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Reviewed by Jasmina Kolbl[1]

»Schools should educate scientifically literate citizens, since they can contribute to the development of society in the technological field, because a technologically developed society enables sustainable development and greater prosperity.« (Devetak, p. 5)

Understanding of concepts cannot be transmitted from a teacher to the students. To put it another way, understanding is not a commodity that can be transferred. Instead, each learner must create his or her own understanding of specific concepts. Teachers can support the development of students' understanding, but they cannot give them knowledge. Information can be transmitted from one person to another, but understanding develops when a learner actively and mentally works to give meaning to experiences and ideas.

The quality of education and motivation for learning are becoming increasingly dependent on the quality of the visual aids used in the learning process. Specifically, numerous visualisation tools are readily available today, but only seldom has their impact on students' understanding of chemistry or their motivation for learning chemistry been evaluated. With this in mind, we cannot be surprised by the growing number of scientific papers and journals dedicated to debating this issue from various standpoints. In an effort to apply this, Iztok Devetak's monograph could be read as an analysis of the key factors ensuring the quality of science knowledge in the educational system.

Providing High Quality Science Knowledge Using Submicrorepresentations includes contributions by authors from various backgrounds – theorists, practitioners, activists – enabling a discussion rooted in the perspectives of various levels and fields of engagement in chemistry education, especially the impact of sub-microrepresentations on learning, thus giving the book a specific value.

Iztok Devetak (an assistant professor for Chemical Education at the Faculty of Education, University of Ljubljana) has authored this monograph, intended

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primarily for science teachers who are part of the education system at the primary and secondary levels, graduate and post-graduate students of different science fields and science education, science teacher educators, science curriculum developers, science education researchers, science textbooks authors and editors and, last but not least, to the politicians who are responsible for the national educational system. However, it might be appealing to the exceptionally broad range of people who are involved in science education and engaged in improving it. For school administrators, supervisors, school board members and other stakeholders in the educational system, this monograph provides some solutions to the most significant problems in science teaching and learning regarding using sub-microrepresentations in the science classroom.

Examining the structure of the monograph, it is obvious that the author did not overlook the importance of good book structure. The text is divided into segments presented a logical sequence, enabling the reader to find the information he or she is looking for. Where necessary, essential items are highlighted.

In addition to the forward at the beginning and summary at the end, this book has six chapters and concludes with references and an index. Each chapter concludes with a summary of the problem described or suggestions for further reading on a topic.

Chapter 1, entitled *Triple Nature of Science Concepts*, explores all three levels of chemical concept presentations that are crucial in chemistry teaching and learning: (a) the macro- or tangible (what can be seen, touched or smelt); (b) the submicro- (atoms, molecules, ions and structures); and (c) the symbolic (symbols, formulae, equations) levels. Johnston was the first to integrate the three levels in i.e. »chemistry triangle« (p. 9). The following is an overview of the historical development and upgrading of this model until Devetaks' Interdependence of Three Levels of Science concepts representations (ITLS) model is introduced (p. 10). An ITLS model demonstrates the connections of the three levels of chemical concepts, supported by different visualisation tools for developing students' adequate mental model of the science phenomena observed.

Chapter 2, entitled *Science Teaching and Learning*, presents a model of teaching and learning chemistry, reflecting the complexity of the subject and the slightly modified ITLS model presented in Chapter 1. It is crucial that the teacher integrate the triple nature of chemical concepts through a variety of educational material and teaching approaches.

Chapter 3, entitled *Visualisation and Learning*, describes the theoretical basis of visualisation in science learning, as developed by some respected researchers in the fields of science and chemistry education (e.g. Treagust, Gilbert, Justi), supported by the learning theories developed by Meyer, Marzano, Bloom and others.

Chapter 4, entitled *Science Concepts Visualisation*, is the most extensive and important chapter in this monograph. It describes various ways of visualising abstract science concepts, such as analogies and metaphors, models and modelling, sub-microrepresentations, animations and simulations at the submicroscopic level of chemical concepts. The results of the study of students' understandings and chemical misconceptions identified by submicrorepresentations represent a particular value of the fourth chapter. Submicrorepresentations (SMRs) are a powerful tool for identifying misconceptions of chemical concepts. Research also shows that they can be also used for generating proper mental models of chemical phenomena in students' long-term memory. Detailed misconceptions of some specific chemical concepts, such as the structure of matter, chemical reactions, and solutions and electrolyte chemistry at the particulate level, are presented. In addition, the author also offers some explanations of the possible reasons that cause the previously described misconceptions (e.g. textbooks' pictorial material and teachers' educational strategies). Conclusions and suggestions for science teachers to avoid generating students' misconceptions at the sub-microlevel of chemical concepts are drawn directly from the research findings.

A discussion with teachers or a perceptive look into a science classroom is sufficient to aid in realising that the learning of scientific concepts is more than a cognitive process. Chapters 5 and 6, entitled *The Influence of Motivation on Science Learning* and *The Influence of Mental Abilities on Science Learning* answer some questions, for example: What is the motivation for science learning?, Do male and female students differ in motivation for learning science?, How do students' formal reasoning abilities affect the science knowledge?, How spatial abilities influence students' abstract chemical concepts understandings? and so on. Most chemists would probably agree that chemical experimentation is one of the crucial visualisation tools in chemistry teaching and learning at the macro level that motivates students. Maintaining a sufficiently high level of motivation or interest for the learning of submicro- and symbolic level of chemical concepts represents a considerable challenge for chemistry teachers at all levels of education. It is vital to realise that students' formal reasoning abilities influence their success in solving chemical problems, which include the submicrolevel of chemical concepts and that visualisation abilities also significantly influence students' academic achievements.

Readers might find the summary of main ideas presented in the last chapter useful; while some might feel that the author tends to repeat himself.

While these ideas have been rather thoroughly interpreted in previous chapters, it is useful to conclude the monograph by summarising some crucial points presented in the book. However, the author is well aware of the fact that is essential to introduce different visualisation abilities to illustrate abstract science/ chemical concepts to the students at the beginning of the science education, thus also the application of SMRs.

Multiple groups of Slovenian readers have finally acquired a book that deals with the issue of the quality of science knowledge, especially from the importance of visualisation in science education. The reviewed monograph is well worth reading by anyone interested in better understanding the use of submicrorepresentations in the science/chemistry teaching.

On the basis of the research results that are reviewed in *Providing High Quality Science Knowledge Using Submicrorepresentations*, by Iztok Devetak, PhD., it is recommended that teachers should more frequently incorporate submicrorepresentations in their educational process when explaining macroscopic observations and before using symbolic chemical language at the elementary, secondary and tertiary levels.