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EXAMINATION OF SECONDARY SCHOOL STUDENTS' CONCEPTIONS ABOUT METALLIC BONDING AND PROPERTIES OF METALS

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Abstract: This study examines secondary school students' conceptions about metallic bonding and properties of metals by using a diagnostic instrument. The diagnostic instrument titled "iron" was designed to test out student understanding of the basic notion of metallic bonding and the relation between the properties of particles and bulk properties by Taber (2002). In the present study, a translated version of the true/false diagnostic instrument which contains 20 questions was administered to 942 students who are attending at 10th grades (374 students), 11th grade (333 students), and 12th grade (235 students) from different secondary schools. At the end of the study, it was found that the students had the octet rule alternative framework. They apply the full outer shells explanatory principle to explain metallic structure. It was concluded that students have alternative conceptions about the relationship between the properties of metal atoms and the properties of the metallic structure. For example, most of the students think "iron conducts electricity because iron atoms are electrical conductors" and "the reason iron rusts is that iron atoms will rust if exposed to damp air".

***Keywords*:** Metallic bonding, secondary school students, metallic properties

Introduction

Understanding chemical bonding and the particulate nature of structures are fundamental to success in chemistry. Although a number of alternative conceptions related to covalent and ionic bonding have been described in the literature, there are very few studies investigate students' understanding metallic bonding. Research has shown that students have a poor understanding of the bonding in metals and models for metallic structure and bonding at all level (Coll & Taylor, 2002; Coll & Treagust, 2003; Coll, 2008; Taber, 2003). Cheng and Gilbert (2014) indicated that the students were unable to visualize the metal structure in a scientific way. Taber (2003) investigated learners' mental model for metallic bonding in his interview study and characterized learners' conceptualizations of metallic bonding. He found that while some of the students did not think the metallic substance represented would have any bonding, others thought there was some form of interaction in metals, but this was not proper bonding. In Taber's study, some of the students suggested there would be ionic or covalent bonding in metals or metallic bonds existed between two metals. Taber (2003) found that students seemed to accept the "sea" metaphor uncritically, and to develop images of cations and/or electrons floating, swimming, etc. in the sea without thinking through the consequences of such a model.

Besides, understanding of chemical bonding needs to understand the particulate nature of matter meaningfully. On the other hand, students often have considerable difficulty in using atomic/molecular level models of matter to explain the properties of substances. A review of several studies by Nakhleh (1992) indicates that students' understanding of the model of matter is relatively limited. The most prevalent student conceptions are that matter is continuous and that the macroscopic properties of matter may be extrapolated to its particles (Ben-Zvi, Eylon and Silberstein 1986). Krnel, Watson and Glazar (1998) proposed that students regard particles as small pieces of an object with all its properties. A similar situation is seen between metallic structures and metal atoms. Metallic bonding and properties of metals place in the secondary school curriculum of many countries. To investigate high school students' conceptions about metallic bonding and properties of metals is important. In this connection, the research question is the following:

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Do students have alternative conceptions about the relationship between the properties of metal atoms and the properties of the metallic structure?

Methods

Context of the study

The topic of metallic bonding is placed in 9th grade secondary chemistry curriculum in Turkey. The sea of electrons metaphor for the metallic bond is used in teaching metallic bonding commonly in 9th grade.

Research Participants

The participants consisted of 942 students who are attending at 10th grades (374 students), 11th grade (333 students), and 12th grade (235 students) from different secondary schools in Balıkesir. The sample can be considered to be representative of the wider population of secondary school students.

Data Collection

In the present study, a translated version of the true/false diagnostic instrument which contains 20 questions was used. The original English language version of the diagnostic instrument titled "iron" was designed to test out student understanding of the basic notion of metallic bonding and the relation between the properties of particles and bulk properties by Taber (2002). The instrument was first translated into Turkish by the author, and was then checked by an English lecturer.

Data Analysis

The overall facility of the instrument in terms of the percentage of correct responses on each item and across the instrument was considered. Firstly the number of students selecting the correct response, the number of students selecting an unambiguous (True or False) response, the number of 'I do not know' responses, and the number of non-responses (no response given for item) were determined for data analysis. After then, the correct responses as percentage of total number of students completing the instrument was calculated.
To determine the reliability of analysis was used intra-judge reliability which would involve a single judge scoring at the same test at two different times (Gay and Airasion, 2000, p.176).

Results and Findings

It is seen that the results of the percentage of correct answers to each item in three grades were very close to each other. It can be seen from the students' responses to Q1, they know that iron is metal and all metals have a type of bonding called metallic bonding (90%/78%/89%). Almost half of the students know that the iron atoms are packed together and the structure is held together by metallic bonding (54%/61%/54%). Taber (2001) has cited that some of the students find way to understand the metallic bond as a variation on the ionic or covalent case. In this study it was found that most of the students assumed that metals were molecular (%17/21/18) as seen from Q17. On the other hand, there are no molecules in a metal. Almost half of the students thought that the atoms in a metal were held together by ionic bonds. Another important point that most of the students used the full outer shell/octet stability while explaining the bonding. This was called octet alternative framework by Taber (1998, 1999). According to analysis of second item, it was found that most of the students (24%, 22%, 26%) had octet alternative framework thinking.

Conclusion

At the end of the study, it was concluded that the students had the octet rule alternative framework and they applied the full outer shells explanatory principle to explain metallic structure. It was also found that students had alternative conceptions about the relationship between the properties of metal atoms and the properties of the metallic structure. For example, most of the students think "iron conducts electricity because iron atoms are

electrical conductors" and "the reason iron rusts is that iron atoms will rust if exposed to damp air". Another important conclusion is that most of the students assume that metals are molecular.

Recommendations

First of all, the students should be presented fundamental conditions of the bond occasion generally taking into account electrostatic attraction and energy. The main problem about difficulties concerning the bonding is that students do not make sense why the atoms come together to occur the chemical bonds. It should be avoided the simple explanations of bonding such as electron sharing or transferring. If different models are used to explain metallic bonding, why these different models used should be clarified.

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