Student-generated Submicroscopic and Symbolic Representations: Evaluating their Conceptual Knowledge and Highlighting their Perceptions

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Meaningful understanding of chemistry, among others, includes the ability of an individual to think simultaneously at macroscopic, submicroscopic and symbolic level[1,2]. In this study we investigated students' ability to translate macroscopic representations into equivalent submicroscopic and symbolic ones. We used the semi-structured interview technique and our sample was 16 Greek students of 11th Grade. Students were shown pictures of 6 materials and were asked to construct a particulate drawing depicting the particles of each material, to describe and explain their drawings, to symbolize each material in chemistry and to explain their way of thinking. Materials were pictures of: metallic sodium, sodium chloride, water, gaseous oxygen, aqueous sodium chloride solution and aqueous solution of oxygen. These materials correspond to the following chemical concepts: chemical element, ionic and molecular compound, physical states of matter and aqueous solution.

Our findings showed that students struggle with the examined chemistry concepts. The students demonstrated difficulties in describing verbally the representations, which they had constructed, and often failed to use proper terminology such as "atom", "molecule", etc. In addition, in most cases there was no correlation between the submicroscopic and symbolic representations that students had generated for the same material. For example, while almost all students could correctly write the molecular formula of water (H_2O), more than half had problems drawing an appropriate particulate diagram. Frequently, students could not interpret the symbolic representations, which they had written (e.g. the subscripts in a molecular formula), explaining that they had just memorized the symbols. Students displayed a tendency to extrapolate macroscopic properties of matter (e.g. color) to particles. Some students argued that metallic sodium consists of two types of particles, because except of sodium there is a second component which gives the metallic properties to the material. Many students used the same particulate model of bonding regardless of whether the compounds involved were ionic or covalent (e.g. they portrayed sodium chloride as consisting of molecules). Regarding aqueous solutions, some students did not recognize the presence of water molecules, while a lot of misconceptions were revealed concerning the phenomenon of dissolution for both ionic and covalent compounds. Generally, our results indicate that students' performance in linking the three levels of chemistry is poor. Student-generated representations can be used to evaluate conceptual understanding and to reveal existing misconceptions.

References

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