education in chemistry

Metavisualisation helps with mental models

By Fraser Scott | 18 March 2021

Research-based tips for improving your students' sub-microscopic understanding of particle models

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Researchers asked students to consider what's going on during the precipitation of silver chloride

Johnstone's triangle summarises levels of representation regularly used when thinking about chemical concepts. Of the three levels, the sub-microscopic is probably the most important for understanding or explaining how chemical processes occur. A student's understanding of how the sub-microscopic level is visually represented, for example in diagrams, is directly linked to their understanding of the underlying chemistry concepts.

Many visual representations can explain the same underlying chemistry. For example, when drawing a particle diagram you could represent water as a simple circle, or choose to show the individual atoms. An important consideration is how students regulate their own understanding,

known as metacognition. Metacognition when encountering multiple representations of the same chemical phenomenon is termed metavisualisation.

Microscopic models

In a new study, researchers have investigated whether a task incorporating a metavisual strategy can improve students' sub-microscopic level understanding. Their study focused on precipitation reactions from mixing salt solutions. It involved only six undergraduate students, but analysed their actions and thoughts in depth.

The researchers asked the students to consider the mixing of aqueous solutions of KCl and $AgNO_3$. The students' task required them to use coloured clay to construct a visual representation of the sub-microscopic level immediately after mixing, and then after the precipitation of AgCl. Next, students compared their representations with a scientifically correct particle diagram of the same reaction. Finally, they reconstructed their own representations. The final two tasks are metavisual strategies.

For their analysis, the research team photographed the clay models and took audio recordings of the students' discussions as they proceeded through the activity.

The researchers found evidence that the students used self-regulation to refine their mental models at the sub-microscopic level. Fourteen broad ideas emerged from the analysis. These revealed the specific moments of metavisualisation. For example, students realised their representations did not depict water, which is important to understanding dissolution. Students also realised the importance of illustrating the crystalline structure of AgCl.

Teaching tips

- The team's findings suggest that the strategy of viewing a representation at the sub-microscopic level, then revising it based on students' prior knowledge and interaction with their peers, can contribute positively to students' formation of chemical mental models. This approach can expose misconceptions at the sub-microscopic level and allows students to correct them.
- The sub-microscopic level is often difficult for students because we cannot observe it directly. A greater exposure to visual representations of the sub-microscopic level should help.
- You can extract the specific task used in this study from the paper and use it within your own setting without alteration. You could also adapt the idea to any chemical concept that can be usefully represented through particle diagrams.

- The research also revealed that visual representations are not always as clear to students as we might think. Therefore, discuss the visual representations you choose, and use a variety of visual representations for the same concept.

References

S W Locatelli and B Davidowitz, *Chem. Educ. Res. Pract.,* 2021, DOI: 10.1039/d0rp00339e