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Experiential Learning: Its Effects on Achievement and Scientific Process Skills

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ABSTRACT

The purpose of this study is to determine the effects of experiential learning model on student teachers' achievement in chemistry as well as their scientific process skills. The pre and posttest research pattern with treatment and control groups was used throughout the study. While the treatment group received education through experiential learning model, the control group was taught within a traditional teacher-centered approach. The sampling consisted of 40 student teachers studying Chemistry Education at Hacettepe University. Data collections tools were the chemistry achievement test and the scientific process skill test. As the study concluded, experiential learning is an effective approach on academic achievement and scientific process skills. The applicability of experiential learning to high school chemistry curriculum out of teaching curricula rather than those at the universities can be investigated. The impact of experiential learning on other variables can be identified.

Keywords: Achievement; Chemistry Laboratory; Experiential Learning; Scientific Process Skill; Student Teachers.

INTRODUCTION

Learning occurs as a result of experiences and individuals do not always learn in the same way (Yoon, 2000; Kolb, 2000; 1984). To increase the quality of education, learning environments appropriate for individual differences should be created. Differences in general characteristics of students are reflected on their learning processes. Experiential learning theory emerged as a result of taking students' individual differences into consideration. Experiential learning theory depends on studies by Dewey, who takes experiences as basis in learning, Lewin, who emphasizes the importance of students' being active in the learning process, and Piaget, who perceives intelligence not only as characteristics at birth but also as a conclusion of the interaction between the individuals and their environments as well (Yoon, 2000; Kolb, 1984). Experiential learning theory defines learning as a process consisting of four steps. According to Kolb, students should experience four phases of learning when learning a topic. Experiential learning cycle should be structured from concrete experiencing to observation and then from abstract conceptualization to active experimentation (Kolb, 1984). Concrete experiences are turned into abstract concepts within this process and these concepts are used in attaining new experiences.

Experiential learning is considered as an effective way of educational approach. The

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reason for this is the impact of experiential learning on the development of learners' metacognitive skills, enhancing the skills through the implementation of the knowledge to the real situations, and giving the learners the ability of self-learning (Kolb & Kolb, 2006). In experiential learning model, Kolb focuses on experiential learning process rather than routine learning characteristics (Turesky & Gallagher, 2011). It is envisaged in the experiential learning that the validation and internalization of individual change and development are ensured (Healey & Jenkins, 2000). Experiential learning based education requires activities planned appropriate to all learning ways. In general, concrete experience requires full participation of individuals in the activity, while reflective observation requires individuals to develop various perspectives, abstract conceptualization requires attainment of the theoretical knowledge by the individual and active experimentation requires individuals to implement the knowledge. Implementation of the learning cycle in the classroom environment is essential in realization of effective learning (Bahar & Bilgin, 2003; Svinicki & Dixon, 1987). Experiential learning model consist of concrete experience, reflective observation, abstract conceptualization and active experimentation phases. At concrete experience phase, learners require special occasions and examples and to be involved in events. Therefore, topics need to be related to the daily life. Additionally, sample case analysis and role-playing activities should be appropriate to the learning method (Kolb, 1984). Reflective observation is the learning situation where it is important to develop various perspectives by thinking on what is learnt and observed. At this phase, thoughts and opinions about the topic are reflected, the way the facts occur is questioned and certain decisions are made (Kolb, 1984). Reflective observation shall be considered as the phase where various situations emerge at the concrete experience phase is analyzed and solutions for potential problems are sought. At abstract conceptualization phase, on the contrary to learning through concrete experiences, logic, thought and concepts are focused. This phase requires that the theoretical knowledge on the topic should be presented within a certain structure. In this respect, summarizations and explanations made by the teacher would be appropriate (Healey & Jenkins 2000; Kolb, 1984). Active experimentation phase should allow students to learn through implementations and implement what they learn as well. Instead of observing and listening, participating gains importance. Students, who prefer this learning approach, enjoy implementing what they learn and, in other words, seeing that what they learn is useful (Hein & Budny, 2000; Kılıç, 2002; Kolb, 1984). At the first phase of the learning cycle, students have concrete experiences related to the topics. The second phase involves attaining different perspectives towards the gained experiences within a questioning approach. At the third phase, students comprehend the logical structure of what they learnt through their experiences. The final phase of the learning cycle would be the active experimentation.

As learning is a lifelong process and individuals need to learn, interpret or judge situations they experience under various conditions, scientific process skills are very important for significant learning (Bilgin, 2006). Scientific process skills are tools for learning science and understanding scientific studies while setting an essential goal of learning (Anagün & Yaşar 2009). Scientific process skills are listed under three groups as basic skills, experimental process skills and causative process skills (Çepni, 2005). These are not only the skills that are used by scientists in their studies but also are skills that show their effects on individuals' personal, social and global live (Huppert, Lomask & Lazarowitz, 2002). Therefore, using scientific process skills within the experiential learning cycle would ensure the development of basic skills, experimental process skills and causative process skills.

According to the research studies, the most effective and permanent learning in science would be obtained through laboratory method (Bağcı & Şimşek, 1999; Güven & Gürdal, 2002). Laboratory method is the way students follow in learning topics through techniques such as observing, experimenting, learning by doing or presentations in laboratories or purpose-built classrooms (Ergün & Özdaş, 1997). Laboratory studies enable students to participate in activities related to science and experience scientific method, while contributing to development of skills to make observations, produce ideas and interpret topics (Kaptan, 1998). This method also improves individuals' skills like reasoning, critical thinking, developing scientific perspective and problem solving (Serin, 2002). The effectiveness of laboratory applications having such influence on learning science need to be investigated and its impact on different variables need to be determined. Laboratory applications offer the individuals the opportunity of direct contact with the substance world through the help of using the tools, data collection techniques, models and scientific theories (Singer, Hilton & Schweingruber, 2006). Thus, it will be possible for the individuals to learn science and comprehend the scientific studies. Scientific process skills, which facilitate learning, attain research methods, ensure individuals' active participation and responsibility taking in learning as well as increasing permanence of learning, could be developed through laboratory studies in science. The literature review indicates that there are not many studies examining the effect of experiential learning on the laboratory applications, which enable science learners to develop the skills of observation, generating ideas and making interpretations. This study is significant in terms of revealing the importance of chemistry laboratory applications based on the model of experiential learning rather than traditional verification laboratories. Especially, in classes with scientific contents such as chemistry, laboratory method could be used to increase student teachers' achievement levels and improve their scientific process skills. The current study, which has been conducted on this basis, aims to find out the effects of experiential learning model in the chemistry laboratory on chemistry achievement and scientific process skills. In the light of this approach, the aim of this study is to analyze the effects of experiential learning model to be implemented in the chemistry laboratory on student teachers' achievement in chemistry and their scientific process skills.

METHODOLOGY

In this study, which aims to analyze the effects of teaching at the chemistry laboratory through experiential learning model on student teachers' achievement in chemistry and their scientific process skills, was designed within the pre and posttest research pattern with control and treatment groups. Control and treatment groups were determined according to the independent sampling groups' method.

a) Sample

The sampling of the study consisted of 40 student teachers studying Chemistry Teaching at the Faculty of Education at Hacettepe University. The study was conducted within the General Chemistry class. The treatment group was taught through the experiential learning model, while the control group was taught through the traditional teacher-centered model.

b) Data Collection Tools

Chemistry Achievement Test

Student teachers' achievement levels were assessed through the chemistry achievement test developed by the researcher. Chemistry achievement test consists of 15 multiple-choice questions on acids and bases. Reliability and validity studies were done with the participation of 325 student teachers. The achievement test has been administered to the student teachers who are attending science teaching and chemistry teaching programs of the education faculty and have taken the chemistry course. To evaluate the chemistry achievement test, correct answers and wrong answers have been scored as 1 and 0 respectively. The achievement test has been administered to the student teachers who are attending science teaching and chemistry teaching programs of the education faculty and have taken the chemistry course. To evaluate the chemistry achievement test, correct answers and wrong answers have been scored as 1 and 0 respectively. Item analysis was made with the ITEMAN Windows Version 3.50 statistics software and the chemistry achievement test of 15 items with 0.49 average difficulty values, 0.54 average distinctiveness, and the 0.64 reliability coefficient. The literature points out that the item discrimination index of the test is very high (Ebel, 1972), the test comprises of medium difficulty items according to item difficulty index (Özçelik, 1981), and it is at an acceptable level in terms of reliability (Turgut, 1992).

Scientific Process Skills Test

To determine student teachers' scientific process skills, Scientific Process Skill Test (SPST) developed by Okey, Wise and Burns (1982) was used. The test was adapted by Geban, Aşkar and Özkan (1992) into Turkish. It consists of 36 multiple-choice questions. It involves questions assessing skills to define variables in a problem (12), establish and define hypothesis (8), make operational explanations (6), design required analysis on the solution of problems (3), draw and interpret graphs (7). Reliability coefficient of the test is found to be 0.82. The reliability of the adapted version of the test into Turkish was found to be 0.81. Therefore, the test was interpreted as reliable and it was implemented to both control and treatment groups as pre and posttests. For the evaluation of scientific process skills test, correct and wrong answers have been scored as 1 and 0 respectively.

c) Phases of Experiential Process

The applications in the chemistry laboratory have been carried out by using the experiential learning model for the experimental group and the traditional verification laboratory approach for the control group. Experiential learning model applied in the laboratory in treatment group is organized with well-structured activities appropriate to concrete experience, reflective observation, abstract conceptualization and active experimentation. At the *concrete experience* phase, the study made use of the meaning resolution tables prepared on the acids, bases and titration topic. At the *reflective observation* phase, the study lodged activities such as brainstorming and problem solving relevant to the topic. At the *abstract conceptualization* phase of the study, the teacher presented the topics of acids, bases and titration and ensured the relationship between theory and practice with the help of laboratory studies. At the *active experimentation* phase, students implemented their learnt knowledge on acids, bases and titration into various experiments. Students performed their experiments individually. They were provided with feedback by the teacher throughout the experiments, which enabled students to overcome challenges they faced during their experiments and comprehend the relationship between theory and practice.

Traditional teacher-centered laboratory approach has been employed in the control group, and the student teachers have been formerly given the instructions showing detailed information about the aim of the experiment, how to do it and how to analyze the data. The findings of the experiment have been used to verify the notions, principles and laws which have been known previously.

d) Data Analysis

Difference between the pre and posttest scores obtained from the control and treatment groups have been analyzed. During the data analysis, nonparametric tests were used as the number of sampling was below the advised number in the literature and it did not meet the normality assumptions (Green & Salkind, 2008; Leech, Barret, & Morgan, 2005). In analysis of the data, potential difference between control and treatment groups before and after the application was assessed via the Mann-Whitney U-Test. After the experiential learning and traditional teacher-centered learning, the difference between the pre and posttest scores was analyzed through the Wilcoxon Signed Rank Test.

FINDINGS

Chemistry achievement test score averages of treatment group student teachers trained through experiential learning model and of the control group student teachers who were taught according to the traditional teacher-center method were analyzed through the Mann Whitney U-test. According to the analysis results, there is not a statistically significant difference between the pretest scores of control and treatment groups ($U=189.50$; $p>0.05$). This conclusion shows that there was no significant difference between the knowledge levels of the control and treatment group student teachers before the application.

The difference between the pre and posttest average scores of student teachers was analyzed according to the Wilcoxon Signed Rank Test. Outcome of the test is displayed on Table 1.

Table 1. *Wilcoxon Signed Rank Test Results of Control and Treatment Groups at the Chemistry Achievement Test*

Chemistry Achievement	N	M	S	Z	p
Treatment Group Pretest	20	3.80	1.44	-3.935	0.000
Treatment Group Posttest	20	8.65	1.87		
Control Group Pretest	20	3.60	1.67	-3.630	0.000
Control Group Posttest	20	6.60	1.98		

Table indicates that the average scores of student teachers obtained from the chemistry achievement test increased after the applications (Z: -3.935; Z: -3.630; $p<0.01$). These result shows that the experiential learning model applied to the treatment group and the traditional teacher-centered model applied to the control group were effective on the increase in the chemistry achievements of student teachers.

Average posttest scores of student teachers obtained at the end of the traditional teacher-centered or experiential model applications were analyzed through the Mann Whitney U-test.

Table 2. *Mann Whitney U-Test Results of Treatment and Control Groups regarding their Chemistry Achievement*

Chemistry Achievement	N	Rank Average	Rank Total	U	p
Treatment Group Posttest	20	25.90	518.00	92.000	0.003
Control Group Posttest	20	15.10	302.00		

Table indicates that there is a statistically significant difference between the posttest chemistry achievement scores of the student teachers at the control and treatment groups ($U=92.00$; $p<0.05$). This result shows that the average scores of chemistry achievement posttest results obtained by the student teachers at the treatment group, who were applied the experiential learning model were higher than those of the student teachers at the control group, who received traditional teacher-centered training and this indicated a statistically significant difference favoring the treatment group.

Data obtained from the scientific process skills pretest in the research were analyzed through the Mann Whitney U-test and there was no statistically significant difference found between the averages of students at the control and treatment groups (U=159.50; p>0.05). This result shows that there is not a significant difference between the scientific process skill levels of teachers at the control and treatment groups before the applications.

The average scientific process skill test scores of student teachers at control and treatment groups were analyzed through the Wilcoxon signed rank test. Findings are displayed on Table 3.

Table 3. *Wilcoxon Signed Rank Test Results on Scientific Process Skills of Treatment and Control Groups*

Scientific Process Skills	N	M	Sd	Z	p
Treatment Group Pretest	20	20.35	3.17	-3.323	0.001
Treatment Group Posttest	20	23.75	3.42		
Control Group Pretest	20	19.05	4.36	-1.559	0.119
Control Group Posttest	20	20.05	3.85		

After the applications average scientific process skill scores of student teachers at control and treatment groups were observed to have increased. There is a statistically significant difference found between the pre and posttest results of student teachers at the treatment group (Z:-3.323; p<0.01). It was seen that he increase in the scientific process skills of student teachers in the control group was not statistically significant (Z:-1.559; p>0.05). This conclusion shows that experiential learning model is essentially effective on improving student teachers' scientific process skills, while the traditional teacher-centered teaching, which was applied to the control group, was not effective.

The average scientific process skills pre and posttest scores of student teachers were analyzed through the Mann Whitney U-test.

Table 4. *Mann Whitney U Test Results of Scientific Process Skills at Control and Treatment Groups*

Scientific Process Skills	N	Rank average	Rank total	U	p
Treatment Group Posttest	20	25.75	515.00	95.000	0.004
Control Group Posttest	20	15.25	305.00		

Scientific process skills of student teachers at control and treatment groups were observed to have statistically significant differences in terms of their posttest average scores (U=95.00; p<0.05). This means that experiential learning model administered to student teachers at the treatment group produced higher scientific process skills posttest scores than that of the control group, who received traditional teacher centered education. This indicates a statistically significant difference favoring the treatment group.

The results of the Wilcoxon Signed Rank Test administered to compare the pre and posttest scores of control and treatment groups at the sub dimension of scientific process skills and the results of the Mann-Whitney U-test administered to compare the posttest scores of the control and treatment groups are summarized on Table 5.

Table 5. *Results of Wilcoxon Signed Rank Test and Mann Whitney U-test related to the Scientific Process Skills Sub Dimensions*

Scientific Process Skills	Group	Pretest		Posttest		Wilcoxon signed rank test		Mann Whitney U -Test	
		M	SD	M	SD	Z	p	U	p
Identifying the variables in the problem	1	4.90	1.83	6.05	2.01	-2.21	0.027	171.50	0.435
	2	4.65	2.01	5.55	2.21	-1.75	0.080		
Establishing and defining hypothesis	1	5.80	1.58	6.70	1.23	-2.16	0.031	165.50	0.335
	2	5.45	1.64	6.30	1.34	-2.55	0.011		
Making operational predictions	1	3.95	1.15	4.75	1.29	-2.19	0.028	100.00	0.005
	2	3.10	1.45	3.35	1.63	-0.54	0.588		
Designing required analysis for the solution of the problem	1	2.05	0.83	2.45	0.69	-2.31	0.021	137.00	0.067
	2	1.60	0.82	1.95	0.89	-1.62	0.106		
Drawing and interpreting graphs	1	3.65	0.99	3.80	0.83	-0.60	0.548	187.50	0.690
	2	3.40	0.82	3.75	0.64	-1.43	0.154		

1: Treatment, 2: Control

Table 7 indicates there are significant differences between the pre and posttest average scores of student teachers at the treatment group in terms of identifying variables in the problem, establishing and defining hypothesis, making operational predictions, designing required analysis for the solution of the problem sub dimensions. Significant differences were observed for the control group in the sub dimension of establishing and interpreting hypothesis. Posttest results of control and treatment group in sub dimensions of the control and treatment groups were compared and a statistically significant difference was found between the posttest scores of two groups regarding the making operational predictions sub dimension.

DISCUSSION

This study investigated the effects of teaching through experiential learning theory on academic achievement and scientific process skills. It is concluded that experiential learning is a theory effective on academic achievement and scientific process skills.

At the experiential learning practice implemented in the chemistry laboratory, student teachers participated in discussions and problem solving activities to develop perspectives towards acids and bases. They attained theoretical knowledge through the explanations and summarizations of the course instructor. They implemented the learnt knowledge by doing experiments at the laboratories for the final phase. Experiential learning model consists of concrete experience, reflective observation, abstract conceptualization and active experimentation phases. Generally, concrete experience requires active participation of individuals in the activity, while reflective observation is the period when they are expected to develop various perspectives, abstract conceptualization is the obtaining of theoretical knowledge and the active experimentation is the implementation of the learnt knowledge. Implementation of the learning cycle in the classroom is essential in realization of permanent and effective learning (Bahar & Bilgin, 2003; Svinicki & Dixon, 1987). Concrete experience, reflective observation, abstract conceptualization and active experimentation phases of the experiential model implemented with materials and activities to the student teachers are seen as the reason for the increase observed in their chemistry achievement levels. The findings of the present study is supported by the related research in the literature which reveal the positive effect of experiential learning on academic achievement, meaningful learning and learning outcomes (Kılıç, 2002; Gosen & Washbush, 2004; Gencel, 2006; McCarthy &

McCarthy, 2006; Ives-Dewey, 2009; Clements & Cord, 2013; Ernst, 2013; McLeod, 2013; Konak, Clark & Nasereddin, 2014; Manav & Eceoglu, 2014; Matuso, 2014).

Looking at the effects of experiential learning and traditional teacher-centered learning on chemistry achievement levels of student teachers, it was found that experiential learning was effective. This conclusion of the study is explained at the experiential learning environments as the emergence of dynamic teaching/learning experiences (Carey, 2007). Experiential learning applications expand the course content and improve students' knowledge levels through real life practice while encouraging students to think effectively and come to conclusions using the data obtained through questioning. Teaching strategies that ensure active participation of students with the help of scientific research such as experiential learning improve conceptual learning more when compared to more passive techniques (Ernst, 2013). Moreover, experiential learning enables learners to make connections between the choices and results (Petrocelli, Seta & Seta, 2013). Experiential learning motivates students for active learning while presenting them the opportunity to think over conceptual situations (Ramburuth & Daniel, 2011). It was determined that Kolb's experiential learning model enabled students to shift themselves from considering knowledge as a series of recognized knowledge towards considering it as a tool for questioning themselves as well as making contributions (Groves, Leflay, Smith, Bowd & Barber, 2013). Individual experiences of learners stand out in experiential learning. Therefore, the role of the teacher has changed from the one who transfers the information to the one who facilitates and organizes meaningful experiences based on the individual needs of the learners (Manolis, Burns, Assudani & Chinta, 2013). As a result of the positive effect of experiential learning on achievement and scientific process, students attain conceptual understanding and effective thinking skills, while bringing dynamic practices to the learning environment and creating the expectation in students to question and contribute.

Kolb's experiential learning model is known to be one of the most effective learning models (Duff, 2004). Learning in the experiential learning model is defined as a process emerging through the transformation of knowledge and experiences (Deryakulu, Büyüköztürk & Özçınar, 2009). Traditional teacher-centered learning and experiential learning models both aim to teach new knowledge to the learners. While traditional teacher-centered learning depends on more abstract and classroom-centered techniques, experiential learning aims to involve students actively in concrete experiences (Stavenga de Jong, Wierstra & Hermanussen, 2006). Experiential learning promotes the association of knowledge and creativity at a high level (Ives-Dewey, 2009). The reason for the effect of experiential learning on chemistry achievement is seen as the active participation of students in concrete experiences as well as the combination of knowledge and creativity.

There is evidence that experiential learning improves advanced learning in addition to changing and improving students' thoughts about themselves (Armsby, 2013). Experiential learning led to changes in students' thoughts about themselves and the learning environment. Students agreed that they understood the implementations of concepts in the real world in a better way, that their interest in the topic improved and that they would remember what they learnt from their experiences in the classroom. Students indicated that with the help of the tasks assigned during experiential learning, their self-confidence levels improved (Cornell, Johnson & Schwartz, 2013). Experiential learning model is found to enable students to be aware of their professional identities, question their own actions and note the importance of their suspicions. Students expressed that experiential learning helped them analyze complex situations deeply while playing an important role in their ways of taking responsibilities or displaying reactions (Pallisera, Fullana, Palaudarias & Badosa, 2013). These changes observed in thoughts of students about themselves are believed to improve their scientific process skills.

Experiential learning process is found to improve students' comprehension of knowledge in depth (Groves, Bowd & Smith, 2010). Experiential learning both provides learning opportunities by thinking and internalizing deeply and ensures learning the knowledge in a more meaningful way (Wu, He, Weng & Yang, 2013). Experiential learning also gives the individuals the opportunity of reviewing the meanings of their experiences and questioning their professional contributions and effects in a critical way (Armsby, 2012). Therefore, the problem solving activities and experiments participated by student teachers during the experiential learning practice are seen as the reasons for their scientific process skills, which consist of identifying variables in the problem, establishing and defining hypothesis, making operational predictions, designing required analysis for the solution of the problem along with drawing and interpreting graphs.

The role of the teacher has changed in today's educational life in either experiential learning model or other teaching activities. This research is important as it enables teachers of the future to know modern teaching activities, learn about the types of activities within this model and implement all these experiences in their teaching profession.

CONCLUSION

The most important factor of an education system is the teacher with no doubt. The effective power of teachers on students and educational programs is stronger than other factors. It is important to improve the qualifications of education faculties and the student teachers studying in these faculties. In this respect, this study planned to serve the aim of improving the qualifications of student teachers and it was found that experiential learning practices at the chemistry laboratory were effective on academic achievement and scientific process skills.

Individual experiences are prominent in experiential learning. Therefore, this study is important as it organizes significant experiences for student teachers in terms of their individual requirements, presents them with the opportunity to think deeply, improves their problem solving and decision making skills and encourages them to implement the new ideas as products of their experiences. Additionally, this study is believed to contribute to the literature by attracting the attentions of students' teachers, motivating them, improving their transferrable skills and preparing them for the following stages of learning.

The current study has been conducted with a sample consisting of prospective chemistry teachers. The effect of experiential learning can also be examined with a sample comprising high school students. The applicability of experiential learning to high school chemistry curriculum out of teaching curricula rather than those at the universities can be investigated. The research about the effects of experiential learning can be carried out in other disciplines as well. The impact of experiential learning on other variables can be identified.

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