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The Effect of Guided-Inquiry Laboratory Experiments on Science Education Students' Chemistry Laboratory Attitudes, Anxiety and Achievement

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Abstract

The study aims to search the effect of guided inquiry laboratory experiments on students' attitudes towards chemistry laboratory, chemistry laboratory anxiety and their academic achievement in the laboratory. The study has been carried out with 37 third-year, undergraduate science education students, as a part of their Science Education Laboratory Applications I and II courses. In Science Education Laboratory Applications I course traditional laboratory method has been conducted, in Science Education Laboratory Applications II course guided inquiry laboratory experiments have been conducted. At the beginning of the academic year, Chemistry laboratory Attitude Scale and Chemistry Laboratory Anxiety Scale were administered as pre test and they were administered as post test following to the guided inquiry experiments. The findings have revealed that as a result of the applications, there has been a significant increase in students' attitudes towards chemistry laboratory, and their academic achievement and a decrease in their chemistry laboratory anxiety.

Keywords: guided inquiry laboratory, chemistry laboratory attitude, anxiety, achievement

1. Introduction

Laboratory practicehas unquestionable importance in chemistry education. In effective chemistry education, theoretical explanations should be supported by laboratory applications (Kurbanoğlu & Akim, 2010). The aims of laboratory work can be listed as developing understanding related to the scientific content, problem solving skills, science processes skills and understanding the nature of science. Students are expected to realize the connection between experiments and scientific theory. Sotiriou and Bogner (2015) state that while solving a scientific problem, students should act like a scientist and follow scientific processes. By scientific inquiry, students determine the problems, develop solutions and alternative solutions for these problems, search for information, evaluate the information and communicate with their friends (Katsampoxaki-Hodgetts, Fouskaki, Siakavara, Moschochoritou, & Chaniotakis, 2015). But traditional laboratory doesn't allow this. The traditional laboratory format is called as "expository laboratory", "cook-book style laboratory" and "verificationlaboratory". Today, traditional laboratory method is being used widely (Tsaparlis & Gorezi, 2005). Concannon and Brown (2008) mention that traditional labs only focus on scientific terminology, concepts and facts and they contain detailed procedures and tell students what they will observe during experiments. In this method, students follow instructions written in the lab manual step by step and the outcome is pre-determined. Students already know the scientific theory when they start doing their experiments. In this format, students only think about following the directions written in the lab manual. For this reason, students cannot develop higher order cognitive skills. Despite traditional laboratory method having some advantages like conducting many experiments in crowded classes within a limited time and using limited sources, this method has many disadvantages. Students often cannot learn effectively since they just concentrate on the lab manual and they generally do not have real life connections. Donaldson and Odom (2001) state that in traditional laboratory, students' ability to follow instructions have been considered instead of their questioning , designing, conducting and analyzing an experiment. According to Madhuri, Kantamreddi and Goteti (2012), the most important negation of cook book style laboratory is it doesn't help students translate scientific outcomes into meaningful learning.

Traditional laboratory method is inadequate for supporting the development which is aimed by laboratory. According to Baseya and Francis (2011) changes in lab style can help students develop scientific processing skills and understand the nature of science. Teachers should move away from traditional lecturing and cookbook style laboratories to active learning strategies such as problem based learning, cooperative learning and inquiry based learning which help students to develop their cognitive processes and help them to become lifelong learners (Tessier & Penniman, 2006). Inquiry based learning supports students apply their knowledge, understand real world situations and supports discovery (Ketpichainarog, Panjipan, & Ruenwongsa, 2010; Toth, Ludvico, & Morrow, 2012; Rattanavongsa & Rachahoon, 2014). Inquiry based learning help educators to increase students' self confidence and learning (Wall, Dillon, & Knowles, 2015).According to Arnold, Kremer and Mayer (2014)students need to develop scientific inquiry skills while learning scientific facts and principles. In inquiry based learning environments, students are more active and they guiding their own learning processes. Inquiry based teaching has some varieties, such as guided inquiry and open ones (Jiang & McComas, 2015). Zion and Sadeh (2007) state that inquiry based learning has three levels:

1. Structured inquiry: The teacher structures the problem and the processes,

2.Guided inquiry: The teacher asks the question and students construct the solution process.

3. Open inquiry: Students determine the problems in the given context and try to solve them.

Taitelbaum, Mamlık-Naaman, Carmeli and Hofstein (2008) and Hofstein, Shore and Kipnis (2004) state that inquiry based laboratories support students' meaningful learning, conceptual understanding, and understanding of the nature of science. Inquiry based laboratories are more student-centered , contain limited direction of the teacher and students take more responsibility. Inquiry based laboratory requires students to search for knowledge, generate hypothesis, collect data, interpret evidence and make conclusions (Chang, Sung, & Lee, 2003). In this laboratory method, students can design their own experiments and instead of following a verification process, they try to reach the scientific concepts by themselves and they develop higher order cognitive skills. Akkus, Gunel and Hand (2007) compare the effectiveness of inquiry based approach with traditional teaching practices. The findings of the study reveal that inquiry based teaching approach have a positive effect on students' achievement.

Inquiry based laboratories are separated into two groups as guided inquiry and open inquiry. Students develop understanding of science by participating in hands on, open ended and student-centered activities in guided inquiry method (Irinoye, Bamidele, Adetunji, &Awodele, 2014). Guided inquiry method has many advantages. For example, the results of the study of Irinoye et al. (2014) showed that guided inquiry method enhanced students' learning and retention. In guided inquiry laboratory method, student search for an experiment through the given problem. In this method, the experiments are similar with the expository experiments, but a lab manual is not given to the students. Students search for the experiment process and reach scientific information through the experiment. Guided inquiry laboratory settings encourage students to make scientific research and consider science as careers (Hendrickson, 2015).Gaddis and Schoffstall (2007) state that guided-inquiry experiments are generally based on a discovery, the procedure is predetermined but the outcome is not specified. In open inquiry laboratory method, students search for a solution for an unstructured problem and they establish the laboratory process while solving the problem. But, finding a solution for the problem and establishing their own experimental processes take time. Particularly, since traditional teaching method is widely used in our country, it is difficult for students to adapt to such a format. Therefore, guided inquiry experiments are more suited to our student profile. Chatterjee, Williamson, McCann, and Peck (2009) display that students have more positive attitudes towards guided-inquiry laboratories than open-inquiry laboratories and they believe that they learn more with guided-inquiry laboratories than open-inquiry ones. Similarly, Thompson (2007) in his study presents guided inquiry activities related to the plant function and states that students like these activities and understand the nature of science better. Conducting open inquiry experiments in crowded classes is difficult but guided-inquiry experiments can be adapted to large classes more easily. Gaddis and Schoffstall (2007) claims that guided-inquiry experiments have some advantages of open inquiry experiments (i.e. developing higher order thinking skills, searching and discovery) and the practical advantages of traditional ones.

Since traditional laboratory experiments force students to follow a lab manual, students learn scientific information difficultly and they cannot notice the relationship between the experiment and scientific theory. As a result, students cannot reach the goals of scientific laboratory, they develop negative attitudes towards laboratory and their anxiety level increases.

In the content of the study, prior and following to the guided inquiry laboratory experiments students' attitudes towards chemistry laboratory and their chemistry laboratory anxiety have been investigated. Affective dimensions such as attitude and anxiety effect students achievement and performance in laboratory (Bowen, 1999). For this reason, developing positive attitudes towards learning environment and decreasing anxiety are important subjects. Eddy (2000) states that students' anxiety in chemistry laboratory effects their achievement in laboratory activities. Kurbanoğlu and Akim (2010) in their study reveal that chemistry laboratory anxiety is correlated negatively to chemistry attitudes and to self-efficacy. Karışan and Yılmaz-Tuzun (2013) and Bowen (1999) say that when students' control their anxiety in laboratory, they will develop their laboratory skills and positive self efficacy beliefs. For this reason, in the content of the study, the effect of guided inquiry experiments on students' attitudes towards chemistry laboratory and chemistry laboratory anxiety will be investigated. It is thought that increasing students' positive attitudes towards laboratory and decreasing chemistry laboratory anxiety will increase students' performance.

2. Objectives of the Study

Specifically the study aims at determining the effect of guided inquiry laboratory experiments on science education students' attitudes towards chemistry laboratory, chemistry laboratory anxiety and their academic achievement in these laboratories.

3. Methodology of Research

The present study has been carried out with third-year, undergraduate science education students at Kahramanmaraş Sütçü İmam University, as a part of their Science Education Laboratory Applications I and II courses during the 2013-2014 academic year. The course duration has been 6 hours per week (4 laboratory hours plus 2 theoretical study hours). In the study, single group pre and post test research design has been used. In the content of the study, in Science Education Laboratory Applications I course (fall semester) traditional laboratory method has been conducted, whereas, in Science Education Laboratory Applications II course (spring semester) guided inquiry laboratory has been used.

3.1 Traditional Chemistry Laboratory Experiments

Science Education Laboratory Applications I course has been taught in the fall semester. In Science Education Laboratory Applications I course, students conducted both secondary school science experiments and 7 chemistry experiments. The chemistry experiments conducted in the fall semester are listed below:

1. Determination of the density of liquids
2. Separating mixtures by using the difference of their boiling points
3. Creating FeS compound
4. Displaying law of constant proportions in MgO compound
5. Preparation of solutions with desired concentration
6. Comparison of different metals' oxidation tendencies
7. Producing aspirin

These experiments have been conducted by the traditional laboratory method. Students have followed the instructions of the given laboratory manual and conducted verification experiments. The chosen experiments have been typical general chemistry laboratory experiments. In traditional laboratories, all details related to the experiments have been written in lab manuals. In the experimental process, students have followed the instructions and conducted the experiment. In traditional laboratory experiments students have worked alone. Following the each experiment, a quiz which asks for theoretical and scientific information related to the experiments has been given. An average of 7 quizzes has been evaluated as the students' chemistry laboratory achievement. Students' chemistry laboratory achievement in the fall semester has been evaluated as Chemistry Achievement Pre-Test.

3.2. Guided Inquiry Laboratory Experiments

Guided inquiry chemistry experiments have been conducted in Science Education Laboratory Applications II Course in the spring semester. In the content of the course, students have conducted both secondary school science experiments and 7 chemistry experiments. Students have worked in groups of 3 and have carried out one experiment per week. The experiments have been given to the students in a semi-structured problem format. The chemistry experiments conducted in the spring semester are listed below:

1. Can you identify the type of the metal in your hand by calculating the specific heat of the metal?
2. Can you calculate the amount of $KClO_3$ in a mixture of $KClO_3$-KCl?
3. How can you determine the water content in a hydrated $CuSO_4$?
4. I have put a quantity of HCl solution into the flask you see in my hands. How do you calculate the amount of HCl in this solution?
5. Can you find a way to separate the components of water?
6. How do you cover the key with copper?
7. Can you make soap at home?

The guided inquiry laboratory method has been conducted by considering the steps in Blanchard et. al's (2010) study. The steps of the guided inquiry experiments conducted in our study are listed below:

1. A semi-structured problem has been given to the students group a week before. In the content of the application, basic chemistry experiments have been given in a semi-structured problem format. Students have been given a new question every week.

2. For the solution of the mentioned problems, the students have searched for an experimental process until the next laboratory practice.

3. Groups have decided on an experimental process based on their research.

4. Student groups have explained their research and experimental process. They have discussed their process with other groups and shared their ideas. At this point, students have explained all stages of experiments, the materials they have used and why they have chosen this process and materials.

5. Materials required in the experiments have been provided by the teacher.

6. During the experiments, students have taken notes related to their observations.

7. The theoretical part of the course, students have been required to explain the information they have reached by their observations and experimental data.

8. By following to the experiment, the groups have tried to answer the questions related to the experiment and the conclusions have been discussed in the classroom.

After each experiment, a quiz which asked for theoretical and scientific information related to the experiments has been given. An average of 7 quizzes has been evaluated as the students' chemistry laboratory achievement. The students' chemistry laboratory achievement in the spring semester has been evaluated as Chemistry Achievement Post-Test.

At the beginning of the 2013-2014 Academic Year, Chemistry Laboratory Attitude Scale (CLA) and Chemistry Laboratory Anxiety Scale (CLAx) have been administered as pre test. At the end of the spring semester in which guided inquiry chemistry experiments have been conducted, the mentioned data collection tools have been administered as post test and the pre-test and post-test results have been compared. At the end of the spring term, a semi-structured interview form which asks for the students' views related to applications has been given.

4. Sample of Research

Thirty seven third year science education students have participated in the study.

5. Instruments

The students' attitudes towards chemistry laboratory and their chemistry laboratory anxiety have been evaluated by likert type scales and the students' views relating to guided inquiry laboratory experiments have been determined by a semi-structured interview form. The information related to these data collection tools has been given below.

5.1Chemistry Laboratory Attitude Scale (CLA)

The scale developed by Yeşilyurt (2003) to identify students' attitudes towards physics laboratories was adapted to determine students' attitudes towards chemistry laboratories by Ercan (2014). The scale is a five point Likert type scale and consists of 33 statements: 17 negative and 16 positive. Cronbach Alpha reliability coefficient was found to be 0,85.

5.2 Chemistry Laboratory Anxiety Scale (CLAx)

Chemistry Laboratory Anxiety Scale developed by Bowen (1999) and translated to Turkish by Azizoğlu and Uzuntiryaki (2006) was used for this Anxiety Scale. CLAx scale is a five point Likert type scale consisting of 20 statements [15 statements that support anxiety (positive) and 5 statements that do not support it (negative)] and four sub dimensions. Obtaining higher scores in the scale shows absence of anxiety towards chemistry laboratory. Based on dimensions, Cronbach Alpha reliability coefficients of the translated scale were found to be 0,88 in the "using laboratory tools and implementing experimental procedures" dimension (items 2, 7, 12, 17); 0,87 in the "working with other students" dimension (items 4, 9, 14, 19); 0,86 in the "collecting data" dimension (items 3, 8, 13, 18) and 0,87 in the "using the laboratory time" dimension (items , 10, 15, 20) (Azizoğlu & Uzuntiryaki, 2006). Ercan (2014) calculated Cronbach Alpha coefficients of the scale as 0,81; 0,78; 0,71 and 0,73.

5.3 Semi-structured Interview Form

The interview form consists of 4 open-ended questions which asks for the students' views related to guided inquiry laboratory experiments. The questions are given below:

1. Do you prefer conducting experiments with traditional laboratory format or guided inquiry format? Explain the

reasons for your answer.

2. Do you think that conducting experiments in guided inquiry format contributes your teaching skills? Please explain.

3. Evaluate the course in terms of the method and its'contributions.

4. Explain your alternative suggestions about the course.

6. Data Analysis

At the beginning of the academic year, CLA and CLAx have been administered as pre test and they have been administered as post test following the guided inquiry experiments. While evaluating academic achievement in the laboratory, students' quiz average of traditional laboratory experiments (fall semester) has been evaluated as pre test and their quiz average of guided inquiry experiments(spring semester) has been evaluated as post test. Paired sample t-test has been conducted to determine the differences between pre and post test results CLA, CLAx and Academic Achievement (AA). The paired samples t-test results are displayed in Table.

Table 1. The Paired Samples t-Test Results of CLA, CLAx, and Academic Achievement

	N	X	ss	df	t	p	Effect size (r)
PreCLA	37	125,97	12,26	36	-3,84	0,00	0,54 (wide impact)
PostCLA	37	138,24	19,47				
PreCLAx	37	53,72	16,47	36	4,54	0,00	0,60 (very wide impact)
PstCLAx	37	42,21	14,03				
PreAA	37	39,48	11,72	36	15,06	0,00	0,93 (very wide impact)
PostAA	37	64,94	11,17				

The paired samples t-test results display that there is a significant difference between pre test and post test results of CLA in favor of the post test. This finding revealed that as a result of the applications, there is a statistically significant increase in the students' attitudes towards chemistry laboratory. Additionally, t-test results displayed that there is a significant difference between pre test and post test results of CLAx in favor of the pre test ($p< 0.05$). This finding revealed that as a result of the applications, there is a statistically significant decrease in the students' chemistry laboratory anxiety. When students' academic achievement in the fall and the spring semesters are compared, there is a statistically significant difference between the fall and the spring semester grades. The paired sample t-test results display that there is a significant difference in favor of the spring term in which guided inquiry experiments have been conducted ($p< 0.05$). This finding reveals that as a result of the applications, there is a statistically significant increase in the students' academic achievement in chemistry laboratory.

6.1 The Findings Obtained from Semi-structured Interview Form

When students' responses to the interview form related to students' views about guided inquiry experiments were analyzed, it was seen that quantitative data is promoted by quantitative data. When the responses to the 1st question: "Do you prefer conducting experiments with traditional laboratory format or guided inquiry format? Explain the reasons for your answer." were analyzed, it was seen that 5 of the students stated that they would prefer cook book style experiments, but 32 of the students stated that they would prefer guided inquiry laboratory experiments. When the responses were analyzed, the reasons for preferring guided inquiry laboratory experiments can be listed as participating in the learning process actively supports meaningful learning, it develops thinking and inquiry skills. One of the students who preferred traditional laboratory experiments stated that this method is confusing, difficult and tiring since he doesn't know the procedure. The students who preferred guided inquiry laboratory experiments stated that this method encourages students to search and think. Some of the students' responses are given below:

"Meaningful learning occurs because we did research and developed the experimental process".

"It helps to develop student's imagination".

"I participate in the class more actively, and don't memorize, I learn".

"In traditional experiments we don't think and question, just follow a procedure. In guided inquiry format I learn by doing research and applying my findings".

"We conduct the experiments by ourselves. The teacher just guides us when required".

"In traditional laboratory format, the information is given to the students in packages and we memorize it, but forget it in a short time ".

When the responses to the 2nd question "Do you think that conducting experiments in guided inquiry format contributes your teaching skills? Please explain.", were analyzed, it was seen that only one student stated that this method has no contribution on his teaching skills and the rest of the students stated that this method has some positive contributions on their teaching skills. Some of the students' responses are given below:

"I learned how to guide my future students".

"We began to create more original ideas".

"We learned how to design experiments".

"I learned doing something by myself".

"I believe that I can become a teacher candidate who does rearch and observes more in daily life ".

"Of course, yes. Because we did research for the experiments and conducted them. When somebody does everything by himself, he learns better".

"By this method I learn the scientific facts by doing experiments instead of memorizing ".

"In this method I learned where to stop or when to help students, asking appropriate question and where students may have difficulties ".

"I learned how I can grab the students' attention".

"I will use this method when I am a teacher".

When the responses to the 3rd question "Evaluate the course in terms of the method and contributions." were analyzed, it was seen that generally students state that they learn better with this method. Some of the students' responses are given below:

"Doing research for the experiments by ourselves increased our self-confidence".

"It is more beneficial than the cook-book style experiments".

"This term is good. We learned a lot. Experiments were difficult but our teacher gave the required support to us".

"It is a different method. It is difficult to get accustomed to this method but is different and funny".

When the responses to the 4th question" Explain your alternative suggestions about the course." were analyzed, it was seen that some of the students stated that they have some problems related to the group work, while the other students stated that the number of the experiments should be reduced since this method is tiring, more time is required. Some of the students' responses are given below:

"Working with group members who don't care about the work was tiring and wearing ".

"Group members should work equally".

"The number of experiments should be reduced, it is very tiring".

"More time is required".

7. Results and Discussion

The quantitative findings of the study displayed that guided inquiry laboratory experiments developed positive attitudes towards chemistry laboratory and decreased the students' chemistry laboratory anxiety. Similarly some studies revealed that the inquiry based laboratory applications affected developing positive attitudes towards learning environments. For example, Berg, Bergendahl, Lundberg and Tiell (2003) compared outcomes of an open-inquiry and the expository version of a chemistry laboratory experiment. The findings revealed that the open inquiry version has positive outcomes regarding learning outcome, preparation time, time spent in the laboratory and the students' perception of the experiment when compared with expository version. Similarly, Wolf and Fraser (2008) compare inquiry and non-inquiry laboratory teaching in terms of students’ perceptions of the classroom learning environment, attitudes toward science, and achievement among middle-school physical science students. The findings revealed that inquiry based laboratory promoted cohesiveness between students and students found inquiry based laboratory effective.

When students' responses in semi-structured interview form were investigated, it was seen that the students think positively about the guided inquiry laboratory format. The responses to the question "Do you prefer conducting experiments with traditional laboratory format or guided inquiry format? Explain the reasons for your answer." is that, five of the students preferred traditional laboratory method and 32 students preferred guided inquiry laboratory experiments. The reasons of their preference can be summarized as developing research skills, promoting meaningful learning, promoting searching and thinking. Similarly, Tsaparlis and Gorezi (2005) in their study modified a conventional expository physical chemistry laboratory to an inquiry based laboratory format. The results of the study showed that the students were pleased with the format and the participants expressed that they developed many abilities. Additionally Tessier and Penniman (2006) designed an inquiry based laboratory design for microbial ecology. Their results displayed that the students enjoyed the inquiry based laboratory format and the instructors thought that it was an important experience. Serafin and Priest (2015) developed a guided-inquiry Passerini experiment, in their study, the students stated that they enjoyed the experiment. Similarly, The results of Saunders-Stewart, Gyles, Shore and Bracewell's (2015) study displayed that students enjoyed inquiry learning and got positive outcomes. Also Ketpichainarog, Panjipan and Ruenwongsa (2010) explored the effectiveness of an inquiry based cellulose laboratory unit. The results of the study displayed that the students developed their critical thinking, scientific process skills and reacted positively to the application. Bentley, Robinson and Ruscitti (2015) showed that following to the inquiry guided learning projects, the students who participated in the study developed their self confidence and some of the research skills. Additionally, Wang, Núñez, Maxwell, and Algar (2016) designed a guided-inquiry project to teach spectrophotometric instrumentation. The results of the study showed that students' understanding relating ot the subject increased and their critical thinking and research skills improved.

The responses to the interview forms display that students have positive views related to the contributions of the method. An analysis of responses to the question "Do you think that conducting experiments in guided inquiry format contributes your teaching skills? Please explain." displayed that becoming a more researching and observing teacher, increasing control over issues, learning how to attract the attention of the students were stated by students as positive contributions. The responses to the question "Evaluate the course in terms of the method and contributions." display that generally students have difficulties while conducting the experiments at the beginning but they got accustomed to the method by time and they learned better. Most of the students indicated that they will use this method in their classes. The findings displayed that the guided inquiry laboratory format promotes students' learning and develops some skills. Similarly, Hofstein, Nahum and Shore (2001) implemented an inquiry-type chemistry laboratory and assessed the students' actual perceptions of laboratory learning environment and preferred ones. They also compared students' perceptions in traditional laboratories with students in inquiry type chemistry laboratories. The results revealed that the difference between the actual and preferred perceptions related to the inquiry type laboratory is significantly smaller than the difference related to the traditional laboratory. In the guided inquiry laboratory format, the students participated in the research process actively and they learned by discovery. This supports meaningful learning. After students conducted guided inquiry experiments, they did not prefer traditional ones in which they follow a lab manual step by step.

Findings display that as a result of the applications, the students' chemistry laboratory anxiety level was decreased. Chemistry is generally perceived as a difficult subject by students. Chemistry students who have difficulty in understanding subjects in chemistry classes have an anxiety towards chemistry laboratories since various skills are required while conducting experiments. Students' difficulties while understanding chemistry and following a step by step manual on conventional laboratory applications form the basis of this problem. Conducting experiments just like following a cook book recipe makes understanding the relations between the scientific facts and concepts difficult. Therefore, students feel anxious about laboratory courses. However, following the applications, the chemistry laboratory anxiety level of the students was significantly decreased. The reason of this decrease is considered to be becoming active learners in the application process and being aware of the meaning of the steps they follow. When students are aware of the meanings of the steps they follow, they feel more confident and the experiments become more meaningful. In the 2nd term, the chemistry laboratory achievement of the students was increased. This shows that students learned better.

When students' academic achievement in the traditional laboratory format was compared with their achievement in the guided inquiry laboratory format, the findings revealed that the students' academic achievement in the guided inquiry format was significantly higher than their academic achievement in the traditional laboratory format (Table 1). The guided inquiry laboratory experiments have led to an increase in the students' academic performance. Similarly, Tobin et. al (2012) applied a three day inquiry-based workshop for K-8 teachers and their results displayed that the teachers developed an understanding related to some important energy concepts. In some of the studies, we can see similar results. Gaddis, B. A. and Schoffstall, A. M. (2007) developed guided-inquiry experiments in organic chemistry laboratory and stated that these applications will develop students' conceptual understanding in the laboratory. Also, McCright (2012) analyzed the effect of inquiry based learning project related to the environmental problems like climate change, on the change in students' beliefs, attitudes, behaviors and scientific and quantitative literacy. The results of the study displayed that the students' knowledge related to scientific problems increased and their research skills developed. Sesen and Tarhan (2013) investigated the effects of the inquiry-based laboratory activities on high school students' understanding of electrochemistry and their attitudes towards chemistry and laboratory activities. The results of the study displayed that students in the inquiry based laboratory formatlearned concepts related to electrochemistry and produced significantly higher positive attitudes towards chemistry and laboratory work.

The responses to the semi-structured interview form displayed that students have some difficulties while conducting experiments. The responses to the question "Explain your alternative suggestions about the course." displayed that students have problems associated with time limitation and group members' not participating equally in group work. Some of the students state that more time should be given. The responses of the students revealed that it takes time to get accustomed to this method. In some studies, it is stated that educators are faced with many difficulties while doing inquiry activities (Buck, Bretz, and Towns, 2008). Donnelly, McGarr and O'Reilly (2014) stated that it is difficult to adopt inquiry based learning for teachers since it is very different from traditional classroom culture. Although the curriculum has been revised in the light of the constructivist approach, the traditional lecture method is widely used in both theoretical and practical courses. The learning environments in which students sit passively and the teachers transfer information in packages cannot foster the development of students' thinking and inquiry skills. In the inquiry-based learning environment, students are required to think, ask questions and participate actively in the learning process. Thinking and searching processes are difficult for the students who are used to getting packaged information. Because the development of these skills is a matter of process and unfortunately developing them in a short period of time is impossible. Therefore, students have difficulties in the inquiry based activities related to time limitation and they cannot properly conduct research processes.

8. Suggestions

Encouraging science education students to use laboratories properly in their classes depends on developing their laboratory skills as well as reducing anxiety about laboratories. When science education students participate in experimental processes actively and do research to obtain information, their self-confidence increases. Conducting these kinds of applications frequently and replacing traditional cookbook style laboratory experiments will improve the skills of science education students. In the mentioned applications, students' active participation in the research process will also enhance their learning. One of the main problems of chemistry education in our country is the use of the traditional lecturing method continuously. Generally, teachers avoid entering laboratories and conducting experiments. This situation is not valid for only chemistry classes but also for other science courses such as physics and biology. In their professional life teachers train in the same way as they were trained in their past. In order to prevent this, science education students should search actively and participate in inquiry based laboratory experiments from the beginning of undergraduate level, instead of cook book style experiments. Recommended laboratory format takes more time when compared with the traditional cook book style format and laboratory hours should be increased as a solution. Science education students taught by traditional laboratory format can avoid conducting experiments in the future. When cook book style experiments are conducted, laboratories becomes places where students just follow written instructions, but in the future, laboratories will become places in which teachers guide the experimental process and help their students. Unfortunately, traditional laboratories cannot develop these skills for pre service science teachers. Pre service teachers who take no responsibility for their experiments in the undergraduate level remain insufficient in the use of laboratories. When considering the importance of science education, the importance of training of teachers who can use laboratories and carry out experiments arises. Therefore teacher training should be carried out using appropriate methods in the laboratory under the light of this view.

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