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A study of determination of pre-service chemistry teachers’ understanding about acids and bases

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Abstract

It is very important that determining students cognitive structures for acquiring meaningful learning. The main purpose of this study is to determine pre-service chemistry teachers’ cognitive structures relating to acid-base with word associations test (WAT). The sample of study consisted of 56 pre-service chemistry teachers who have been studying in chemistry education department at Dokuz Eylül University, in Turkey. At the end of study, it was found that WAT clearly distinguished between first and third year students. Moreover, this result was supported by the findings that the third year students generally produced more associations than first year students and third year students’ responses were more homogeneous. Also, forming of associations like acid PH, bases-hydroxyl, showed that pre-service teachers accomplish meaningful associations about the basic concepts of acid-base.

Keywords: Acids-bases, cognitive structure, word associations test

1. Introduction

Learners bring to lessons some prior knowledge which influence how learners learn new scientific knowledge and play an important role in subsequent learning. Particularly, through the impact of constructivist learning approach, researches on exploring learners’ prior knowledge have become great important. Because, according to this approach, learners built new knowledge by correlating them with existing knowledge [1]. In this way, every learner actively constructs their own knowledge [2; 3]. For this reason, investigating students’ cognitive structures, including their prior knowledge and experiences, is extremely important to asses what learners know about a domain of knowledge [4]. In summary, if teachers or researchers have evidence of a learners’ cognitive structure, appropriate teaching methods could be used to help students connect past experiences and new information [5]. Also, teachers through probing learners’ cognitive structure could determine what students learned in the learning process [3]. Teachers could examine their teaching methods and select suitable methods or materials to support the learning according to results of assessment.

Additionally, an analysis of a learner cognitive structure is important for conceptual changes and development. Because, both learners’ misconceptions and connections between concepts are revealed in this process [6]. Consequently, exploring learners’ cognitive structures is more effective on determining prior knowledge,
assessment of learning process and identifying conceptual changes.

In addition to exploring learners’ cognitive structures, another point is considered how measurements in identifying cognitive structure can be more objective, more reliable and more effective [7]. There are many methods that have been used to determine students’ cognitive structure such as free word association, controlled word association, tree construction, concept map and flow map [3; 8]. However, researchers mostly have used word association tests (WAT) within these methods to explore learners’ cognitive structures for many years [9; 10; 11; 12; 13]. Researches have shown that WAT is a powerful technique to reveal concepts in learners’ mind and connections between them [14; 15]. On the other hand, the use of WAT in chemistry education is not widespread unlike other science fields.

It is known that chemistry is one of the most difficult subjects in secondary schools. Because, many students have difficulties in understanding of fundamental chemical concepts [16; 17]. As many basic concepts of chemistry are abstract, these concepts are constructed in students’ minds in different way. There are many studies specifically investigating students’ understanding of several chemical concepts such as mole concept, atom, molecule, chemical equilibrium, chemical bonding, phase changing, acid-bases [18; 19; 20; 21]. Particularly, in these studies, it is found that students at different ages have similar misconceptions about acid-bases. On the other hand, researches on students’ cognitive structures are limited in the literature [16; 22].

In this research, it was aimed to determine chemistry pre-service teachers’ cognitive structures relating to acid-bases with word associations test (WAT). To be able to reach this aim, these research questions are addressed:

- Is there any meaningful relationship between the basic concepts related to acid-bases which students store in long term memory?
- Are there any differences in terms of associating concepts between first and third year students in chemistry education department?

2. Method

2.1. Sample

The sample of the study consisted of 56 chemistry pre-service teachers who have been studying in chemistry education department at Dokuz Eylul University, in Turkey. The distribution of class level of the sample was as follows; first year students (N =28) and third year students (N =28).

2.2. Instrument

In this study, Word Association Test (WAT) was used as a measuring tool. To conduct the WAT, ten keywords considered as cornerstones of the conceptual framework of acid-bases were selected by researchers. These keywords were: acid, base, PH, POH, neutralization, buffer, indicator, titration, electrolyte and hydrolysis. Each key word was placed at the top of the page and ten times down the side of the page. Students were asked to list the first 10 words that came to their mind for each key word in 30 seconds. The researchers controlled the time allocated for each key word and students were told that they passed the other key word after the filling 30 seconds-period for each key word. On average, respondents needed approximately 5 minutes to complete the WAT. To define the content of the WAT, expert judgment was provided by three chemistry educator in the universities and also secondary school chemistry curriculum was analyzed by researchers.

2.3. Data Analysis

In the data analysis, the answers given for the key concepts were analyzed in detail in order to evaluate whether the answers were meaningful or acceptable in terms of acids-bases or not. A frequency table showing the frequencies of the usage of the words and concepts was prepared. Based on this frequency table, concept maps were
created. While mind maps were formed, firstly the highest frequency in the table was determined. The highest frequency interval as cut-off point was taken \( f > 20 \) in the first cell of the mind maps. Then cut-off point was lowered step by step until all stimulus words appeared on the map [8].

3. Findings and Discussion

The first research question was aimed to determine that whether there was any meaningful relationship between the basic concepts related to acid-bases in the students’ cognitive structures. For this reason, mind maps of all groups were drawn by using frequency tables according to results of WAT. Figure 1 and 2 shows the WAT maps of the first and third year students in chemistry education department respectively. It is seen from Figure 1 and 2 that both first year and third year students accomplish meaningful associations about the basic concepts of acid-bases such as acid- PH, bases-hydroxyl, titration-indicator, neutralization-acid-base, hydrolysis-water, indicator- phenolphthalein, electrolyte- conductivity.

The second research question was aimed at discovering whether or not any differences in terms of associating concepts between first and third year students. As seen from Figure 1 and 2, in spite of the similarities between first and third year students regarding responses words associations with the key words, the main differences could be clearly seen in the maps. For example, while response words “burn”, “sour” and “strong” for the acids were given in the first years students at the cut-off point 10-14, these response words did not appear in the third year students.

![Figure 1. The first year students' WAT maps at the cut off point 10-14](image-url)
These connections show that first year students mostly link stimulus word “acid” through daily life concepts. On the other hand, especially in the third year students, the presence of response words such as Lewis, Hydronium and HCl, to key word acid is very important since they indicated meaningful learning in the existing cognitive structure. Also, it was determined that first year students formed more associations between key words than third year students. Particularly, although WAT maps, the key word “titration” are linked to “analyte, titrant and color changes” in the first year students, these associations are not formed in the third years. One of the possible explanations behind this result might also be related to experiments which were done by the first year students in the chemistry laboratory mostly consisted of titration experiments. Generally, it was found that third year students linked less the number of response words with the key words. It may be said that the reason of this is being attended analytical chemistry and laboratory in the second year at university.

4. Conclusion

At the end of the study, it was found that WAT clearly distinguished between first and third year students. Moreover, this result was supported by the findings that the first year students generally produced more associations than first year students and first year students’ responses were more homogeneous. Also, forming of associations like acid- PH, bases-hydroxyl, showed that pre-service teachers accomplish meaningful associations about the basic concepts of acid-bases. In the light of these result, it can be said that WAT can be used both to determine learners’ prior knowledge, to reveal associations in learners’ cognitive structures and to identify learners’ weakness and strengths in a content area [8].

Acknowledgements

A small part of the main study is given in this report because of the five pages limit.
References