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Special Section

General Section

Ph.D Abstracts

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Students' mental models of chemical reactions

Unpublished Ph.D thesis, Faculty of Education, The University of Waikato

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Previous research on topics such as atomic structure and chemical bonding indicates that students' mental models are often inconsistent with the scientific models, which may impede learning of advanced concepts. International research suggests that model-based teaching and learning in science education shows promise in overcoming student misconceptions, but research about modelling for chemical reactions is sparse. In an attempt to redress this schism, this study took the form of an inquiry into a cross-age study of 67 students drawn from secondary schools and universities to investigate their mental models of chemical reactions. This naturalistic qualitative inquiry was based within an interpretive paradigm and constructivist epistemology, in which data were generated from interviews with the participants. The data for this inquiry were derived from semi-structured interviews, incorporating the Interview-About-Instances (I.A.I) technique to probe students' mental models of chemical reactions for various chemical phenomena.

Thematic analysis of the students' discourse of their mental models revealed different types of mental models, named Model A, B, and C. Each of the mental models was characterised based on features of energy change and the process of chemical reactions at the submicro level. Model A was considered as an initial mental model, which was based on students' experience with changes of matter in their daily life. This model was also attributed with the notion of agent-driven chemical change as its core characteristic. Basically, Model A explained most of the properties of chemical reactions, including the rate, spontaneity and reversibility of reactions. Although, it can be considered a 'causality model', it seemed essential for young students in making sense of the chemical phenomena that surround them. On the other hand, Model B was based on either the attributes related to kinetic theory of particles or attributes related to chemical bonding but this type of mental models seemed to share some characteristics of Model A. However, Model C was likely to incorporate the attributes related to both kinetic theory of particles and chemical bonding as core ideas used in explaining chemical reactions. Students' preference towards a given model in their mental models is consistent with previous studies. This preference is probably because of their early exposure to the kinetic theory, and it is simplistic but powerful in explaining the nature of chemical phenomena. Nonetheless, the model of chemical bonding was considered

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(pp. 181–182)

an ‘enabling’ model for understanding of the chemical phenomena in terms of rearrangement of atoms and as an affordance to make sense of energy change.

Students’ mental models were also compared according to their level of education. Generally, most senior university students were found to hold Model C, while junior university and Form 6 students’ mental models were mostly Model B, and all secondary school students’ mental models were Model A. It seemed then that the more exposed the students are to formal education in chemistry, the more consistent their mental model become with the scientific view. Although students’ mental models were categorised in such a manner, all of the mental models shared common attributes, such as the role of reacting agents in reaction spontaneity, energy as a part of reactions, and irreversibility presumptions. This finding indicates that students’ initial mental models were not ‘erased’ but rather coexisted with the advanced mental models, which were developed through formal education. This relationship is similar to how science operates, where superseded models co-exist with more sophisticated models and are still used for practical purposes although scientists are aware of an old model’s limitations and discrepancies.

A general conclusion that can be drawn from this study is that students’ mental models were found to be lacking in attributes that relate to scientific ideas such as particle model, particle collisions, activation energy, and entropy despite these ideas having been introduced in their formal learning. Therefore, it is recommended that students should be engaged in developing mental models that enable them to link between macro and submicro levels through modelling an instruction approach that emphasises the understanding, application and construction of models.