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## ***How Students of the Eighth Grade of Elementary School and the First Grade of High School Interpret the Representations of the Structure and Composition of Substances<sup>2</sup>***

### **Extended summary**

One specificity of teaching and learning chemistry is related to the need to simultaneously review the contents of chemistry at three levels: the *macroscopic* level, where based on observation one may describe properties and changes of substances, the *submicroscopic* level, that is, the level of atoms, molecules and ions, and the *symbolic* level, where the structure of the given substance and interactions between atoms, molecules, and ions are represented by means of chemical symbols, formulas, and chemical equations. For students of different age it is rather challenging to use multiple levels of representation and integrate the information from chemical representations of different levels in order to understand chemistry. The issue how well students interpret the information in the representations is important for their success in chemistry learning. The aim of this research is to examine how students of the eighth grade of elementary school and the first grade of high school interpret the representations of the structure and composition of substances and how successful they are in transforming the representations of one level into another. The importance of this research is related to the need of each individual to understand the basic ideas of chemistry for a safe and responsible life in modern society, including those about the particulate nature of substances, chemical bonds, pure substances (elements and compounds) and mixtures, which are mediated in chemistry classes and chemistry textbooks through different representations. From the aim thus defined, the follow-

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ing research questions arose: (1) How do students of the eighth grade of elementary school and the first grade of high school interpret representations related to the structure and composition of substances? (2) Which level of representation is difficult for students of the eighth grade of elementary school and the first grade of high school to interpret? (3) To what extent do students in the eighth grade of elementary school and the first grade of high school successfully transform one level of representation into another? A total of 193 students participated in the research, 81 students attending the eighth grade of elementary school and 112 students attending the first grade of high school. The instrument in this research was a test prepared according to the aim of the research and research questions. The requirements in the test referred to different levels of representations related to the structure of atoms, molecules and ions, chemical bonds, pure substances and mixtures. The validity of the test in accordance with the aim and research questions was established by the members from the Department of Chemical Education of the University of Belgrade - Faculty of Chemistry, who were not involved in the preparation of the test, while teachers working in schools where the research was conducted estimated that all test requirements are in accordance with the chemistry curricula. The testing took 45 minutes (one classroom period) for each group of students. Their participation was voluntary, and achievement on the test had no influence on the mark in chemistry. A Mann-Whitney U Test revealed a statistically significant difference in the total achievement of the eighth-graders ( $Md = 15$ ,  $n = 81$ ) and the students of the first grade of grammar school ( $Md = 23$ ,  $n = 112$ ),  $U = 1355.5$ ,  $z = -8.315$ ,  $p = 0.000$ ,  $r = -0.598$ . The percentage of correct answers in the group of high school students is higher for 23.7 %. The results of the research showed a low contribution of submicroscopic representations to the understanding of chemistry contents in the group of the eighth-graders, while the first-grade high school students were more successful in their interpretation. The research has shown that the eighth-grade elementary school students experience difficulties in understanding and interpreting the representations, and in making translations between different levels of representations, especially when the information is mediated by using submicroscopic representations. It was easier for the students of both groups to solve tasks in which the symbolic level was a starting point and it was required its connection with the submicroscopic level, than in the opposite direction. The results indicate that special attention must be paid during regular classroom periods in elementary school and in chemistry textbooks to provide the elementary school students with appropriate explanations of the submicroscopic representations. It is important for them to notice how knowledge about the structure of a substance makes it possible to explain the properties of the substance that can be observed macroscopically, as well as to explain the changes of the substance. Instead of quickly moving from one level of consideration of properties and changes of substances to another, it is important to devote more time to connect the macroscopic, submicroscopic, and symbolic representations, including the explanations of their limitations.

**Keywords:** chemistry, elementary school, high school, representations

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