Making Thinking Visible in Chemistry: Classroom Strategies to Identify Misconceptions in the Central Science*

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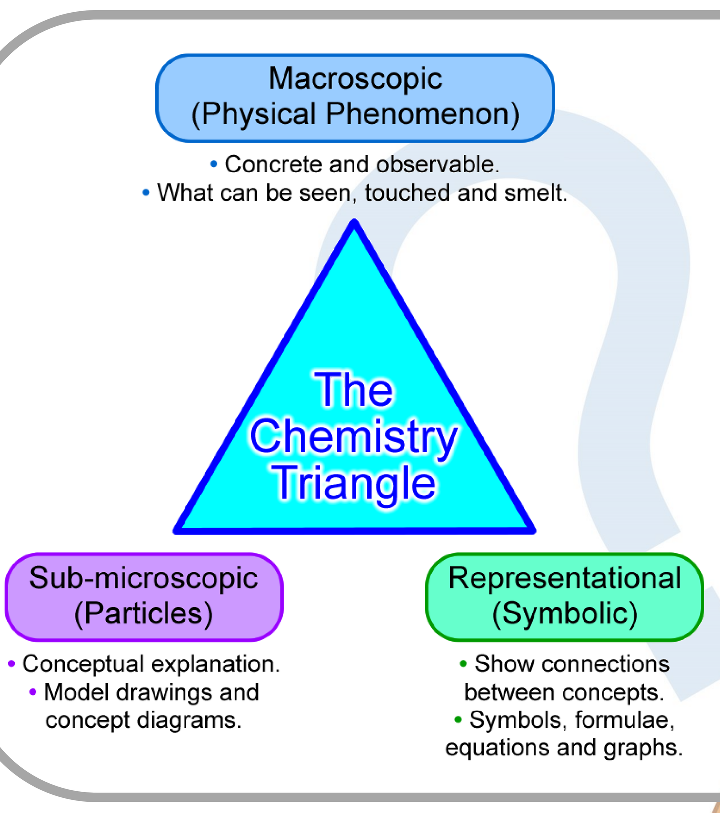
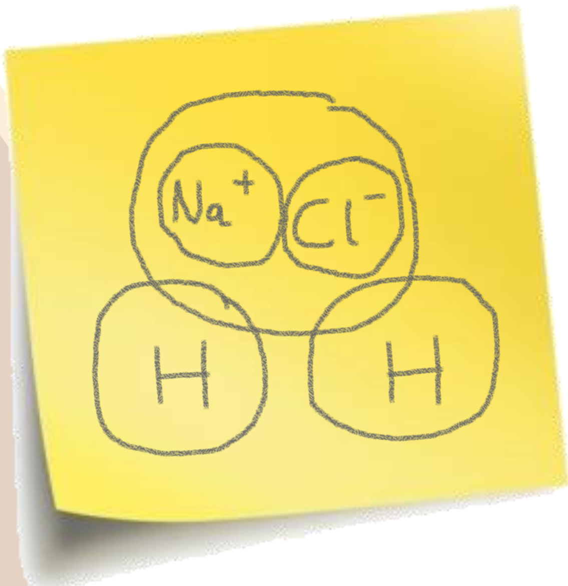
1 Why is Chemistry Difficult?



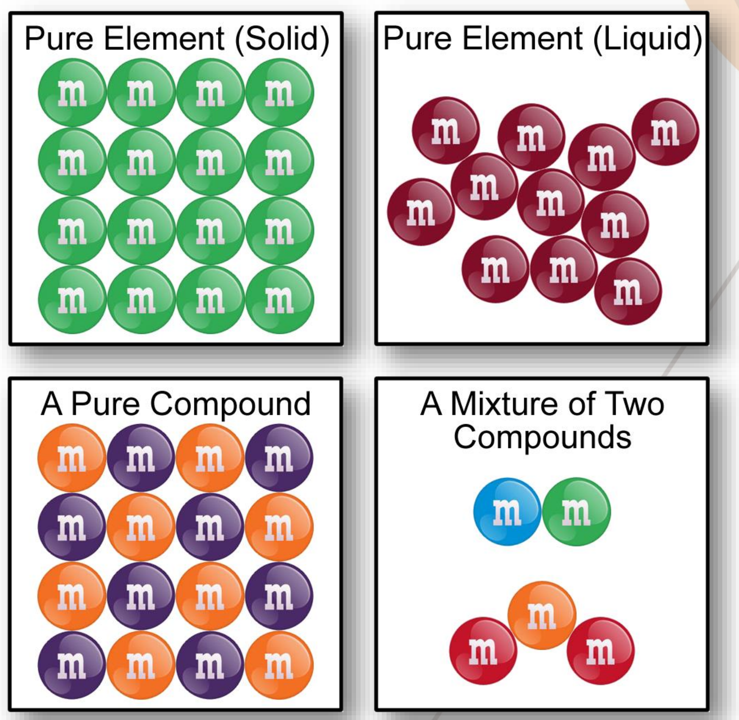
- Students learn by asking questions, making observations and forming concepts (Johnstone, 1991).
- This is relatively straight forward for phenomena that can be observed directly at the *macroscopic level*.
- Most Chemistry teachers begin their instruction at the *macroscopic level*, and then move on to *symbolic representation*.
- Misconceptions arise as students struggle to imagine what might be happening at the *sub-microscopic level*.

2 Examples of Misconceptions



- Students' misconceptions of what is happening at a sub-microscopic level become evident when they are given the opportunity to make their thinking visible.
- The example given on the left illustrates one student's understanding of *sodium chloride dissolved in water* and shows a sodium ion and a chloride ion *inside a water molecule*.
- At this point, the teacher can intervene and address the student's misconception, for example, by using the "*I used to think… …now I think*" visible thinking routine.

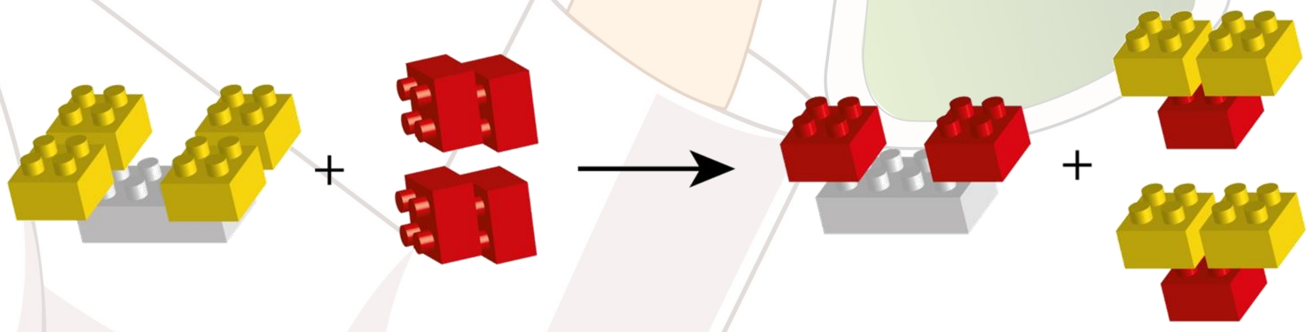
3 Using Models – Candy



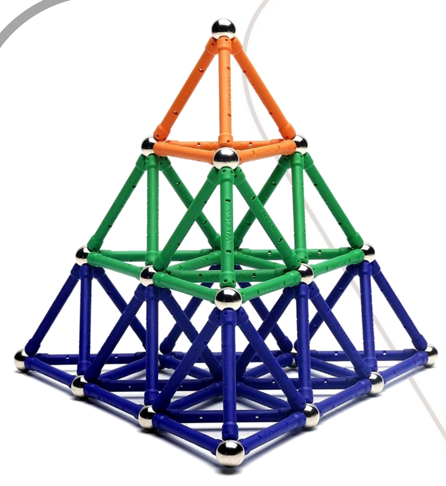
- One strategy that allows students to make their thinking visible in Chemistry is to use candies, such as M&M's, to represent atoms.
- A single M&M's represents a single atom. M&M's of different colours represent atoms of different chemical elements.
- Students arrange M&M's to represent their understanding of elements, compounds and mixtures as solids, liquids and gases.

4 Using Models – Lego®

- Lego® bricks can be used by students to represent atoms. Bricks of different colours can be used to represent atoms of different chemical elements, while bricks of different sizes can be used to represent atoms with different valencies.
- Used creatively, Lego® bricks can be used to represent ionic compounds, polymers and optical isomers. Students can photograph their work and upload the images into a shared document to be evaluated by their peers.

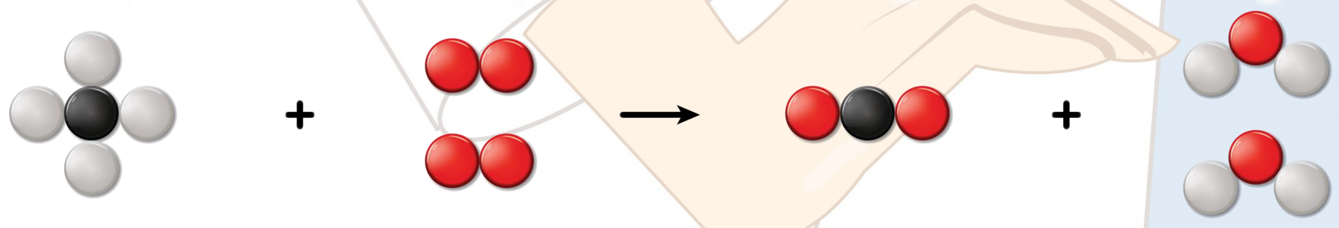


5 Using Models – Magnets



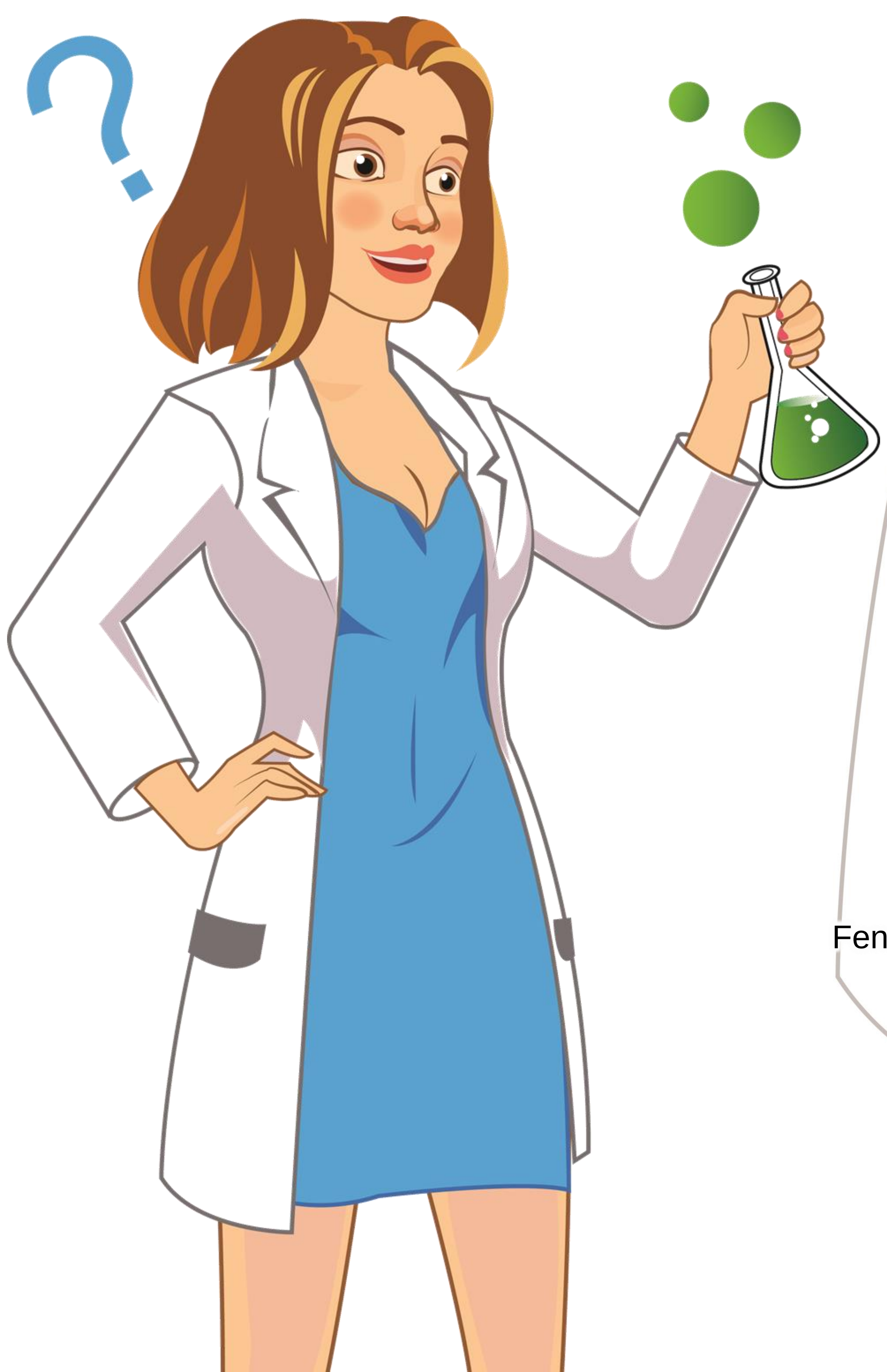
- Coloured button magnets, when attached to a magnetic whiteboard, can help students visualise atoms and ions while balancing chemical equations.
- Ball bearings and magnets allow students to demonstrate their understanding of valence shell electron pair repulsion theory. New bonds can be added easily and can be made to point in any direction.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

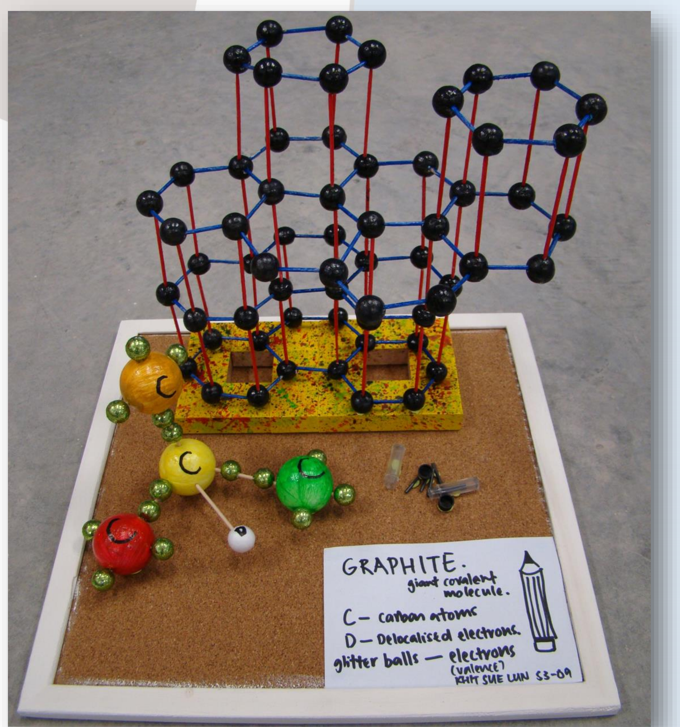


6 My Favourite Mistake

- Students are given a question that can be answered briefly on a small piece of paper, for example, balancing a chemical equation or solving a mole calculation.
- The teacher collects their students' answers and searches for *their favourite mistake*. This could be a common misconception or a novel mistake made by a student.
- The teacher then proceeds to share the incorrect answer with their class, firstly asking what is good about it, and then asking students to identify mistakes and misconceptions.



7 Authentic Transfer Task



- Students can make their understanding of a concept visible through authentic transfer tasks.
- Students transfer their knowledge and understanding of Chemistry to solve authentic – real world – problems.
- In these examples, students have construct models to clearly show the structure and bonding in everyday substances (graphite on the left and sodium chloride on the right).
- The models allows students to make their thinking visible, and allows their teacher to check for any misconceptions about bonding.

Fensham, P. J. (2005, December). *Scientific literacy's challenge to chemical education*. Keynote address presented at the 4th Singapore International Chemistry Conference, Singapore.

Johnstone, A. H. (1991). Why is science difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning, 7*(2), 75-83.

Taber, K. (2002). Chemical misconceptions: Prevention, diagnosis and cure: Volume 1, Theoretical background. London: Royal Society of Chemistry.

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