An analysis of analogies used in secondary chemistry textbooks

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Abstract

Analogies have been an important part of chemistry education for many years. Especially, analogies have been used to teach abstract concepts like chemical equilibrium, nature of matter and chemical bonding. Accordingly, analogies play a central role in supporting the understanding of complex concepts and topics. One of the main sources of analogies is textbooks. The purpose of this study is to examine analogies found in the 9th and 10th grades chemistry textbooks. As a result of this study, it was found that the use of the analogies were limited in both 9th and 10th grades chemistry textbooks. Also, it was determined that these analogies were very simple.

Keywords: Analogy; Chemistry Education; Textbook

1. Introduction

Nowadays, one of the problems encountered in science and chemistry education is that students could not relate between basic concepts. One effective way to deal with this problem is to provide a bridge between new concepts and knowledge what the students already know brackets [1; 2]. This bridge could be provided by analogies.

The use of analogies to support the learning process is not new in chemistry education. One of the first studies about the use of analogies was conducted by Lewis. According to Lewis [3], analogies could be used to teach abstract concepts like chemical equilibrium and nature of the matter. Because, most of freshmen could not understand properly nature of the matter with traditional presentation. In order to learn chemistry, many times students have to understand abstract concepts [4]. To assist in the explaining of abstract chemical concepts, teachers frequently have used analogies as teaching tools. An analogy could be defined as an explicit comparison between two fields: one unknown and the other familiar to the individual [5; 6]. While unknown field is identified as target or object, familiar field is named as analog, base or source. The main purpose is to compare target with analog and become easier understanding of target as analog is familiar for the individual.
Studies have shown that the use of the analogies correctly in learning process has some advantages on students’ learning [7]. Some of them are below:

- Analogies motivate students to learn by provoking their interest.
- Analogies help students construct their own knowledge.
- Analogies provide visualization of the abstract concepts.
- Analogies help students compare similarities of students’ real world and new concepts.

In the literature, analogies have been classified different types [1; 8; 9]. These are:

- Verbal and pictorial analogies.
- Structural, functional and structural-functional analogies which represent analogical relationship between analog and target.
- Pre-organizer, buried-activator and last synthesizer analogies which represent the place of analogies in the learning process.
- Simple, widened and expanded analogies which represent wideness of analogy.

Though analogies mainly are used by teachers to help students achieve conceptual understanding, another source which includes analogies is textbooks. In many countries like Turkey, textbooks are the central tools in the learning process. According to Chiappetta, Ganesh, Lee & Philips [10], more than %90 of secondary school teachers use textbooks to organize and deliver instruction. Consequently, it is important that analyzing the textbooks which involve analogies used by teachers and students.

In Turkey, high school chemistry curriculum was modified in 2008-2009 academic year. As a result of this, chemistry textbooks based on constructivist approach were prepared by ministry of national education. However, according to our informal talk with chemistry teachers, it was emerged that they were not satisfied with analogies in the chemistry textbooks. For this reason, it has been thought that analyzing chemistry textbooks will be beneficial for textbooks authors and programmers.

In this research, it was aimed to investigate analogies found in the 9th and 10th the grades chemistry textbooks. Depending of this aim, these research problems are addressed:

- What types of analogies are frequently used?
- Are analogies used more frequently for particular content areas or at different stages of chemistry textbooks?

2. Method

In this study, descriptive method was used. 9th and 10th grades chemistry textbooks (2 textbooks) were used as a source [11; 12]. Identified analogies in the chemistry textbooks were classified according to literature [1; 9; 13]

2.1. Data Collection and Analysis

In the process of data analysis, each unit taken under examination has read carefully by researchers. Firstly, the texts in each unit were analyzed page by page. Secondly, analogies found in the chemistry textbooks were classified according to following features: whether it was verbal or pictorial, analogical relationship between the base and the target, relationship between the analog and target, wideness of analogy. Each analogy was further classified independently by the researchers. Finally, these analogies are presented with schemes and categorized.

3. Findings and Discussion

As a result of this study, a total of twenty two analogies were identified from two textbooks. While seventeen
analyses of these are in the 10th grades chemistry textbook, the other five in the 9th grades chemistry textbook. Characteristic of these analogies is presented in Table 1.

| Category                        | 9th Grades | 10th Grades |
|---------------------------------|------------|-------------|
| Representation of the analogy   | Verbal     | 3           |
| Analogy                         | Pictorial  | 2           |
| Analogical relationship         | Structural | 2           |
|                                 | Functional | 1           |
|                                 | Structural-Functional | -- |
| Relationship between the base   | Pre-organizer | 1    |
| and the target                  | Buried-activator | 4    |
|                                 | Last Synthesizer | --   |
| Wideness of analogy             | Simple     | 3           |
|                                 | Widened    | 1           |
|                                 | Expanded   | --          |

When 9th grades chemistry textbook was analyzed, it was seen that most of the analogies were related to chemical bonding. In this topic, usually pictorial and buried-activator analogies were used to visualize the abstract concepts like polarity, ionic bonding. Also, it was determined that some of the analogies could cause misconceptions in students’ minds. For example:

“Although distance between magnets and iron powder stays the same, you observed that the forces of attraction changed as the number of magnet rises. Similarly, non-metal atoms have different forces of attraction though these atoms have same number of electron shell. Because forces of attraction changes with the number of protons found in the nucleus of an atom”.

In this analogy, it could be perceived as proton is equal to the magnet. Because of this, it should be explained that proton does not pull electron and also electron does not stick to proton.

Other topics in which analogies were used were found to be “photosynthesis” and “digestion”. Especially, these analogies are very simple and verbal.

Consequently, it was determined that analogies used in the 9th grades chemistry textbook were very few and inadequate. In addition, most of the abstract topics like atomic structure and chemical changes were presented without any analogy.

The results of analyzing of 10th grades chemistry textbooks have shown that analogies do not intensify one topic unlike 9th grades chemistry textbook. For instance, structure of the atom and periodic table includes 4 analogies, chemical bonding involves 3 analogies. Content of the analogies in the 10th grades chemistry textbook are presented in the Table 2.

| Content                  | Number of Analogy |
|--------------------------|--------------------|
| Electrification          | 1                  |
| Models of the Atom       | 1                  |
| Structure of the Atom    | 1                  |
| Quantum Mechanic         | 1                  |
| Mole Concept             | 1                  |
As a result of analyzing, it was determined that structure of the atom, first unit, mainly consists of verbal, structural and buried-activator analogies. Particularly, it is deficient that analogies are not supported by pictures in the teaching of abstract concept such as atom. Also, both of the analogies in the textbook are not last synthesizer. So, there are not any analogies to assess the learning process. In addition to these, some deficient points were determined in analogies. One of these analogies is below:

“If we need many nails, we buy pocket of nail or kilos of nail. We do not count nail. Similarly, we identify small particulate which we could not count as a general concept”.

According to this analogy, students could not understand relationship between mole concept and Avogadro’s number. Because, it is not explained that a mole is equivalent how much quantity of something.

In the second unit, periodic system, it was confirmed that there are four analogies. In general, these analogies are both very simple and not suitable for students’ cognitive structure. Some of the analogies are as follow:

“There are four seasons in a year and we know that every season have some specific quality. If we think that periodic table looks like a year and seasons resemble blocks in the periodic table, four blocks in the periodic table like seasons will have some specific quality”.

Although this analogy explains blocks in the periodic table, it does not explain how these blocks are formed. Accordingly, it is necessary that teacher help students relate blocks between atoms’ electron configuration.

Similarly, the other analogies were found to be “attraction between chemicals, the phases of matter and mixtures” have some deficiencies. Some of these analogies are presented below:

“A person is a social presence and he/she has to communicate with other people. But we spend time with people that have the similar trait with us more than the others. Similarly, chemicals attract the molecules that have the similar quality with themselves more than other molecules”.

In this analogy, polar and non-polar molecules were resembled individual traits. But this analogical relationship was not explained exactly. Another analogy is below:

“People prefer sports shoes when they walk. Because other tips of shoes are not flexible unlike sports shoes. The reason of this, there is an air pocket in the shoe sore. When people take a step, air in the air pocket press and relax. As a consequence, the chance of volume affects their foot comfortably.”
In this analogy, it was aimed to explain how the volume of a confined ideal gas varies with its pressure at a constant temperature. However, it was not stated that relationship between volume and pressure within a closed system. For this reason, this analogy is both simple and inadequate.

4. Conclusion and Recommendation

Chemistry textbooks remain a fundamental tool in chemistry education. According to Lumpe and Beck [14], as much as 75% of classroom instruction and 90% of homework are structured around science textbooks. Therefore, it is crucial that how the knowledge and key concepts are presented in the textbooks, and whether analogies are used correctly. In this study, analogies used in the 9th and 10th grades chemistry textbooks were investigated. The findings of this study revealed that although the analogies were used to teach abstract concepts like mole concepts, chemical bonding and enthalpy, many of these analogies were simple, verbal and inadequate. Particularly, it was found that there were few analogies in the 9th grades chemistry textbooks and these analogies were in only two units. In this context, firstly, analogies which could cause misconceptions should be revised and removed deficiencies. Secondly, widened or expanded analogies should be used instead of simple analogies. Also, last synthesizer analogies should be used in the learning process. Finally, analogies should be supported by pictures to visualize the abstract concepts.

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