Gifted Education School Network 2022/23

KLA/ Cluster: STEAM education

Lesson Design

Acknowledgements: This lesson example was adapted/ adopted from the try-out by Mr POON Ka-yeung of St Paul's School (Lam Tin)

School	St Paul's School (Lam Tin)
Level	Secondary 1
Topic	Unit 6: Matter as particles
Lesson Duration	60 minutes (a double lesson)
Learning Objectives	Knowledge - To understand that there is space between particles - To explain a puzzling phenomenon of mixing water and alcohol using the particle theory Skills - To make scientific observations and measurements - To use the particle model to approximate a phenomenon Attitude - To appreciate the process of scientific inquiry
Prior knowledge of students	Basic measurements for volume and mass using appropriate instruments.
Highlights of this exemplar	Simply explaining to students the concepts of particle theory, such as that there is space between particles, that particles can move by themselves, etc., is highly ineffective and cannot foster deep conceptual understanding in students. The lesson begins with a puzzling phenomenon in mixing water and alcohol that results in a reduction in volume but conservation of mass. Students are guided to conduct a scientific investigation and use the newly collected data and scientific ideas to explain the phenomenon.
Differentiation Strategies employed	● Higher-order questioning

Activities	Rationales for Implementation
Introduction to a puzzling phenomenon in mixing water and alcohol The teacher fills two measuring cylinder with 50 mL of water each and asks students to look at the measuring cylinders to confirm that there is 50 mL of liquid in each. The teacher asks students to predict what the total volume would be if all the water were poured into a single measuring cylinder.	Students often think that there is no space between particles (i.e., the particles are packed too close together). It is **counterintuitive** to think that there is empty space between particles that appear to be densely packed in perception. The teacher can use the reduction in volume when mixing water and alcohol to ask students about the possible reasons. Some students may think that the liquid did not completely transfer from one cylinder to the

The teacher pours the contents of the two graduated cylinders into one cylinder and shows the students that the volume is 100 mL. The teacher then fills one cylinder with 50 mL of water and the other with 50 mL of alcohol. Again, the teacher asks the students to predict the total volume. The teacher asks a student to pour the contents of the two measuring cylinders into one cylinder and have the students observe that the total volume is less than 100 mL. The teacher asks the students what they think is the cause of the decrease in volume.	other (measurement error), while others may think that the alcohol evaporated. The teacher should create an open and unbiased learning environment to encourage students to express their thoughts publicly. The teacher can clarify and ask students for further clarification as needed so that gifted/ students feel that their ideas are valued by the teacher.
Extension of the puzzling phenomenon of mixing liquids in the context of conservation of mass The teacher re-enacts the mixing of liquids (e.g., water and alcohol) with students weighing each measuring cylinder with the liquid inside. The teacher asks a student to record these weights and asks students to predict the total mass when the two liquids are poured together. The teacher then pours out the liquids and weighs the combined liquid to confirm that the mass remains the same. The teacher asks the students what they think causes the phenomenon (decrease in volume, but conservation of mass).	Adding the idea of conservation of mass can increase the **complexity** and **abstractness** of the phenomenon. With this additional information, gifted/ more able students can reconsider whether their initial thoughts about why volume is decreasing are still accurate. For example, if students think that the volume decreased because the alcohol evaporated, this idea becomes moot. The teacher should ask students to share their thinking by providing scaffold to support their hypotheses, e.g., "If the volume decreased due to evaporation of the alcohol, the total mass should also decrease."
Activity: Mixing beads of different sizes The teacher demonstrates mixing beads of different sizes by putting one type of bead into a measuring cylinder and another bead into another cylinder. The teacher asks students to record the combined mass and volume compared to the values before mixing. The teacher asks the students what they think is causing the smaller total volume while the total mass remains the same. The teacher then introduces the particle representation of water, as well as that of alcohol. Students then use the experience of mixing beads to explain the puzzling phenomenon of mixing water and alcohol.	The activity "Mixing Beads" can serve as a bridge and analogy to the puzzling phenomenon. The teacher can ask questions to support students' mental visualisation of the particle concept, such as: - Why did the total volume get smaller after mixing the beads? - Which bead is larger and which bead is smaller? - How can they be drawn? By drawing, students visualise their concepts first. After mixing the beads, it is a logical transition for the teacher to introduce the ideas of the particles. Gifted/more able students can then apply the particle ideas along with their experiences mixing beads to explain the puzzling phenomenon.
Explanation of the puzzling phenomenon by the particle theory	Class dialogue should focus on explaining both mass and volume. Students' drawings should be asked to explain the concept of scientific drawing, e.g., that the number of

The teacher asks the students to explain the cause of the puzzling phenomenon of mixing water and alcohol.	particles is related to mass and the height of the particles represents volume. The teacher can challenge students' thinking about particle size by asking which particle is larger (the alcohol or the water) to further engage gifted/more able students.

Reference:

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