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STUDY THE DISCOVERIES IN THE FIELD OF CHEMISTRY.

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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 inlaboratory, 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.

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.

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.

Chemistry 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.

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.

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.

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

Reference

1) Wang, J. J., Núñez, J. R. R., Maxwell, E. J., & Algar, W. R. (2016). Build Your Own Photometer:
2) A Guided-Inquiry Experiment To Introduce Analytical Instrumentation. *Journal of Chemical Education, 93*, 166-171. http://dx.doi.org/10.1021/acs.jchemed.5b00426

3) Wolf , S. J., & Fraser, B. J. (2008). Learning environment,

4) attitudes and achievement among middle-school science students using inquiry-based laboratory activities.*Research inScienceEducation*, *38*, 321–341.