Investigating the Effects of Project-Oriented Chemistry Experiments on Some Affective and Cognitive Field Components

İnci MORGİL1, Hatice GÜNGÖR SEYHAN2, Nilgün SEÇKEN3

1 Prof. Dr., Hacettepe University, Faculty of Education, Dept of Chem. Education, Ankara-TURKEY
2 Res. Assist., Hacettepe University, Faculty of Education, Dept. of Chem. Education, Ankara-TURKEY
3 Assist.Prof.Dr., Hacettepe University, Faculty of Education, Dept. of Chem. Education, Ankara-TURKEY

Received: 13.03.2007 Revised: 02.05.2008 Accepted: 18.08.2008

The original language of article is Turkish (v.6, n.1, April 2009, pp.89-107)

Keywords: Project Supported Chemistry Laboratory Practices; Attitude Against Chemistry; Attitude Against Chemistry Laboratories; Anxiety of Orientation; Scientific Process Skills.

SYNOPSIS

INTRODUCTION

The most important feature of effective science education is to support theoretical explanations with actual practices in the laboratory. In the studies of Hofstein and Lunetta (2003) on this issue, the adequacy of some recent practices was discussed and suggestions were made for practices in the 21st century. The laboratory practices generally aim to improve the students’ abilities by providing observation and equipment utilization for conducting the experiments. Other authors evaluated the aims of the laboratory practices in science education: (Lunetta, Hofstein & Giddings, 1981; Boud, Dunn & Hegarty-Hazel, 1986; Hodson, 1988; Garnet & O’Loughlin, 1989; Hegarty-Hazel, 1990; Woolnough, 1991). These studies classified the aims of laboratory practices under four categories, which were: (1) Actualizing the conceptual learning, (2) Attaining technical skills, (3) Attaining research skills, and (4) Producing effective learning products.

There are various factors that affect the success of the above mentioned chemistry laboratory practices. Apart from the physical conditions of the environment where the experiment takes place, individual cognitive variables related to the person conducting the experiment, affects the students' learning and achievement, regardless of the method of the experiment. Bowen (1999) developed a tool in his college chemistry study in order to assess the anxiety levels of the students and investigated its validity. This tool indicated the relationship between the chemistry laboratory anxiety and the dimensions of working with chemicals, using the tools and materials, collecting data, working with other students, and using time efficiently. The study also involved the utilization of this tool in educational experiments, which aimed at improve learning. Together with anxiety, students’ attitudes
(Anders, et al. 2003) and scientific process skills (Beaumont-Walters & Soyibo, 2001) affect their skills for conducting the experiments, as well as the results.

PURPOSE OF THE STUDY

The general aim of this study is to prepare project-based chemistry experiments related to various chemistry topics via group study by pre-service chemistry teachers. Also it is tried to find answers to the following questions:

1. Did pre-service teachers’ performance change after mentioned applications?
2. Had conducted applications effect on pre-service teachers’ attitude towards chemistry, attitudes towards chemistry laboratory, anxieties and scientific process skills?
3. How was the physical condition of laboratory where project-based chemistry experiment applications were conducted and what were the difficulties encountered by pre-service teachers in laboratory studies?

METHODOLOGY

Experimental method was used in the study and pre test-post test experiment design without control group was selected. Firstly Scale of Attitude towards Chemistry, Scale of Attitude towards Chemistry Laboratory, Anxiety Orientation-Motivation Questionnaire and Scientific Process Skills Test were administered to pre-service chemistry students at the beginning of the applications of project-based chemistry experiments as pre-test. The same tests were administered one-week later applications as post-test. Also in the application process of post-tests, Difficulties Encountered in Laboratory Questionnaire was administered to pre-service chemistry students.

Before commencing the research, the researchers informed the students about the study. Students chose their topics among a group of topics on the agenda that either occurred in their environment or that they planned to teach in their practice as chemistry teachers. After the students’ experiments were determined, students watched and discussed the previously recorded videos with the main author. The misconceived portions of the experiment were explained and the students’ misconceptions were corrected. The students were provided with the opportunity to try the experiments beforehand, in which all the necessary security precautions were taken. Students were video-recorded and photographed while conducting their experiments. Students finally transferred the designed and applied experiments into electronic format as presentations. The titles of the experiments were as follows: (1) Making the Silver Tree, (2) Total Hardness Determination in Water, (3) What is the basic element of organic components and how is the nitrogen that is found in organic substances determined? (4) Making recyclable paper, (5) Obtaining solid soap with the reaction of Sodium-hydroxide dissolution with oils, (6) The burning of Glycerin by itself, (7) Making Glue, (8) The Qualitative Analysis of Proteins, (9) The Synthesis of Boric Acid Methyl ester, (10) The Reversible Reaction of Chromate Ions, (11) The reactions of aluminum metal with HCl and NaOH, (12) Obtaining components that provide the green color for a leaf, (13) Changing Location Reaction and (14) Examining the effect of heat on dissolubility.

1) Samples

The sample of the study was 38 year 4 students from Hacettepe University, Faculty of Education, Department of Chemistry Education in the 2005-2006 Spring Semester. Fourteen teams of two or three students were formed.
2) Instruments

a) Scale of Attitude towards Chemistry Laboratory
   It is a 5-point Likert-type scale of 18 statements, which involved the negative and positive attitudes towards chemistry laboratory. Students’ responses to the statements were “strongly agree, agree, neither agree nor disagree, disagree and strongly disagree”. After the pilot studies, the alpha reliability coefficient of the scale was calculated as 0.89 after the factor analysis (Oskay et al., 2006).

b) Scale of Attitude towards Chemistry
   It is a 5-point Likert-type scale of 21 statements, which was developed by Şimşek (2002) in order to assess the attitudes of students towards chemistry. Students’ responses to the statements were “strongly agree, agree, neither agree nor disagree, disagree and strongly disagree”. The alpha reliability of the scale was calculated as 0.82.

c) Anxiety Orientation-Motivation Questionnaire
   The Anxiety Orientation Motivation Survey consists of 16 positive and negative anxiety statements, which aim to evaluate the anxieties of the students. It was prepared as a 5-point Likert-type scale. Students’ responses to the statements were “strongly agree, agree, neither agree nor disagree, disagree and strongly disagree”. Its alpha reliability coefficient is 0.88 (Güngör Seyhan & Morgil, 2005).

d) Scientific Process Skills Test
   The test, which assesses students’ cognitive abilities to define the variables, define and understand the hypotheses, design, comment on the data and graph the findings, was originally developed by Okey, Wise and Burns (1982). The test consisted of 36 multiple-choice questions with a reliability coefficient of 0.81.

f) Difficulties Encountered in Laboratory Questionnaire
   In order to determine the difficulties encountered by the students in the laboratory, a questionnaire, which was developed by Bozdoğan and Yalçın (2004) was administered. The alpha inner consistency coefficient of the questionnaire was calculated as 0.89. It is a 5-point Likert-type scale of 16 statements. Students’ responses to the questions were “always occurs, usually occurs, sometimes occurs, rarely occurs and does not occur”.

g) Conducted Interview with Pre-service Chemistry Teachers
   Student Interview Form consisted of 5 questions was given to 7 willing pre-service chemistry students who filled Difficulties Encountered in Laboratory Questionnaire. Their general ideas and suggestions related to applications were determined by examining of their interview forms.

FINDINGS

The pre and posttest averages of the Scale of Attitudes towards Chemistry Laboratory are examined, a statistically significant difference can be observed that favors the posttest. At the end of the project-oriented chemistry laboratory practice, there was an increase in the positive tendencies. The results of the Scale of Attitudes towards Chemistry displays the students’ pretest averages as 2.86 and the posttest averages as 3.62. In comparing the pre and posttest averages, there is a statistically significant difference that favors the posttest. At the end of the practice, there is an increase in the attitudes of the students towards chemistry in positive tendencies. There is a statistically significant
difference between the pre and posttest results of the Anxiety Motivation-Orientation Survey that favors the pretest. This difference shows that at the end of the project-oriented chemistry laboratory practice, an increase was observed in students’ anxiety levels. A significant increase was found in the scientific process levels of the students at the end of the project-oriented chemistry practice (t(38) = - 2.763, p<0.05). Before the practice, the Scientific Process Skill test average of the students was Xpre= 26.71, whereas it was Xpost= 27.39 after the practice. Even though the difference is not very significant, this finding proves that project-oriented chemistry laboratory practice does in fact have an effect on improving students’ scientific process skills. The responses of the students to the difficulty questionnaire, as the participants of the study, show the following important results: students mentioned that they wanted to do the preparations before the experiments, in which the conditions were available for that. They also said that the experiments were intersecting with their knowledge and they did not have any difficulties in conducting the experiments. However, the disadvantage they stated was that it took a lot of time to obtain the tools and fix them when necessary. Another important negative aspect here is that they could not find the same conditions in the chemistry laboratories, where they did the project-oriented chemistry experiments, as they found in the ICT-assisted research laboratories, which they really wanted to have access to.

Some of the answers given to the question “what is the prior aim of laboratory applications?” by 7 pre-service teachers are:
- They expressed that theoretic knowledge will be permanent by using of scientific process skills such as observation, data collection, and formation of hypothesis.
- They expressed that obtained knowledge by doing experiment will be permanent.

Some of the suggestions of pre-service chemistry teachers related to enhancement of advantage of laboratory applications are:
- Activities consisted of more applications should take place,
- The number of laboratory course should be increase,
- Every stage and aim of experiments should be known like in this application.
- Topics in theoretic courses and experiments conducted in laboratories must be parallel.

**DISCUSSION**

According to the results of our study, it was concluded that pre-service chemistry teachers’ scientific process skills increased as statically. It was determined that scientific process skills have significant effect on pre-service chemistry teachers’ performance in applications and this result was compatible with the dissertation of Yavuz (2006). Also Doğruöz (1998) expressed that interest towards science topics of experimental group students who are taught with methods consisted of scientific process skills more than control group students’ who are taught with traditional learning method. A significant increase was observed in pre-service chemistry teachers’ attitudes towards chemistry and chemistry laboratory after applications. Also it was determined that pre-service chemistry teachers’ attitudes contributed to their performance in applications as statically. Many research studies have been conducted to investigate the educational effectiveness of laboratory work in science education in facilitating the attainment of the cognitive, affective, and practical goals Hofstein and Lunetta (1982; 2003). Hofstein and Lunetta (1982) suggest that laboratory activities have the potential to enhance constructive social relationships as well as positive attitudes and cognitive growth. Also, more recently, in Nigeria, Okebukola (1986) summarized his study, claiming that a greater degree of participation in the science laboratory resulted in an improved attitude towards chemistry learning in general and towards learning in chemistry laboratory in particular. It was
observed that pre-service chemistry teachers’ anxiety decreased after project-based chemistry experiment applications. This result was compatible with the study of Abendroth and Friedman (1983). In another study conducted to decrease of anxiety, educational solution methods were investigated and various curriculum programs were develop (Hill & Horton, 1986). According to obtained data from Difficulties Encountered in Laboratory Questionnaire, it was arise that condition of hands-on learning activity settings such as laboratory where project-based chemistry laboratory experiment applications conducted must be better.

Finally, learning science in the laboratory with special attention to scholarship associated with models of learning, argumentation and the scientific justification of assertions, students’ attitudes, conditions for effective learning, students’ perceptions of the learning environment, social interaction, and differences in learning styles and cognitive abilities (Hofstein & Lunetta, 2002).
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