this way they have opportunity to associate their learning with these daily life experience. Also, daily life applications provide them ability to apply the new situations to the learned ones (Costu, Unal & Ayas, 2007). In this study, the pre-service elementary teachers studied about their daily life experiences during the instruction and this instruction might have promoted their understanding. Furthermore, the POE tasks allowed the pre-service elementary teachers to investigate scientific phenomena in small groups. They made prediction about scientific events by inquiring, they observed those events and then they compared their prediction and explanation based on their observations they had made during the instruction. They removed the cognitive conflict between their prediction and observation by doing explanations. So, the POE tasks provided conceptual understanding and learning in-depth for them. Moreover, group discussions gave the pre-service elementary teachers opportunity to share different thoughts as it was declared by Costu, Ayas and Niaz (2010, 2012), White and Gunstone (1992). Additionally, in coherence with the results, the research similarly reported that POE activities promoted understanding of scientific concepts adequately (Akgun & Deryakulu, 2007; Costu, Ayas & Niaz, 2010, 2012; Kearney, 2004; Searle & Gunstone, 1990; Tao & Gunstone, 1997, 1999).

On the other hand, the results of ATCS showed that there was no significant difference between the control and experimental groups' pre- attitudes toward chemistry lesson before instruction. However, it was found that there was a statistically significant difference between the experimental and control groups' ATCS scores in favour of the experimental group after the instruction. These results showed that the laboratory activities, based on POE tasks, promote the pre-service elementary teachers' attitude toward chemistry lesson positively. Similarly Koseoglu, Tumay & Kavak (2002) found that POE task improved the pre-service elementary teachers' attitudes toward chemistry lesson. Yavuz & Celik (2013) underlined that, the POE task on the subject of gases promoted undergraduates' attitudes toward chemistry in coherence with the results of this research. Furthermore, ATCLS was applied before and after instruction. While there was no significant difference between the control and experimental groups' pre-attitudes toward chemistry laboratory, it was found that there was significant difference between the experimental and control groups' post-attitudes in favour of the experimental group. According to the results, laboratory activities based on POE task promoted the pre-service elementary teachers' attitude toward chemistry laboratory.

POE inquires to interpret nature of scientific event, in this way POE contributes attitude toward laboratory as indicated by Bilen and Aydogdu (2010). In this study worksheets including POE tasks were prepared and each task began a brief story related to learning issue, so they had opportunity to observe the learning subjects in daily life and they worked out a problem related to their experiences by completing the POE task. This situation might have promoted their concentration and interests to their investigation, and it might have affected their attitudes positively toward chemistry lesson and chemistry laboratory. Many researchers have underlined that, if the pre-service elementary teachers associate the science subjects with daily life and they use this

associations for social and environmental problems, their attitudes are influenced positively (Hofstein & Mamlok-Naaman, 2011; Ramsden, 1998) like our results. Furthermore, cooperative team work was conducted during the process. POE activities enhanced the cooperative team work and provided the students an opportunity to assume responsibility, to develop self-confidence, and to work as a scientist using scientific methods. In addition to this, cooperative team work increased individual responsibility (Coppola & Lawton, 1995). Moreover, the pre-service elementary teachers completed their POE tasks actively under guidance of the instructor. In previous researches indicated that, the pre-service teachers' attitude toward chemistry promotes when they participate in learning process actively (Ben-Zvi, Hofstein, Samuel & Kempa, 1976; Okebukola, 1986), they are responsible for their own learning (Bilen, 2009) in coherence with this study. Also, the pre-service elementary teachers' peer interactions and cooperation may influence their attitudes when they discussed during in all POE steps. During the instruction, the pre-service elementary teachers shared and discussed their personal predictions about the story in the predict stage; their observations and experiences related to experiment in the observe stage; their results, reconciliations, conflicts, interpretations and solutions in the explain stage. As White and Gunstone (1992) emphasized discussion is very important part of the POE and it is very effective especially in the explain phase. In addition to discussions, they inquired the

reason of the problem given in the story in the predict stage and conflict between their prediction and observation in the explain stage.

## 5. CONCLUSION

In conclusion, according to the results of the study, application of laboratory activities developed based on POE related to "Mixtures, Physical and Chemical Changes, Acids and Bases" had a great role for increasing the pre-service elementary teachers' understanding of scientific concepts and developing positive attitudes towards chemistry lesson and chemistry laboratory, in contrast to traditional cook-book laboratory instruction. For this reason, it can be suggested that laboratory activities based on active learning methods like POE should be developed, used and generalized in the pre-service education curriculum and chemistry classes widely. Also, alternative conceptions which were determined in this research and laboratory activities which were developed by the researcher will be guide researchers and instructors. Furthermore, two-tier diagnostic test which was developed this research will make major contributions for future research and it will provide with opportunities to educators and teachers to assess pre-service teachers' alternative conceptions and understanding of the target concepts. Researchers can use this test as pre-test and post-test for evaluating of effect of different learning environments on students' achievement and conceptual understanding.

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ve sonra elde edilen puanların normal dağılım gösterip göstermediğini belirlemek amacıyla Shapiro Wilk testi yapılmış ve verilen normal dağılım göstermediği belirlenmiştir. Bu sebeple verilerin analizinde parametrik olmayan istatistik yöntemleri kullanılmıştır.

Mann Whitney U testi sonuçlarına göre, grupların ön test puanları arasında anlamlı fark bulunmazken, iki aşamalı kavram testi ( $U=147.500$ ,  $p<0.05$ ,  $z=-4.018$ ,  $r=0.54$ ), kimya dersine karşı tutum ölçeği ( $U=105.000$ ,  $p<0.05$ ,  $z=-4.690$ ,  $r=0.63$ ) ve kimya laboratuvarına karşı tutum ölçeğinden ( $U=201.500$ ,  $p<0.05$ ,  $z=-3.106$ ,  $r=0.42$ ) elde edilen son test puanları arasında deney grubu lehine istatistiksel açıdan anlamlı bir farklılık tespit edilmiştir. Ayrıca iki aşamalı kavram testinin ön test uygulamasında belirlenen asitlerin kuvveti, indikatörler, nötralleşme, asitlerin özellikleri, pH, günlük yaşamdaki asitler ve bazlar, çözümler, çözünürlük, fiziksel ve kimyasal değişim konularındaki alternatif kavramların yüzdesinde, son testte deney grubunda daha yüksek olmak üzere düşüş belirlenmiştir.

Sonuç olarak karışımlar, fiziksel ve kimyasal değişim, asitler bazlar konusunda uygulanan tahmin-gözlem-açıklamaya dayalı laboratuvar etkinliklerinin geleneksel yaklaşıma kıyasla, kavramsal anlama, kimya dersine ve kimya laboratuvarına karşı tutum ve alternatif kavramların giderilmesinde daha etkili olduğu belirlenmiştir. Bu sebeple öğretmen eğitiminde laboratuvar etkinliklerinin tahmin-gözlem-açıklama gibi aktif öğrenme yöntemleriyle desteklenmesi önerilmektedir. Ayrıca çalışma kapsamında belirlenen alternatif kavramların, geliştirilen etkinliklerin ve iki aşamalı kavram testinin araştırmacılara ve eğitimcilere büyük katkı sağlayacağı düşünülmektedir.