The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2018

Volume 9, Pages 36-41

ICEMST 2018: International Conference on Education in Mathematics, Science and Technology

The Effect of Inquiry Based Chemistry Experiments Practıces on Inquiry Skills and Scientific Creativity

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Abstract: Inquiry based research requires individuals to think about a subject, to reason, to conduct indepth research and to discuss the results. Inquiry based research lead the individuals to explore knowledge, investigation, and discovering facts. Permanent learning in science is thought to occur through inquiry, research and exploration. For this reason, in disciplines such as chemistry learning should be conducted by questioning, researching and exploring, that is, inquiry-based research. The purpose of this research is to investigate the effect of inquiry based chemistry experiment practices on the inquiry skills and scientific creativity of prospective teachers. The sampling consisted of prospective chemistry teachers studying at Hacettepe University. In the research, inquiry skills scale and scientific creativity test were used as data collection tools. As a result of the research, it has been determined that inquiry based chemistry experiment practices are an effective approach in order to improve inquiry skills and scientific creativity of teacher candidates. The research findings also reveal that the inquiry-based chemistry experiment practices allow the chemistry to be more understandable, given the opportunity to practice the theoretical knowledge and makes chemistry experiments fun.

Keywords: Inquiry-based practice, Chemistry experiment, Inquiry skills, Scientific creativity

Introduction

Education systems that rely largely on digestion and reproduction of subject content have not produced the desired results. In place of feeding students ready-made knowledge, student-oriented approaches that emphasize how and where to find and use knowledge have become more prominent. One of these approaches is inquiry-based learning (Çalışkan, 2008). The term inquiry refers to searching for knowledge and doing research on phenomena. According to the U.S. National Research Council (NRC), inquiry helps students to comprehend scientific concepts, to realize what they know about science and how they know it, to comprehend the nature of science, to gain the skills necessary to become individual researchers, and to improve their science-related skills and attitudes (Hassard, 2005). Inquiry-based learning activities enable students to increase their knowledge, learn how to think scientifically, and understand how scientists work in natural life (NRC, 2000). This learning approach consists of several steps: doubt or curiosity, defining the problem, generating hypotheses, gathering information, analysis of information and its evaluation, testing the hypotheses, and resuming research in a new way (Obenchain, & Morris, 2003). As a matter of fact, problem solving, constructing hypothesis and experiment and technical innovation require specific form of scientific creativity (Lin, Hu, Adey, & Shen, 2003). Scientific creativity has three dimensions: creative thinking, scientific knowledge and scientific inquiry skills (Park, 2011). According to Demir (2014), scientific creative thinking ability can be defined as “thinking ability that brings together interdisciplinary areas of science, technology and art (aesthetic) and provides individuals’ unique solution ideas of a challenging problem from these areas’ points of views”. As it can be seen from this definition, scientific creativity brings together both the uniqueness of the discipline and different disciplines’ aesthetic aspects. It is considered as a multidimensional and sophisticated field (Demir, 2014). The emphasis here is on the inquiry skills and scientific creativity. The purpose of this research is to investigate the effect of inquiry-based chemistry experiments on the inquiry skills and scientific creativity of prospective teachers.

Method

In the study, a single group pretest-posttest research design was used. The research was carried out in the general chemistry laboratory course. Within the scope of the course, chemistry experiments with investigative research focused on teacher candidates have been carried out.

Sampling

The study group of the study is consists of 17 prospective chemistry teachers' who are studying at Hacettepe University, Faculty of Education. The study was carried out in the General Chemistry Laboratory course during the spring semester of 2017-2018 academic year.

Data Collection Tools

In the research, inquiry skills scale and scientific creativity test were used as data collection tools.

Inquiry Skills Scale

The scale was developed by Aldan Karademir and Saracaloglu (2013). The scale consists of 14 statements in a 5-point Likert Type. Scale consists of information acquisition, information control and self-confidence as named three sub-dimensions. The Cronbach Alpha reliability coefficicent of the whole scale 0.82 and .76, .66, .82 for the sub-dimensions, respectively.

Scientific Creativity Test

The Turkish version of the scale developed by Hu and Adey (2002) was done by Deniş Çelikler and Balım (2012). Scale The scale consists of 7 items aiming to measure the characteristics of students such as extraordinary use, problem finding, product development, scientific imagination, problem solving, scientific experimentation and product design. The Cronbach Alpha reliability coefficient of the scale is 0.86.

Data Analysis

Analysis of the data obtained from the study was carried out using the SPSS 15 packet program. Descriptive statistics were performed primarily when analysis of data from scales was performed. Thus, the inquiry skill levels of the sample group were determined. The research inquiry skills and scientific creativity level change were examined by the Wilcoxon Signed Ranks Test.

Experimental Processing Steps

1. Inquiry: This step is usually intended to create a problem in your mind and to present a solution proposal. For this purpose, open-ended questions can be exploited from the results of observations of any researcher, from astonishing events related to the subject in the process of problem formulation.

2. Disclosure of existing knowledge: In this step, it is aimed to find possible solutions of the research based on existing knowledge.

3. Estimation: It is aimed to express students' proposals starting with "I think" by their reasons. The students are predicting the problem starting with the question mark.

4. Planning and implementing the application: In this step, it is aimed that the students plan and implement the plan to solve the research problem given to them. In this study, students follow the guideline given in order to solve the research question.

5. Interpretation and presentation of results: At this stage of the students return; they record and analyze their observations during the research process. Students share their findings and new information. Students are expected to analyze the data they obtain about the experiment and to interpret and comment on the solution proposals.

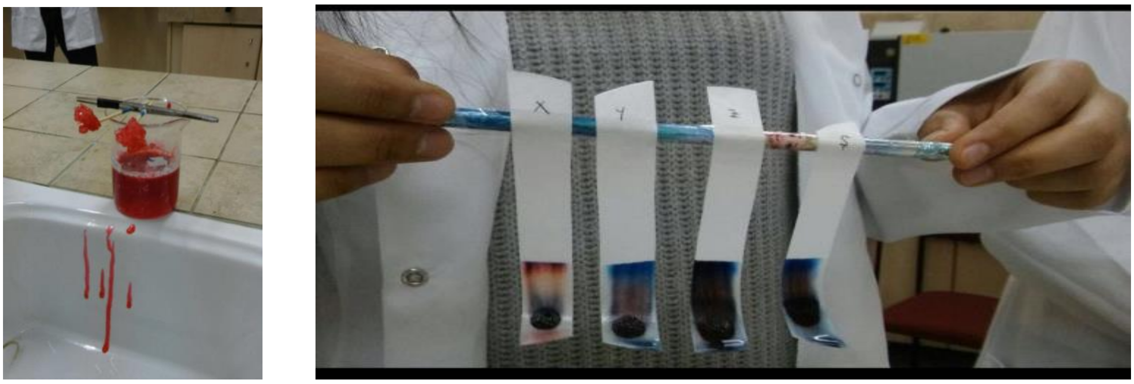

Figure 1. Sample application images

Results and Discussion

Findings Related to Inquiry Skills

Descriptive statistics related to the average of the scales applied within the context of effect of inquiry based chemistry experiment practices on the inquiry skills and scientific creativity of prospective teachers are summarized in Table 1.

Table 1. Descriptive statistics of pre-test data

		X	SD
Scale	Inquiry skills	3.94	.52
Sub-dimensions	Information acquisition	4.18	.49
	Information control	3.92	.64
	Self-confidence	3.54	1.04

When we examine the Table 1, we can say that the level of inquiry skills of prospective teachers is high (X: 3.94). When the sub-scales of the inquiry skills scale are examined, it is noteworthy that the prospective teachers have the highest average in the dimension of information acquisition (X: 4.18).

The difference between pre-test and post-test scores of prospective teachers inquiry skills level was examined by Wilcoxon signed rank test, and the results are seen in Table 2.

Table 2. Wilcoxon signed rank test results of inquiry skills

Inquiry skills		N	X	sd	Z	p
Measurement	Pre-test	17	3.95	.59	-1.117	.264
	Post-test	17	4.10	.48		

When the table was examined, it was seen that there was no statistically significant difference between pre-post test scores of inquiry skills ($Z=-1.117$, $p>0.05$).

The difference between pre-test and post-test scores of prospective teachers inquiry skills level was examined by Wilcoxon signed rank test, and the results are seen in Table 2.

Table 3. Sub -dimensions analyses of inquiry skills

Inquiry skills		N	X	sd	Z	p
Information acquisition	Pre-test	17	4.18	.49	-.252	.801
	Post-test	17	4.20	.57		
Information control	Pre-test	17	3.92	.64	-2.027	.043*
	Post-test	17	4.29	.49		
Self-confidence	Pre-test	17	3.54	1.04	-.269	.788
	Post-test	17	3.60	1.26		

From the table it has seen that, there was a statistically significant difference between pre-post test scores of information control sub- dimension of inquiry skills scale ($Z = 2.027$; $p < 0.05$).

Findings Related to Scientific Creativity

When the scientific creativity test is evaluated, the originality score is calculated. When scores are calculated, the students who enter the first 5% of all correct answers are given 2 points, the students whose answers between 5% and 10% of all correct answers are given 1 point. Other correct answers have a score of 0.

Descriptive statistics of the prospective teachers' related to scientific creativity test before and after the application are summarized in Table 4.

Table 4. Descriptive statistics of scientific creativity pre-post test

Scientific creativity test	Originality score (Pre-test)	Originality score (Post-test)
Item 1	7	6
Item 2	14	16
Item 3	8	10
Item 4	10	8
Item 5	13	16
Item 6	16	11
Item 7	14	13

The difference between pre-test and post-test scores of prospective teachers scientific creativity test scores was examined by Wilcoxon signed rank test, and the results are seen in Table 5.

Table 5. Wilcoxon signed rank test results of inquiry skills

Scientific creativity		N	X	sd	Z	p
Measurement	Pre-test	17	.66	.17	-2.053	.040*
	Post-test	17	.76	.19		

When the table is examined, it is seen that there is a statistically significant difference between scientific creativity pre-post test scores ($Z = -2.053$, $p<0.05$).

Results and Discussion

In this research, it has been determined that inquiry-based chemistry experiment application is an effective approach to scientific creativity and to the information control dimension of inquiry skills. When the literature is examined, the existence of studies supporting the research result is noteworthy (Bayrak, 2014, Demir, 2014; Kadayıfçı, 2008, Karakaş & Afacan, 2017; Abdi, 2014; Maxwell, Lambeth & Cox, 2015; Şen, Yılmaz & Erdoğan, 2016; Kaya & Yılmaz, 2016; Yıldırım & Türker Altan, 2017; Akcanca, 2017).

Inquiry based teaching is seen as teaching initiatives for students to gain the skills of inquiry, to understand the science and to improve their creativity. In order to draw the curiosity of the students during the inquiry process, it is appropriate to start the course by giving daily life situations. Then students should be asked to make estimates about what to do, and the students are asked to question the lesson. Inquiry-based teaching sparks students' curiosity as well as their scientific understanding by drawing examples from daily life and asking the students to make predictions. It gives students the opportunity to learn by exploring and through student-centered inquiry (Yoon, Kim, Kim, Joung, & Park, 2013). An inquiry-based environment permits students to activate their knowledge and helps them to organize their work so that they can be successful in the inquiry process (Pedaste & Sarapuu, 2012). The success of inquiry-based learning can be explained in terms of students being active participants in researching concepts and developing related skills (Lane, 2007). Students learn science as they obtain the skills needed for scientific inquiry through active learning (Hassard, 2005), applying a student-centered approach that enables them to obtain academic skills and take responsibility for absorbing and strengthening their knowledge. With scientific inquiry applications, students become aware of information acquisition, information control and self-confidence criteria. At the same time, activities such as creating a work plan in the laboratory, setting and testing hypotheses, setting up an experimental process, repeating the experiment for best results, writing a research report and presenting the results give the students the ability to work as scientists (Alkan, 2012).

In addition, inquiry-based environments provide opportunities for students to learn and acquire research skills (Spronken-Smith & Walker 2010), an in-depth understanding of scientific questions (Wu & Wu, 2011), opportunities for open and reflective debate (Khishfe & Khalick, 2002), the need for interdisciplinary study of individuals (Mousoulides, 2013), is thought to be the development of scientific creativity of prospective teachers'. Scientific creativity skills are specific to the field and involve individual's personality, thinking abilities, school surroundings, laboratory approach, different unique activities, appropriate learning processes and dimensions of subject matter knowledge. Subject matter knowledge and laboratory approach are considered as fundamentals for developing scientific creativity skills. It is necessary to prepare rich learning environments by using various learning approaches, methods and techniques with appropriate planning and applications for the development of scientific creativity (Demir, 2014). The inquiry-based chemistry laboratory environment contributed to the development of scientific creativity of prospective teachers. The results of this study that scientific creativity skills can develop with experiential applications such as inquiry based experiments are supported by other results findings (Demir, & Şahin, 2013; Demir, 2014). Teachers need to develop a special teaching effort for improving creativity in the science classroom, if the development of scientific creativity is one of the major goals of science learning (Kang, Park, & Hong, 2015). All these characteristics of inquiry could have contributed to the results of this study.

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