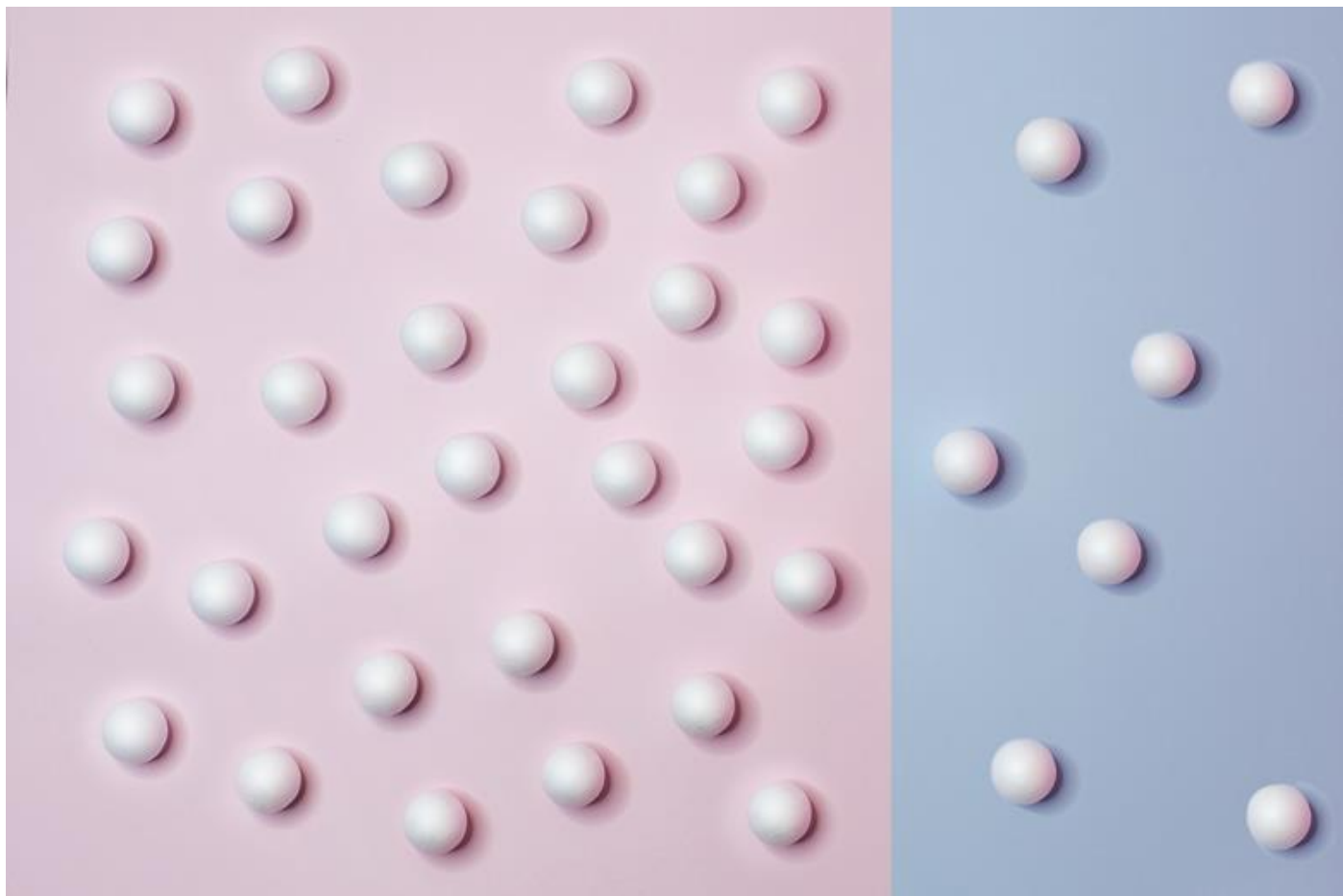


What is difficult about concentration?

By [Fraser Scott](#) | 13 May 2021

Fresh insight offers tips for teaching the mathematics of moles, volume and molarity



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Use this fresh insight into students' mathematical misconceptions to inform your own teaching

A group of researchers has provided new insight into students' misconceptions about concentration in a recent [study](#). Previous research has focused on students' ideas about the nature of solutions and the process of dissolution. This study, led by Andrés Raviolo, investigated quantitative aspects.

Concentration is a fundamental concept in secondary school and university chemistry curriculums. It challenges students because it requires prior understanding of other concepts – solute, solvent, solution, mixtures, dissolution, mass and many others.

Mathematically, concentration links three variables: moles (n), volume (V) and molarity (M). The relationship between these variables is used in many common chemistry calculations. The research team investigated students' understanding of this mathematical relationship.

Concentrating on the problem

Andrés and their co-researchers developed a 'Reasoning with molarity' questionnaire and gave it to 303 first-year university students. The students had to carry out calculations mentally. This encouraged them to use proportional reasoning strategies, which gave more opportunities to identify misconceptions. Next, the research team questioned 18 students on their answers in think-aloud interviews.

The researchers found that approximately half of the students had no clear understanding of molarity. Students often relied on algorithmic approaches to solving concentration problems due to a lack of conceptual understanding. For example, many students were not clear about the difference between n and M . Solving concentration problems using only algorithmic procedures can prevent students from developing the understanding needed to see beyond the numbers.

Additionally, inverse proportional reasoning was a problem for many students. It was more problematic in tasks where students had to, for example, use the number of moles and molarity to qualitatively determine which solution occupies the smallest volume. In other words, tasks that related extensive and intensive properties together. M is an intensive property. This means that it is constant upon changing the size of the system under consideration. If some solution is removed, both parts still have the same molarity. The n of the solute and the V of the solution are extensive properties. Their values change as the size of the system changes. If solute is added to a solution, n increases, or if solvent is removed, V decreases.

Teaching tips

- It is unlikely that our curriculums include opportunities for students to tackle conceptual questions about concentration. Fortunately, you can use the Reasoning with molarity questionnaire developed in this [study](#) in your own classes.
- During the interviews in this study, many students were able to self-correct their original mistakes by reasoning out loud. This approach would be easy to adopt in a classroom.
- This study showed that proportional reasoning was not necessarily an issue for students. However, applying it in a different context, such as chemistry, was a challenge. Explicitly highlight the various examples of proportional reasoning within chemistry to help students to transfer this concept to a new context.

References

A Raviolo *et al*, *Chem. Educ. Res. Pract.*, 2021, **22**, 486–497, DOI: [10.1039/d0rp00344a](https://doi.org/10.1039/d0rp00344a)