SHS Web of Conferences **66**, 01006 (2019) https://doi.org/10.1051/shsconf/20196601006
ERPA 2019

Examining the instructional materials motivation of prospective chemistry teachers' in laboratory

Fatma Alkan[1,*]

[1]Hacettepe University, Faculty of Education, 06800, Beytepe, Ankara, Turkey

Abstract. The aim of this study was to determine effect of inquiry based learning method on the instructional materials motivation of prospective chemistry teachers' in chemistry laboratory. A pretest–posttest control group design was used in the study. The study group was consists of 22 prospective chemistry teachers' who are undergraduate students at a University. There were 11 prospective chemistry teachers' in each of the experimental and control groups. The study was carried out in analytical chemistry laboratory. In the experimental group had been followed inquiry-based chemistry laboratory experiments. In the control group had been experienced traditional verification laboratory experiments. The instructional materials motivation survey was used as data collection tool. In terms of instructional materials motivation there was no difference between the experimental and control groups before laboratory application. After the application the results indicated that inquiry-based learning is effective in improving instructional materials motivations prospective chemistry teachers.

1 Introduction

Laboratory practice is accepted as a fundamental and useful part of science education. Many studies have shown that laboratory education has not achieved their full purpose. Why doesn't laboratory practice provide the expected benefit? According to science researchers, the answer to this question is seen as the use of traditional verification-type laboratory activities in laboratory applications [1]. In traditional verification-type laboratories, students are given clear directions that indicate the aim of the experiment, how to conduct it, and how to analyse the data; students then follow these directives cognitively and rather passively. Laboratory education should be structured in such a way as to lead the student to question and research from traditional verification-type laboratories. Laboratories should be equipped with scientific inquiry processes in order to improve learners' ability to observe, produce ideas and make comments [2, 3, 4]. For effective learning, activities need to be done with consciously. Conscious individuals will be able to take part in society as the products of the education process only when they are equipped with the ability to question [5]. Inquiry-based learning activities enable students to increase their knowledge, learn how

* Corresponding author: alkanf@hacettepe.edu.tr

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).

to think scientifically, and understand how scientists work in natural life [6]. Inquiry-based learning approach comprise of that 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 [7]. In inquiry-based learning, the instructor provides a complex case and expects students to solve the problem by gathering information and testing experimental results [8]. Scientific inquiry is to provide learners active participation in the learning process and help to develop the acquisitions to learning [9]. An individual with strong inquiry skills knows how to acquire information, where to use it, and how to integrate this information with prior knowledge. Laboratory applications are seen as the only places where inquiry skills will be developed with these features.

1.1 The aim of the study

Laboratory education should not be a process in which the teacher determines the experiments, establishes relationships with the subjects previously learned, performs demonstration experiments and prepares and gives the steps that the students will follow during the experiment [10]. The aim of the students in the laboratories where such applications are made is to reach the information requested by the teacher. In order to achieve this goal, they quickly realize that they need to produce, copy, or express information in some way [11]. Instead of this, laboratories should be a place where the teacher asks students to identify a problem, a place where students relate to previous research to solve this problem, a place where students indicate the purpose of the research, a place where students estimate possible outcomes, a place where students identify the approach and procedures to be used and conduct an investigation [10]. The aim of the study is to the effect of scientific-inquiry-based chemistry laboratory applications as opposed to traditional verification-type laboratories. As such, this study examines the effect of scientific-inquiry based chemistry laboratory on students' instructional materials motivation level.

2 Method

In this study, pre-test post-test control group design was used. Control and experimental groups were determined through objective sampling. The experimental group completed chemistry laboratory applications using a scientific-inquiry-based learning approach, whereas the control group used a traditional verification laboratory approach.

2.1 Sampling

The sample of the study is consists of 22 prospective chemistry teachers' who are studying at Hacettepe University, Faculty of Education. The study was carried out in the Analytical Chemistry Laboratory course during the spring semester of 2014-2015 academic year. There are 11 prospective teachers in the experimental group and 11 in the control group.

2.2 Data collection tools

The instructional materials motivation survey was developed [12] and adapted to Turkish by [13]. The scale consists of 24 items in 5-point Likert type. The scale has two sub-scales: attention-relevance and confidence-satisfaction. The Cronbach alpha reliability coefficient of the scale is 0.83 for the whole scale and for the sub-scales are 0.79 and 0.69. The

Cronbach Alpha reliability coefficient obtained from the sample data's is 0.91, for sub-scales 0.88; 0.87.

2.3 Data analysis

Analysis of the data obtained from the study was performed with the SPSS 17 packet program. In the study, data obtained from experimental and control groups were analysed in terms of the difference between pre-test and post-test scores. Nonparametric tests [14] were used since sampling numbers were below the recommended values (Kolmogorov-Smirnov $p<.05$). The difference between pre-test and post-test scores was examined by Wilcoxon signed rank test and the post-test scores of experimental and control groups was analysed with the Mann-Whitney U-test. The difference between the instructional materials motivation sub-scales according to the experiment-control group was examined by "Multivariate Variance Analysis MANOVA". MANOVA analysis takes into account the eta square value criterion determined, when interpreting the differences in the outcome-dependent variables by the independent variable. The effect size defined .01 as small, .06 as moderate, and .14 and above as large square values of eta [15].

2.4 Experimental operation

2.4.1 Experimental group

According to source, inquiry-based chemistry laboratory activity is comprised of five phases, as described below [16].

Phase 1: In this study, prospective teachers examine their knowledge about volumetric analysis. They looked primarily at the importance of neutralization titrations in their daily lives.

Phase 2: Prospective teachers researched the place of neutralization titrations in our daily lives; to this end, they conducted experiments and observations about the acid levels of freshly squeezed fruit juice and factory-produced fruit juice, and they then compared and discussed their data.

Phase 3: In the analytical chemistry laboratory, prospective teachers researched available data on the acid levels of freshly squeezed fruit juice and factory-produced fruit juice and compared this information to their own experimental data.

Phase 4: To fulfill this phase in the present study, prospective teachers researched the importance of precipitation titrations and oxidation-reduction titrations. They identified applications and explained these processes by reference to commonly used foods and chemicals.

Phase 5: Prospective teachers in the present study completed this phase by discussing what they had learned about volumetric analysis methods and their importance with their instructors and other prospective teachers.

2.4.2 Control group

The traditional verification-type laboratory approach was applied to the control group. Prospective teachers' have already been given chemistry experiments sheets. The experiments sheets contains information's about the purpose of the experiment, how to do the experiments, and how to analyse data acquired from the experiment. In the traditional verification laboratory approach, the data obtained from the experiments and analyse results were used to verify the previously known concepts, principles and laws.

3 Results

Descriptive statistics related to pre-test scores of prospective teachers' instructional materials motivation level before scientific inquiry in chemistry laboratory application are summarized in Table 1.

Table 1. Descriptive statistics of pre-test data

Pre-test data			**Experiment**		**Control**	
			X	**sd**	**X**	**sd**
Scale	Instructional materials motivation level		3.69	.55	3.77	.51
	Sub-scales	Attention-relevance	3.64	.55	3.84	.66
		Confidence-satisfaction	3.73	.67	3.72	.48

When Table 1 is examined, it has seen that the prospective teachers' instructional materials motivation levels is high level (X:3.69; X:3.77). When the subscales of the instructional materials motivation scale are examined, it is noteworthy that the medium and highest scores is in the data collection. The comparison of instructional materials motivation averages for the two groups before application was examined by Mann-Whitney U-test. According to the analysis results there is no statistically significant difference between the averages ($U=64.000$; $p>0.05$).

Descriptive statistics of the prospective teachers' related to scales after the application are summarized in Table 2.

Table 2: Descriptive statistics of post-test data

Post-test data			**Experiment**		**Control**	
			X	**sd**	**X**	**sd**
Scale	Instructional materials motivation level		4.25	.51	3.83	.36
	Sub-scales	Attention-relevance	4.27	.57	3.72	.49
		Confidence-satisfaction	4.24	.49	3.92	.37

When Table 2 is examined, it is noteworthy that the increase of prospective teachers' instructional materials motivation and it is noteworthy that the average of the experimental group was higher than the control group.

The difference between pre-test and post-test scores of prospective teachers' instructional materials motivation level was examined by Wilcoxon signed rank test, and the results are seen in table.

Table 3: Wilcoxon signed rank test results of instructional materials motivation

Instructional materials motivation		**N**	**Mean rank**	**Sum of ranks**	**Z**	**p**
Experiment	Pre-test	11	3.00	3.00	-2.825	.005*
	Post-test	11	6.82	75.00		
Control	Pre-test	11	4.88	39.00	-.534	.594
	Post-test	11	9.00	27.00		

When the table is examined it has seen that there is a statistically significant difference between pre-post test scores of experimental group (Z=-2.825, p<0.05; Z=-0.534, p>0.05), for the control group the difference was not statistically significant. The difference between post-test scores of groups' instructional materials motivation level was examined by Mann-Whitney U-test. The results show that there is a statistically significant difference between experimental and control groups of instructional materials motivation level (U=33.000, p<0.05).

Table 4: Sub-scales analyses of instructional materials motivation

Instructional materials motivation	**Experiment**	**Mean rank**	**Sum of ranks**	**Z**	**p**
Attention-relevance	Pre-test	3.50	7.00	-2.517	.012*
	Post-test	7.10	71.00		
Confidence-satisfaction	Pre-test	1.00	1.00	-2.701	.007*
	Post-test	6.00	54.00		

When the table is examined, it has seen that there is a statistically significant difference between pre-post test scores of attention-relevance and confidence-satisfaction sub-scales of instructional materials motivation scale for experiment group (Z=-2.517, Z:-2.701 p<0.05).

Table 5: Sub-scales analyses of instructional materials motivation

Instructional materials motivation	**Control**	**Mean rank**	**Sum of ranks**	**Z**	**p**
Attention-relevance	Pre-test	5.92	35.50	-.816	.414
	Post-test	4.88	19.50		
Confidence-satisfaction	Pre-test	4.00	12.00	-1.874	.061
	Post-test	6.75	54.00		

When the table is examined, it has seen that there is no statistically significant difference between pre-post test scores for control group.

The comparison of attention-relevance and confidence-satisfaction sub-scales of instructional materials motivation level of prospective teachers' in the experiment and control groups was examined with MANOVA. Firstly, it has been examined whether the data can be met by MANOVA's assumptions. The normality of distribution of the data and homogeneity of group variances were tested. And it was found that the data obtained from the instructional materials motivation survey provided a normal distribution count and a homogeneous count of group variances. MANOVA analysis was interpreted as Wilks' Lambda value [17]. Another assumptions of MANOVA is homogeneity of variances. For the equality of variances, it was looked at the Levene test and the equality of variances in terms of dependent variables was accepted [p>.05].

MANOVA results show that inquiry-based chemistry laboratory and traditional verification laboratory approaches have a significant effect on the instructional materials motivation of prospective teachers' (Wilks' Lambda=.656, $F_{(2.19)}$=4.991 η^2=.344, p<.005).

Table 6: Interaction between experiment and control groups instructional materials motivation sub-scales

Source	Dependent variable	Sum of squares	Sd	Mean squares	F	p	η^2
Group	Attention-relevance	2.344	1	2.344	9.922	.005*	.332
	Confidence-satisfaction	.936	1	.936	6.265	.021*	.239

When the table is examined, it is seen that there is a significant effect of teaching method on the attention-relevance and confidence-satisfaction sub-scales of the scale. The explanation percentage of instructional materials motivation component of attention-relevance variable with teaching method independent variable was 33.2% and component of confidence-satisfaction variable with teaching method independent variable was 23.9%. This of eta square (η^2) are large.

4 Discussion and Conclusion

The study findings indicate that inquiry-based chemistry laboratory is an effective method for enhancing instructional materials motivation level. When the literature is examined, although there is no research results supporting the effect of inquiry-based chemistry laboratory on instructional materials motivations, it is noteworthy that the articles showing positive effects on variables such as academic success, motivation and attitude [18, 19, 20, 21, 22, 23, 24]. In this study the inquiry-based chemistry laboratory was implemented according to the steps of the NRC. Firstly, prospective teachers have been confronted with a contradictory situation. At this point, there has been a desire to search for information and they have determined a suitable test method to achieve this new knowledge. NRC's phase 1 and phase 2 of the inquiry-based chemistry laboratory practice are intended to explain the attention-compliance sub-scales of the instructional materials motivation survey. In addition, the phase 3, phase 4 and phase 5 of the laboratory application are integrated with the confidence-satisfaction sub-scales of the survey. Inquiry-based chemistry laboratory experiments are aimed to develop the beliefs about prospective teachers' abilities. Besides, the daily practice examples of the experiments provided them with independent learning skills and give the opportunity to apply newly learned knowledge and skills. The significant difference in the confidence-satisfaction sub-scales of the survey can be explained with this respect.

Articles about the role of laboratory, its purpose and effectiveness to obtain learning outcomes of chemistry education are noteworthy [1, 25, 26, 27]. Despite the widespread notion amongst chemistry educators that the laboratory is essential location to learn chemistry, it is often a neglected area of teaching and, arguably, of educational research [27]. Researchers state that learning of chemistry in experimental laboratory environments should be made more effective [1, 25]. The lack of research on the learning environment of the science laboratory is one of the shortcomings of science education and chemistry education [28]. Laboratory education perform better, when teachers are sure about the necessity of laboratory and its purpose, devise activities correspond to that purpose, and transfer this knowledge to their students [29]. Therefore, different teaching methods such as inquiry-based laboratory should be used in teacher education and method-strategy information of prospective teachers' should be developed. The effectiveness of laboratory work and field work can be enhanced by creating more opportunities for students for example to talk with other students or to talk with the teacher about the purpose of the experiment, its experimental stages, and the theoretical implication of the findings.

Chemistry can be better understood per students' by the use of methods that will reveal the effectiveness of the chemistry laboratory. The chemistry laboratory can be made more effective by such methods as inquiry-based teaching. Inquiry-based teaching is an important approach because it requires active participation of learners in the research process and develops relevant skills. The use of different approaches such as inquiry-based teaching in the laboratory will enable students to construct the related knowledge well and support their individual development.

References

1. A. Hofstein, V. N. Lunetta, Sci. Educ., **88**, 1 (2004).
2. G. Parim, The effects of inquiry on the concept learning, achievement and development of scientific process skills of 8th grade students as related to photosynthesis and respiration. (İstanbul: Marmara University, Institute of Science, Unpublished Doctoral Thesis 2009).
3. H. Miller, K. McNeal, B. Herbert, J. Geog. High. Educ., **34**, 4 (2010).
4. M. Aydeniz, D. Cihak, S. Graham, L. Retinger, Int. J. Spec. Educ. 27, 2 (2012).
5. Eggen, P., Kauchak, D. *Educational psychology: Windows on classrooms (5th ed.)*. (Upper Saddle River, NJ: Prentice Hall. 2001).
6. NRC, National Research Council. Inquiry and the National Science Education Standards: A Guide for Teaching and Learning. (Washington, DC: The National Academies Press, 2000).
7. K. M. Obenchain R. V. Morris, *50 Social Studies Strategies for K-8 Classrooms.* (New Jersey: Merrill Prentice Hall 2003).
8. A. Woolfolk, *Educational Psychology*. (Boston: Allyn and Bacon 2001).
9. M. Wilder, P. Shuttleworth, Sci. Activ., **41**, 4 (2005).
10. P. J. Tamir, Res. Sci. Teach., **14,** 9 (1977).
11. C.W. Keys, Sci. Educ., **83**, 2 (1999).
12. J. M. Keller, Unpublished manuscript. Florida State University (2006).
13. H. Kutu, M. Sözbilir, Necatibey Fac. Educ. Elect. J. Sci. Math. Educ., **5**, 1 (2011).
14. S. B. Green, N. J. Salkind, *Using SPSS for windows and macintosh: Analyzing and understanding data.* (Upper Saddle River: Pearson; Prentice Hall, 2008).
15. J. Cohen, *Statistical power analysis for the behavioral sciences*. (New Jersey: Lawrence Erlbaum Associates, 1988).
16. C. Justice, W. Warry, C. Cuneo, S. Inglis, S. Miller, J. Rice, S. Sammon, *A grammar for Inquiry: Linking goals and methods in a collaboratively taught social sciences inquiry course.* (Canada: McGraw-Hill Ryerson 2002).
17. B. G. Tabachnick, L. S. Fidell, *Using Multivariate Statistics*. (New York: Harper & Row, Publishers, Inc. 1989).
18. A. Pandey, G.K. Nanda, V. Ranjan, J. Inno. Res. Educ., **1**, (2011).
19. S. Akpullukcu, Y. Gunay, Ege J. Edu., **14**, 1 (2013).
20. A. Abdi, Uni. J. Educ. Res., **2,** 1 (2014).
21. D.O. Maxwell, D.T. Lambeth, J.T. Cox, Asia-Pac. For. Sci. Lear. Teach., **16**, 1 (2015). pp. 1-31.
22. Ş. Şen, A. Yılmaz, I. Ü. Erdoğan, Elem. Educ. Onl. **15**, 2 (2016).

23. G. Kaya, S. Yılmaz, H.U. J. of Educ. **31**, 2 (2016).
24. M. Yıldırım, S. Türker Altan, Mustafa Kemal Uni. J. Grad. Sch. Soc. Sci., **14**, 38 (2017).
25. N. Reid, I. Shad, Chem. Educ. Res. Pract., **8**, 2 (2007).
26. T. Silva, E. Galembeck, Química Nova, **40**, 4 (2017).
27. S. Sandi-Urena, Química Nova, **41**, 2 (2018).
28. A. Hofstein, I. Cohen, R. Lazarowitz, Res. Sci. & Tech. Educ., **14**, (1996).
29. D. Hodson, Educ. Quí., **16**, 1 (2005).
30. C. Koçak-Altundağ, J. of Turk. Sci. Educ., **15**, 2 (2018).