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

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2016

Volume 4, Pages 564-567

ICEMST 2016: International Conference on Education in Mathematics, Science & Technology

AN INVESTIGATION OF UNIVERSTY CHEMISTRY STUDENTS' UNDERSTANDING OF PRECIPITATION TITRATIONS AND RELATED CONCEPTS THOROUGH VEE-DIAGRAMS

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ABSTRACT: In this study, second-year chemistry students' understanding of essential concepts related to precipitation titration was investigated by using Vee-diagrams which are completed during the analytical laboratory course. Three Vee-diagrams concerning three argentometric titration methods were constructed prior to the laboratory study by taking into laboratory manual by the researchers. Vee- diagrams delivered to the students after completing each experiment one by one in the laboratory. Sixteen analytic chemistry students from two faculties participated in the study. It was found that the students were insufficient to define some concepts such as argentometry, precipitation, back titration and indicator. It was also concluded that the students had the calculation difficulties, especially for the back titration.

Keywords: Precipitation titrations, vee-diagram, analytical chemistry laboratory, university students

INTRODUCTION

Laboratory work is one of the fundamental components of undergraduate chemistry courses. If the experiments are conducted in a meaningful way, the laboratory study can provide students with opportunities to engage in a process of constructing knowledge. The Vee-diagram was developed by Gowin to enable students to understand the structure of knowledge and the process of knowledge construction (Novak & Gowin, 1984). The conceptual side of Vee diagram includes philosophy, theory, principles/conceptual systems, and concepts all of which are related to each other and to the topic which is studied in the experiment. Thus, it can provide to explore students' knowledge structure and be used as an assessment tool at the same time. V-diagrams were also used an easement tool by several researchers to gain information about students' understanding of a special topic (Ault, Novak ve Gowin, 1984; Passmore, 1998; Nakiboğlu, Benlikaya ve Kalın, 2002; Nakiboğlu ve Arık, 2005; Nakiboğlu ve Erdem, 2009).

Titrations are the one of the essential topics in all level chemistry classes from high school to general chemistry courses. It was also taught in analytical courses again. Application of volumetric titrimetry contains acid-base titrations, which an acidic or basic titrant reacts with a titrand that is a base or an acid; complexometric titrations based on metal–ligand complexation; redox titrations, in which the titrant is an oxidizing or reducing agent; and precipitation titrations, in which the titrand and titrant form a precipitate (Harvey, 2000). Precipitation titrations are an important part of analytical chemistry classes and common experiments carried out by students in analytical chemistry laboratories. The fundamentals of precipitation titrations are generally explained by selecting argentometry which is a volumetric titrimetry technique used known amount of silver nitrate solution as a titrant or reagent. Mohr, Fajans and Volhard methods are three common argentometric methods.

Although there are limited number studies about students' understanding of acid-base titrations in the literature, it has not been encountered with a detailed study about students' understanding level of precipitation titrations. Therefore, it was aimed to investigate the second-year chemistry students' understanding of essential concepts related to precipitation titration by using Vee-diagrams in this study.

- Selection and peer-review under responsibility of the Organizing Committee of the conference

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METHODS

In this qualitative study, students' understanding of essential concepts related to precipitation titration was investigated by using Vee-diagrams which are completed during the analytical laboratory course.

Participants

Participants in the present study were drawn from two faculties of Balikesir University in Turkey: the Science and Art Faculty, which has 4 year chemistry program, and the Education Faculty, which has pre-service chemistry teacher training program. A total of 16 analytic chemistry students from two faculties participated in the study. While 7 of students (5 female and 2 male, and assigned as C) come from the Science and Art Faculty, 9 of students (6 female and 3 male, and assigned as CE) attend to the Education Faculty. Subjects ranged in ages between 19-22 years. All of the participants studied General chemistry courses1 and 2 in their first year at university.

Instruments

In order to determine students' understanding levels about concepts of precipitation titration, three V-diagrams were used. The Vee-diagrams concerning three argentometric titration methods were constructed prior to the laboratory study by taking into laboratory manual by the researchers. Vee- diagrams delivered to the students after completing each experiment one by one in the laboratory.

Analysis of Data

In analyzing the V-diagrams, a concept-evaluation scheme developed in previous research was used (Abraham et al., 1994; Nakiboğlu, 2003). The students' responses can be separated into different levels of understanding and misconceptions can analyze into different patterns (Nakiboğlu, 2003). The concept-evaluation scheme used in this study is comprised of five categories: Sound understanding (SU), Partial understanding (PU), No understanding (NU), Misconception (MC), No answer (NA).

RESULTS and FINDINGS

Students' Understanding Levels about fundamental concepts of precipitation titration

The primary goal of the conceptual side of vee diagrams was to find out the patterns of students' understandings and misconceptions of the the fundamental concepts concerning precipitation titration such as *precipitation, precipitation titration, argentometry, back titration and adsorption*. These concepts are the most important concepts to comprehend the precipitation titrations meaningfully. The data about students' understanding levels about the fundamental concepts of precipitation titration are presented in Table 1 according to the degree of understanding.

Table 1. Degree of Students' Understanding about fundamental concepts of precipitation titration

Degree of understanding	Precipitation	Precipitation Titration	Argentometry	Back Titration	Adsorption
SU			CE3,CE10, CE11, C1,C4,C7 (f=6) %35,3	CE7,CE12, C1,C2 (f=5) %31,3	CE3,CE12, C2, C7 (f=5) %31,3
PU	CE3,CE5,CE6,CE7,CE9,CE10,CE11, C1,C3, C4,C7 (f=11) %68,8	CE2,CE3,CE6, CE7,CE10, CE11, CE12, C1, C3, C4, C6, C7 (f=12) %75	CE2,CE6,CE7, CE12, C2,C6 (f=6) %35.3	CE2,CE3,CE5 CE6 (f=4) %25	CE2,CE6, CE11,C1 (f=4) %25
NU		CE1, CE5, CE9, C2, C5 (f=5) %31,3	CE1, CE5, CE9, C3 (f=4) %25	CE1, CE9, CE10,CE11, C3, C6, C7 (f=7) %43,8	CE1,CE5, CE9,CE10,C3 (f=5) %31,3
MC	CE1, CE2, CE12, C5, C6 (f=5) %31,3	-	-	-	C4,C5,C6 (f=3) %18,8

According to Table 1, none of students showed a SU for the *precipitation* and the *precipitation titration* concepts. 11 of students showed a PU. 5 of students had misconceptions about precipitation and two

misconception statements were identified. One of them is concerning "thinking the precipitation as saturated/excess saturated solution" and one example expression about this thought is:

"Precipitation is addition excess amount of substance to a solvent that it can be solve (CE2)"
Secondly it was found that students associated the precipitation with concentration and one example expression about this thought is:

"Precipitation occurs when the concentrations of two liquids increase in to one another (C5)"

Although there were not identified any misconception concerning the *precipitation titration*, 5 of students showed the NU. One of the students (C5) suggested that *the precipitation titration was general name of the substances which are determined.* While none of students had misconception about concepts of *back titration* and *argentometry*, it was seen that 3 of the students had misconceptions about the concept of *adsorption* that these misconceptions based on students' confusion adsorption with absorption.

Students' Understanding Levels about procedural knowledge of precipitation titration

Another goal of the conceptual side of vee diagrams was to explore the students' understandings and misconceptions of the procedural knowledge concerning precipitation titration. For this purpose three questions were asked to students. They were a) Which specifications are needed to use a precipitation reaction in volumetric analysis? b) Are there any pH limitations in Mohr method? If there are, please explain. c) What are the general working principles of indicators used in volumetric analysis? The data about students' understanding concerning the procedural knowledge about precipitation titration that obtained from anaysis of three questions were given in Table 2.

Table 2. Degree of Students' Understanding about Procedural Knowledge of Precipitation Titration

Degree of Understanding	Specifications used for precipitation reaction in volumetric analysis	pH limitations in Mohr method	Working principles of indicators
SU	-	CE2, CE6, CE7 (f=3) %18,8	CE9, CE10 (f=2) %12,5
PU	CE2, CE3, CE6, CE7, C7 (f=5) %31,3	CE10, CE11 (f=2) %12,5	CE2, CE3, CE6, CE11, CE12, C1, C2, C4, C6, C7 (f=10) %62,5
NU	CE1, CE5, CE9, CE10, CE11, CE12, C5 (f=7) %43,8	CE1, CE3, CE5, CE9, CE12, C2, C3, C6 (f=8) %50	CE1, CE5, C3, C5 (f=4) %25
MC	-	-	
NA	CE4, C1, C2, C3, C4, C6 (f=6) %37,5	C1, C4, C5, C7 (f=4) %25	-

According to Table 2, none of students showed a SU about specifications used for precipitation reaction in volumetric analysis**,** but degree of students' understanding about pH limitations in Mohr method and working principles of indicators are very low. %62.5 of the students showed a PU about working principles of indicators.

Any misconception about procedural knowledge of precipitation titration was not determined for all of the students, while a NA in 6 of the students about specifications used for precipitation reaction in volumetric analysis for and in 4 of the students about pH limitations in Mohr method was observed.

Students' Understanding Levels about calculation skills concerning precipitation titration

The experimental side of Vee diagram includes *data recording* part that the students record data during the experiment and transform them to a table, graph or make calculation by using chemical equation in the *data transforming* part. It can be obtained students' understanding levels about calculation skills from the analysis of the *data transforming* part of Vee diagram. The development of students' calculation skills is the fundamental for participation titrations. In this study, since three V-diagrams for each argentometric methods that is Mohr, Fajans and Volhard methods were used, the data obtained from the *data transforming* parts of Vee diagrams. The findings about these analyses were presented in Table 3.

Table 3. Degree of Students' Understanding about Calculation Skills Concerning Precipitation Titration

Degree of Understanding	Mohr Method	Fajans Method	Volhard Method
SU	CE1, CE2, CE5, CE6, CE7,CE12 **f=6 %35,3**	CE6, C7 **f=2 %11.8**	-
PU	CE11, C1, C2, C6, C7 **f=5 %29.43**	CE1, CE2, CE3, CE5, CE12, C2, C4, C5, C6 **f=9 %52.9**	C1, C2, C6, C7 **f=4 %23.55**
NU	CE3, C4, C5 **f=3 %17.6**	CE9, CE10, CE11, C1 **f=4 %23.5**	CE1, CE2, CE3, CE5, CE6, CE7, CE9, CE11, CE12, C4, C5 **f=11 %64.7**
MC	CE9, CE10, C3 **f=3 %17.6**	CE7, C3 **f=2 %11.8**	CE10, C3 **f=2 %11.8**

According to Table 3, while none of students showed a SU about calculation skills in Volhard method, 6 of students had SU level of calculation skills in Mohr Method and also 2 of the students showed a SU about calculation skills in Fajans Method.

CONCLUSION

In this study, the students' understanding levels about participation reactions, fundamental concepts and procedural knowledge about participation reaction, and calculation skills of students were investigated by using Vee-diagrams. It was concluded that the degree of the students' understandings of precipitation and precipitation titration concepts were on a level with partial understanding and students had the misconception about precipitation. Another conclusion is about students' calculation skills. Some of the students have gained skills about calculation in SU and PU levels, while none of the students have understood the calculations about back titration in Volhard method.

RECOMMENDATIONS

Recommendations can be divided into two groups. One of them is about learning and teaching precipitation and precipitation titrations and the calculation skills. The teachers should gain information about their students' prior knowledge and pre-requisite knowledge about precipitation and precipitation titration and related concepts concerning them before the laboratory instruction. Besides students' calculation skills and if they construct stoichiometric relationships should be reconsidered before instruction. If they have deficiency about them, these deficiencies should be eliminated. The second recommendation is about usage Vee diagrams in analytical chemistry laboratory as an assessment tool. In this study, the Vee diagrams were applied successfully in assessing both students' conceptual and procedural understandings, and also calculation skills. So, it can be suggested that Vee diagrams are used in analytical chemistry laboratories as an assessment tool and for different purposes.

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