# Representational Issues in Learning Solution Chemistry at Secondary School

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**Abstract :** Students' conceptual understandings of chemistry concepts/phenomena involve capability to coordinate across the three levels of Johnston's triangle model. This triplet model is based on reasoning about chemical phenomena across macro, sub-micro and symbolic levels. In chemistry education, there is a need for further examining inquiry-based approaches that enhance students' conceptual learning and problem solving skills. This research adopted a directed inquiry pedagogy based on students constructing and coordinating representations, to investigate senior school students' capabilities to flexibly move across Johnston' levels when learning dilution and molar concentration concepts. The participants comprise 50 grade 11 and 20 grade 10 students and 4 chemistry teachers who were selected from 4 secondary schools located in metropolitan Melbourne, Victoria. This research into classroom practices used ethnographic methodology, involved teachers working collaboratively with the research team to develop representational activities and lesson sequences in the instruction of a unit on solution chemistry. The representational activities included challenges (Representational Challenges-RCs) that used 'representational tools' to assist students to move across Johnson's three levels for dilution phenomena. In this report, the 'representational tool' called 'cross and portion' model was developed and used in teaching and learning the molar concentration concept. Students' conceptual understanding and problem solving skills when learning with this model are analysed through group case studies of year 10 and 11 chemistry students. In learning dilution concepts, students in both group case studies actively conducted a practical experiment, used their own language and visualisation skills to represent dilution phenomena at macroscopic level (RC1). At the sub-microscopic level, students generated and negotiated representations of the chemical interactions between solute and solvent underpinning the dilution process. At the symbolic level, students demonstrated their understandings about dilution concepts by drawing chemical structures and performing mathematical calculations. When learning molar concentration with a 'cross and portion' model (RC2), students coordinated across visual and symbolic representational forms and Johnson's levels to construct representations. The analysis showed that in RC1, Year 10 students needed more 'scaffolding' in inducing to representations to explicit the form and function of sub-microscopic representations. In RC2, Year 11 students showed clarity in using visual representations (drawings) to link to mathematics to solve representational challenges about molar concentration. In contrast, year 10 students struggled to get match up the two systems, symbolic system of mole per litre ('cross and portion') and visual representation (drawing). These conceptual problems do not lie in the students' mathematical calculation capability but rather in students' capability to align visual representations with the symbolic mathematical formulations. This research also found that students in both group case studies were able to coordinate representations when probed about the use of 'cross and portion' model (in RC2) to demonstrate molar concentration of diluted solutions (in RC1). Students mostly succeeded in constructing 'cross and portion' models to represent the reduction of molar concentration of the concentration gradients. In conclusion, this research demonstrated how the strategic introduction and coordination of chemical representations across modes and across the macro, sub-micro and symbolic levels, supported student reasoning and problem solving in chemistry.

**Keywords :** cross and portion, dilution, Johnston's triangle, molar concentration, representations
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