Promoting the Use of Educational Technology in Learning and Teaching in Science (S1-3) Learning and Teaching Resources

Thermal expansion and contraction

Part A: Background and connections	
Topic	Thermal expansion and contraction
Relevant theme, topic and learning focus	Matter as particles
Prior knowledge	● The arrangement of particles in solid and liquid state. ● Using appropriate instruments to measure the volume of substances.
Previous and subsequent learning activities	<u>Previous learning activity</u>: ● Dissolving of table salt in water (the arrangement of particles in solid and liquid state). <u>Subsequent learning activity</u>: ● Overview on particle models and introduction to particle theory

Part B: Details of the learning activity	
Description	This learning activity involves the use of a technological platform, *DragGame*, to support students' development of sub-microscopic explanation of macroscopic observations in phenomena related to thermal contraction and expansion. Specifically, students are shown a set-up in which 0.2 cm^3 water is injected into a hot syringe (140°C). Water is made up of particles. As the temperature of water increases, the water particles move faster, the spaces between the particles become larger. Water is vapourised and becomes a gas when the temperature of the syringe is higher than the boiling point of water. The volume inside the syringe expands. When the syringe is cooled down, the water particles move slower, the spaces between the particles become smaller. The volume inside the syringe contracts. When the temperature drops below the boiling point, the water vapour condenses to form water droplets. The volume inside the syringe decreases and finally becomes 0.2 cm^3. Students develop rigorous explanation of *why* and *how* things happen in phenomena related to thermal expansion and contraction by constructing linkages between macroscopic and sub-microscopic levels.
Learning objectives	*After the lessons, students should be able to:* <u>Knowledge</u> - describe and explain volume expansion as a result of vaporisation of water using particle level diagrams - describe and explain volume contraction as a result of condensation of water using particle level diagrams <u>Skills</u> - make accurate scientific observations and measurements - create and evaluate particle level diagrams for explaining macroscopic observations related to thermal expansion and contraction
Segment time	80 minutes

Materials	Student Worksheet 1 tablet computer per student (or pair/trios of students) *DragGame* activity, available at: (Stage 1) https://draggame.e-learning.hk/en/templates/291/view/ (Stage 2) https://draggame.e-learning.hk/en/templates/292/view/ Assignment Task sheet Audio-visual materials Demonstration Video 1: https://bit.ly/439Ts5C Demonstration Video 2: https://bit.ly/3XADss8 Amination Video 1: https://bit.ly/4367S6E

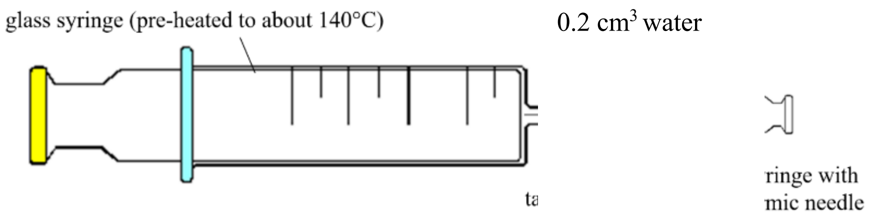
Part C: Implementation

Engagement
(Whole class; Individual work)
(7 minutes)

The teacher introduces the following scenario and assign **Task 1(a)**:

Scenario:

- The plunger of a capped syringe is pushed all the way in. The glass syringe is then heated to 140°C. A drop of water was (0.2 cm^3) is injected into the hot glass syringe.



Individually, students are asked to
(1) predict what they can observe in the set up,
(2) propose reasons for their predictions.

Exploration
(8 minutes)
(Group work)

Students are asked to share their ideas in groups (**Task 1(b)**).

(5 minutes)
(Whole class; Student presentation)

The teacher elicits and captures students' initial ideas and reasoning using public representations.
The teacher makes explicit that when making scientific explanation, it is important to think about what happens at the particle level.
The teacher uses the following questions to elicit and probe student thinking:

- Will the volume inside the hot syringe change?
- What will be the movement of the plunger?
- What substance(s) is/are found in the syringe?
- What is/are the physical state(s) of the substance(s) inside the glass syringe?
- Have the individual particles changed?
- What is between the particles in the hot gas syringe?

Group	Volume inside the	Movement of the	Substance(s) in the syringe	Arrangement of the

	hot syringe	plunger		particles
1				
2				
3				
4				

Note: Teachers should try capturing student ideas but NOT correcting their ideas.

Explanation
(Whole class)
(10 minutes)

The teacher assigns **Task 2(a)** and then performs a demonstration:

Demo Video 1: https://bit.ly/439Ts5C

- 0.2 cm^3 water is injected into the hot glass syringe using a small plastic syringe with a needle.

Students observe the *change in the volume* inside the glass syringe and the *movement of the plunger*.

(Student group work)
(15 minutes)

Students record their observations in **Task 2(a)**.

Students infer *what the substance* inside the glass syringe is.

Students are asked to use *DragGame* to represent the particle arrangement of the substance inside the glass syringe.

The teacher assigns students **Task 2(b)**.

Students first share their particle level diagrams and then discuss the 4 *DragGame* diagrams in a group. Students

(1) evaluate which diagram best represents what happens at the particle level for explaining the macroscopic observations in the demonstration.
(2) give reasons for their choice.

Students also develop explanation to explain how and why things happens at the macroscopic level.

(Whole class)
(15 minutes)

The diagrams capture students' common alternative conceptions:

- The size of the particles would increase because of the expansion of the volume inside the syringe.
- The size of the particles would decrease, and the number of particles would increase because of the 'breakdown' of the particles.
- The particles are all localised near the wall of the plunger instead of

	filling the whole syringe randomly and evenly because the particles are pushed by air/steam. Episodes C1, C2 and C3 show some examples of student explanation of their particle level diagrams. The teacher captures each group choice (i.e., A, B, C or D) using public representations.

	Group
A	
B	
C	
D	

Elaboration (Whole class; individual work) (10 minutes)	The teacher selects two groups to present their thinking. (*Sequence the student presentation by starting with a group choosing the incorrect choice and then a group choosing the correct choice*) In the discussion, the teacher press students to explain key ideas: ● the number of particles should remain unchanged because steam still consists of "water" particles. ● the size of the particles should remain unchanged because steam still consists of water particles; only the distance between the particles increases because the particles move faster. ● the distribution of the particles should be even because the movement of the particles is random. Teacher shows students the *Phet* animation Animation Demo Video: https://bit.ly/4367S6E https://phet.colorado.edu/sims/html/gases-intro/latest/gases-intro_en.html to introduce the concept: As the temperature increases, the particles move faster and the distance between the particles increases.
(Paired work; Whole class) (8 minutes)	The teacher performs another demonstration and assign **Task 3**: Demo Video 2: https://bit.ly/3XADss8 The teacher asks the students to observe what happens when the syringe is being cooled down. Students are asked to construct explanations of how and why things happen in the set-up using particle level diagrams on the *DragGame* platform.

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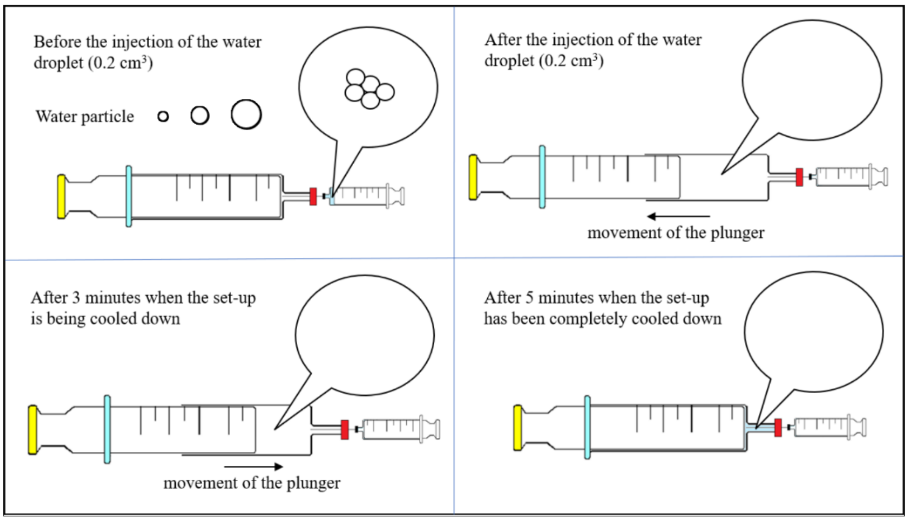

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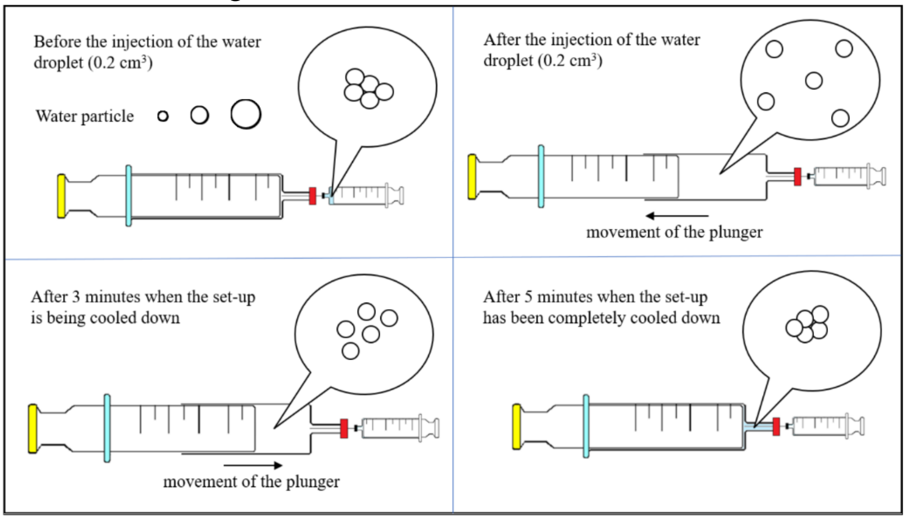
The teacher asks the student to share their explanations in a pair of 2. The teacher shows students the correct drawing and asks students if they have the same diagrams.



The teacher invites 1-2 pairs of students who share the same drawing to explain their diagrams.
The teacher summarises the students' sharing by highlighting the particle arrangement and the reasons for the changes in the arrangement.
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<td>Summary
(Whole class)
(2 minutes)</td>
<td>The teacher invites students to reflect on their learning by self-assessing if they can achieve the learning objectives use their hand to show their depth of understanding. A thumbs up means “a good understanding.” A thumb to the side means “I still have some questions.” A thumb down means “I don't get it.”</td>
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<td colspan="2">Part D: Extensions</td>
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<td>Possible adaptations / extensions / modifications</td>
<td>Depending on the progress of the lesson and student responses, the teacher can decide to use one of the following sets of the DragGame templates:
https://draggame.e-learning.hk/en/templates/262/view/
https://draggame.e-learning.hk/en/templates/263/view/
https://draggame.e-learning.hk/en/templates/264/view/
or
https://draggame.e-learning.hk/en/templates/291/view/</td>
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	https://draggame.e-learning.hk/en/templates/292/view/

Assessment
 	
On-the-fly formative assessment
 	
Evaluation
	Teachers can conduct on-the-fly formative assessments by making strategic adjustment in instruction based on students' drawings in the *DragGame* activities. The following shows some possible student responses:
	
	DragGame Activity 1 (*Game* 291)
	Possible alternative conceptions:
	- number of water particles
	    o increases as the volume inside the syringe increases
	- size of water particles
	    o becomes bigger
	    o due to the thermal 'expansion' of particles
	- distribution of water particles
	    o all are located near the plunger, 'pushing' the wall
	    o all are 'adhering' to the inner wall of the glass syringe
	    o particles are closely-packed/ concentrated at one region
	    o occupying all the space but not in a random fashion
	- air is present in the syringe
	- steam is something different from vaporised water particles
	DragGame Activity 2 (*Game* 292)
	Possible alternative conceptions include:
	- number of water particles
	    o decreases as the volume of the plunger decreases
	- size of water particles
	    o becomes smaller
	    o due to the thermal 'contraction' of particles
	- distribution of water particles
	    o all are located near the needle, 'sucking back' to the plastic syringe
	    o all are 'adhering' to the inner wall of glass syringe
	    o particles are closely-packed/ concentrated at one region
	    o particles are 'collapsing'
	
	The teacher assigns **Assignment Task sheet** as a take-home assignment to summative assess transfer of learning.

Notes to teachers for effective implementation

- The teacher should create an open and warm classroom environment for students to expose their ideas and share their thoughts publicly.
- The teacher can ask students to clarify their *DragGame* drawings and elaborate on their thought and reasoning using dialogic moves (e.g., *Say more*, *Press for reasoning*).
- The teacher can repeat, acknowledge and revoice students' ideas and invite other students to comment on their ideas using dialogic moves (e.g., *Revoice*, *Agree/disagree*, *Add on*).
- Teachers can try to make use of and refer to student ideas when guiding the class to build a class consensus when building explanations so that students think that their ideas are valued by the teacher.
- One major limitation of *DragGame* or any kind of drawn particle diagrams is that the drawing is a static representation and cannot adequately portray and model the time flow of a series of events. This limitation can be addressed by using a 4-grid manga that takes into account the temporal sequence of a process.
- Energy required for change of state can be briefly introduced to enhance connection of ideas between different units within the junior science curriculum although it is not the major objective of this lesson.

Developed by Faculty of Education, The University of Hong Kong