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Development of self-directed learning readiness with experiential learning model in analytical chemistry laboratory

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Abstract

This paper aims to analyse the effect of quantitative analysis practices in analytical chemistry laboratory designed according to the experiential learning model on the self-directed learning readiness of prospective teachers'. In the research, experiential learning model has four steps that are concrete experience, reflective observation, abstract conceptualisation and active participation. A single group, pre-test post-test experimental design was used. The study group consists of 14 prospective chemistry teachers'. The self-directed learning readiness scale and focus group interviews were used as a data collection tool. After the application increase, the level of self-directed learning readiness. Difference between pre-test and post-test scores of the study group was significant. When the sub-scales of the scale examined, there was a meaningful difference in the 'willingness to learn and self-control' sub- scales. In the focus group interviews, the prospective teachers' emphasised that experiential learning provided an understanding of the purpose of quantitative applications of analytical chemistry.

Keywords: Self-directed learning readiness, experiential learning model, analytical chemistry laboratory.

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1. Introduction

The proliferation of information and the fact that the existing information become out of date in a short time necessitates self-directed learning (Levett-Jones, 2005). Self-directed learning is considered as a pre-requisite for lifelong learning (Greveson & Spencer, 2005). Giving opportunity to an individual to control of his or her own learning process, take primary action in this process and evaluate his or her own learning in the end is defined as self-directed learning (Knowles, 1975; Radosavlevikj, 2017). Self-directed learning is an approach that includes the educational features that the learners take responsibility for learning, and decides what, how, where and when the student learns (Guglielmino, 2008). In self-directed learning, learning responsibility shifts from a source like a teacher to the individual. Here, the learner both controls and actively participates in the learning process (Boyer & Usinger, 2015). The learning steps exhibited by an individual with self-directed learning skills are as follows: learning objectives are expressed clearly, learning materials are determined, appropriate learning strategy is selected and implemented and learning outcomes are evaluated (Merriam & Caffarella, 1991). These learning steps are similar to the experiential learning steps of Kolb. Experiential learning is considered as an effective way of educational approach. The reason for this is the impact of experiential learning on the development of learners' skills, enhancing the skills through the implementation of the knowledge to the real situations and giving the learners the ability of self-directed learning (Kolb & Kolb, 2006). In experiential learning model, Kolb focuses on experiential learning process rather than routine learning characteristics (Turesky & Gallagher, 2011). Experiential learning-based education requires activities planned appropriate to all learning ways.

As learners are presented with preferences in the environments where self-directed learning principles are executed, they also gain trust, motivation and lifelong learning skills. Individuals with self-directed learning skills are self-confident individuals. This self-confidence that individuals have stems from undertaking the responsibility of their learning. One of the places in which individuals decide what they will learn, do a research accordingly, distinguish the information needed and use it is laboratories. Laboratory environments are places where practice activities are carried out for students to learn, keep information in mind and use scientific information. Especially, it is impossible to learn abstract sciences like chemistry without performing an experiment. By applying experiential learning model in chemistry laboratory, the self-directed learning readiness of prospective teachers' can be improved. This paper aims to analyse the effect of quantitative analysis practices in analytical chemistry laboratory designed according to the experiential learning model on the self-directed learning readiness of prospective teachers'.

2. Method

A single group, pre-test post-test experimental design was used in the study. The study group consists of 14 prospective chemistry teachers' who are undergraduate students at a University. The self-directed learning readiness scale was used as a data collection tool. Scale was developed by Fisher, King and Tague (2001), and it was adapted to Turkish by Kocaman, Dicle, Ustun and Cimen (2004). The self-directed learning readiness scale consists of 40 items in five-point Likert type and three sub-scales: self-management, willingness to learn and self-control. The Cronbach Alpha reliability coefficient of the whole scale is 0.92 and for the sub-scales are 0.86, 0.85 and 0.83. The Cronbach Alpha reliability coefficient obtained from the sample data's is 0.95, for sub-scales 0.86, 0.88 and 0.90. After the application, focus group interviews were conducted with study group. The data obtained from the focus group interview was used to investigate deeply of the research results.

2.1. Experiential learning steps

The experimental learning model conducted in the laboratory was structured according to the learning process cycle of Kolb (1984). Learning process cycle consisting of four steps that are concrete experience, reflective observation, abstract conceptualisation and active participation. In the concrete experience phase of the research, the experiments of neutralisation titrations, precipitation titrations and oxidation titrations have been conducted. In the reflective observation step, discussions have been made relating to neutralisation, precipitation and redox titrations and result oriented calculations have been made out of the experiment data. In the abstract conceptualisation, problem-solving activities towards topics have been carried out by the course instructor, and it has been ensured that the contact of the data obtained from practical applications, that is experiments, with theoretical information has been made with brainstorming. In the active experience stage, students have been enabled to perform experiments with chemicals they use in the daily life. As an alternative addition to experiments of neutralisation titrations, acid quantitation in lemon sauce, vinegar and fruit juice, and as an alternative addition to experiments of precipitation titration, iodine quantitation in table salt, as an alternative addition to experiments of redox titration, Ca quantitation in calcium tablet and Ca assessment on eggshell have been performed here.

3. Results

3.1. Quantitative findings

Analysis of the data obtained from the study was performed with the SPSS 17 packet programme. In the study, data obtained from study group was analysed in terms of the difference between pre-test and post-test scores. In analysing the data, non-parametric tests were used since sampling numbers were below the recommended values. The difference between pre-test and post-test scores for the whole scale and sub-scales were examined by Wilcoxon signed rank test. Descriptive statistics related to pre-test scores of prospective teachers' self-directed learning readiness level before experiential learning in chemistry laboratory application are summarised in Table 1.

Table 1. Descriptive statistics of pre-test data

	N	Mean	SD	Min	Max
Self-directed learning readiness	14	3.98	0.66	40	200
Self-management	14	3.84	0.62	13	65
Willingness to learn	14	3.99	0.73	12	60
Self-control	14	4.09	0.71	15	75

When Table 1 is examined, it has seen that the prospective teachers' self-directed learning readiness levels is high level (X: 3.91). When the sub-scales of the self-directed learning readiness scale are examined, it is noteworthy that the highest scores are in the data collection.

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

Table 2. Descriptive statistics of post-test data

	N	Mean	SD
Self-directed learning readiness	14	4.35	0.33
Self-management	14	4.23	0.42
Willingness to learn	14	4.36	0.43
Self-control	14	4.46	0.26

When Table 2 is examined, it is noteworthy that the increase of prospective teachers’ self-directed learning readiness.

The difference between pre-test and post-test scores of prospective teachers self-directed learning readiness level was examined by Wilcoxon signed rank test, and the results are seen in Table 3.

Table 3. Wilcoxon signed rank test results of self-directed learning readiness

Self-directed learning readiness	*N*	Mean rank	Sum of ranks	*Z*	*p*
Pre-test	14	2.25	4.50	−3.016	.003*
Post-test	14	8.38	100.50		

According to Table 3, it has seen that there is a statistically significant difference between pre-post test scores of the scale ($Z = -3.016$, $p < 0.05$). The analysis of the sub-scales of the self-directed learning readiness is given in the Table 4.

Table 4. Sub-scales analyses of self-directed learning readiness

Self-directed learning readiness		Mean rank	Sum of ranks	*Z*	*p*
Self-management	Pre-test	5.50	22.00	−1.916	.055
	Post-test	8.30	83.00		
Willingness to learn	Pre-test	3.50	3.50	−2.948	.003*
	Post-test	7.29	87.50		
Self-control	Pre-test	3.50	7.00	−2.692	.007*
	Post-test	7.64	84.00		

When Table 4 is examined, it has seen that there is a statistically significant difference between pre-post test scores of willingness to learn and self-control sub-scales of self-directed learning readiness scale ($Z = -2.948$, $Z = -2.692$, $p < 0.05$), but in self-management sub-scale there is no statistically significant difference between pre-post test scores ($Z = -1.916$, $p > 0.05$).

3.2. Qualitative findings

In the qualitative dimension of the research, focus group interviews were conducted with prospective teachers'. In focus group interviews, 14 prospective teachers' were asked whether experiential learning was effective understanding the purpose of quantitative applications of analytical chemistry and whether it affected self-directed learning readiness in laboratory. Audio video recording was used in interviews with prospective teachers' about experiential learning in quantitative applications of analytical chemistry laboratory. After evaluating the data obtained from the research, it was determined that the opinions of prospective teachers' about experiential learning in chemistry laboratory applications were gathered in different categories.

According to the findings obtained from interviews with prospective teachers', it was determined that the expressions were gathered under the codes of the experiential learning and self-directed learning readiness. The codes and the prospective teachers' who gave their opinions are summarised in Table 5.

Table 5. Qualitative findings related to experiential learning

	Codes	Prospective teachers' (PT)
Code 1	Benefits of chemistry laboratory	PT2, PT3, PT5, PT6, PT8, PT10, PT12, PT13, PT14
Code 2	Difficulty in chemistry laboratory	PT1, PT4, PT7, PT9, PT11

Sample expressions of the benefits of chemistry laboratory codes are given below.

PT 2: ….I think the analytical chemistry laboratory is a difficult lesson. The alternative experiments on these courses gave me a better understanding of quantitative analytical chemistry relating to neutralisation, precipitation and redox titrations……

PT 8: ….it is impossible to understand this course only with the experiments in the data sheet. We learned the subjects better with the experiments we followed the steps…..

PT 14: ….I think it was very useful to do the experiments twice in the lesson. In this way, both our experimental performance improved and we repeated the subjects…..

Sample expressions related to difficulty in chemistry laboratory codes are given below.

PT 4: …I learned that analytical chemistry laboratory course is a very tiring course. We have experimented continuously throughout the semester. I did not like this experience….

PT 9: ….I think the alternative experiments made the quantitative analytical chemistry boring and difficult……

PT 11: … I had a hard time with calculations, there must be an easier way….

The codes and the prospective teachers' who gave their opinions related to self-directed learning are summarised in Table 6.

Table 6. Qualitative findings related to self-directed learning readiness

	Codes	Prospective teachers' (PT)
Code 1	Self-management	PT2, PT3, PT6, PT9, PT11, PT13
Code 2	Willingness to learn	PT4, PT7, PT8, PT14,
Code 3	Self-control	PT1, PT5, PT10, PT12,

Sample sentences related to self-management, willingness to learn and self-control codes are given below.

PT 3: ….I was not very successful in the experiments I followed on the experiments in the data sheet, but alternative experiments taught me how to work in analytical chemistry laboratory….

PT 11: …. the alternative experiments that I followed the steps made me realise what I could do….

PT 7: …. these alternative experiments improved my desire to work in the analytical laboratory…..

PT 14: …When I understood the subject, it was more fun to work in the laboratory……

PT 1: … when you are doing an alternative experiment on a subject, you remember not to make the mistakes you made in the first experiment…

PT 5: ...this laboratory work made me realise what I can and cannot do in the analytical laboratory, so I realised my capacity…..

The self-directed learning code supports the sub-scales of self-directed learning readiness scale.

4. Discussion and conclusion

High school or university students' have to learn a lot of informations about analytical chemistry. But in the laboratory during analysing process the problem of students' is that they cannot establish a relationship between theoretical knowledge and practical application. The main objective in analytical chemistry should be to teach how to obtain the correct analytical data. For this purpose the analytical chemistry curriculum is considered to be discussed in detail at each educational level (Arikawa, 2001). Quantitative chemical analysis studies for students should be handled with both lectures and experimental studies conducted in the laboratory. In analytical chemistry course the issue of qualitative and quantitative analysis, cation–anion analysis, neutralisation titrations, precipitation titrations and oxidation titrations have conduct. The theoretical part of the course provides information to facilitate the learning process and experimental laboratory work. In this way, the complexities to be experienced during the experiment are minimised. These operations cannot be carried out step by step a guided or texts in which the experimental instructions are written. Instead of this interactive steps need to be followed (Guerrero, Jaramillo & Meneses, 2016).

This paper aims to analyse the effect of quantitative analysis practices in analytical chemistry laboratory designed according to experiential learning model on the self-directed learning readiness of prospective teachers'. The study results indicate that the experiential learning model in quantitative analysis practices in analytical chemistry laboratory is an effective method in order to improve self-directed learning readiness. When the literature is examined, it is in line with the result that self-directed learning readiness can be improved with practical activities (Ayan, 2010; Alkan & Erdem, 2013; Alkan & Kocak-Altundag, 2018; Kek & Huijser, 2011; Kocaman, Dicle & Ugur, 2009; Litzinger, Wise & Lee, 2005; Shokar, Shokar, Romeo & Bulik, 2002). Before laboratory application is the self-directed learning readiness level of prospective chemistry teachers' medium level. This finding is supported by other studies (Kirilmazkaya, 2018; Örs, 2018).

The research studies on science learning and teaching has shown that the concepts forming a subject should be given by establishing a relational structure with other concepts. Therefore, the curriculum should be arranged in such a way as to increase the conceptual change between the concepts (Horton, 2007). Students have difficulties to write correct equation for decomposition reaction, to relate what they have learnt in the course and experimental procedures (Onwu & Randall, 2006) and to understand quantitative and qualitative analyses of analytical chemistry (Gunter, Kılınc Alpat & Ozbayrak Azman, 2019). It is not only sufficient for students to understand chemistry concepts, symbols, terminologies and theories in learning chemistry, but they also to represent the instructional language or material teachers used in chemistry in a meaningful way (Chiu, 2005). Teachers should provide meaningful explanations to students, and do something to change students' misconceptions and representations (Adesoji & Omilani, 2012).

Laboratories should be no longer the cookbook type laboratories followed by the data sheets. Instead of this, laboratories should be designed as places where real-world problems are discussed or practiced (Hicks & Bevsek, 2012). Integration of daily life practices into chemistry teaching enables students to better understand and increases student chemistry achievement (Altundag, 2018). Research shows that experiential learning is an alternative way of acquiring knowledge, developing skills, and making learning permanent through practical applications. Well-organised learning activities will teach students the skills to apply knowledge into practice, create positive learning motivation, and increase student interest in learning. The example of experiential learning in teaching science will bring high effectiveness to the development of student's abilities (Giac, Gai & Hoi, 2017). In addition, laboratory practices such as experiential learning, which will be given responsibility to the students, are required. Therefore, every student has a responsibility in obtaining information (Alkan, 2016). The learning environment should be arranged in such a way that learners take responsibility (Rusmansyah, Yuanita, Ibrahim, Isnawati & Prahani, 2019) and activities towards the development of creativity in the applied courses also increase the awareness of responsibility (Suyidno, Nur, Yuanita, Prahani & Jatmiko, 2018). The applications carried out in the laboratory improve the readiness of the students. For this purpose laboratory activities should consist of detailed steps. This makes it easier to understand the purpose of the laboratory. Moreover, more than one activity-experiment should be performed in laboratory in order to enable students to better understand the work carried out (Elzagheid, 2018). When students learned chemistry with practical applications, only a few of them showed that they could establish a relationship between experimental results and theoretical knowledge (Chandrasegaran, Treague & Mocerno, 2007). In order to provide a better understanding of the concepts of chemistry and to eliminate the complexity of the concepts, more activities should be included. In this respect, it is supported that the use of experiential learning model in analytical chemistry laboratory is an effective method and these finding is supported by the literature.

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