The Use of “DragGame” for Enhancing Learning and Teaching in Science (S1-3)

Workshop on designing interactive e-learning activities using Drag Game platform

March 17, 2023

Outline

- Explain why modelling is important for students' academic success at higher class levels using DragGame as an example
- Co-design e-learning activities to support student understanding at the submicroscopic worlds using the DragGame
- Share and discuss the design

Why DragGame?

A curriculum coherence perspective

1. What is “curriculum coherence”? Why is it important?

2. How to create coherent learning experiences of “particles”?

Defining "curriculum coherence"

"Curriculum coherence [is] the alignment of the specified **ideas**, the **depth** at which the ideas are studied, and the **sequencing** of the topics within each grade and across the grades." (Fortus and Krajcik, 2012, p. 783)

Fortus, D., & Krajcik, J. (2012). Curriculum Coherence and Learning Progressions. In B. J. Fraser et al. (Eds.), *Second International Handbook of Science Education* (pp. 783-798). Springer.

Why "curriculum coherence"?

"Learning unfolds across time as students **link** previous ideas and experiences to new ideas and experiences… Coherence [...] is crucial in supporting student learning by providing **alignment** between standards, instructional tasks, and assessments across grades and grade bands."

Fortus, D., & Krajcik, J. (2012). Curriculum Coherence and Learning Progressions. In B. J. Fraser et al. (Eds.), *Second International Handbook of Science Education* (pp. 783-798). Springer.

Types of curriculum coherence

- **Content standards coherence**, which reflects the content hierarchy from particulars to deeper structures
- **Learning goals coherence**, achieved when age and topic-appropriateness learning experienced are sequenced to allow increasingly sophisticated grasp
- **Inter-unit coherence**, achieved when units builds off one another for the students to reach increasingly higher level of knowledge integration
- **Intra-unit coherence**, which involves coordination between coherence of scientific practices, inquiry task sequence and coherence of assessment

Fortus, D., & Krajcik, J. (2012). Curriculum Coherence and Learning Progressions. In B. J. Fraser et al. (Eds.), *Second International Handbook of Science Education* (pp. 783-798). Springer.

Coherence in Next Generation Science Standards

Physical Science Progression

INCREASING SOPHISTICATION OF STUDENT THINKING

	K-2	3-5	6-8	9-12
PS1.A Structure of matter (includes PS1.C Nuclear processes)	Matter exists as different substances that have observable different properties. Different properties are suited to different purposes. Objects can be built up from smaller parts.	Matter exists as particles that are too small to see, and so matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials.	The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter.	The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter, including chemical reactions and nuclear processes. Repeating patterns of the periodic table reflect patterns of outer electrons. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy to take the molecule apart.
PS1.B Chemical reactions	Heating and cooling substances cause changes that are sometimes reversible and sometimes not.	Chemical reactions that occur when substances are mixed can be identified by the emergence of substances with different properties; the total mass remains the same.	Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.	Chemical processes are understood in terms of collisions of molecules, rearrangement of atoms, and changes in energy as determined by properties of elements involved.
			The role of the mass of an object must be	Newton's 2nd law (F=ma) and the

NGSS Lead States. (2013). Appendix E – Progressions Within the Next Generation Science Standards. *Next Generation Science Standards: For States, By States*. The National Academies Press. https://www.nextgenscience.org/sites/default/files/resource/files/AppendixE-ProgressionswithinNGSS-061617.pdf

A closer look of PS1.A of NGSS

Structure
Properties
Conservation

3-5	6-8	9-12
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NGSS Lead States. (2013). Appendix E – Progressions Within the Next Generation Science Standards. *Next Generation Science Standards: For States, By States*. The National Academies Press. https://www.nextgenscience.org/sites/default/files/resource/files/AppendixE-ProgressionswithinNGSS-061617.pdf

Curriculum coherence in Hong Kong

“Holistic curriculum development is recommended to ensure **vertical continuity** and **lateral coherence** in the planning of a school Science curriculum. A coherent Science curriculum with smooth **transition and progression between key stages** enables students to establish a solid foundation in science and proceed smoothly from one key stage to another.” (CDC, 2017, p.49)

The Curriculum Development Council [CDC]. (2017). *Science Education Key Learning Area Curriculum Guide (Primary 1 – Secondary 6)*. HKSAR Government.

"Particle"-related objectives in KS3 Science (1)

Secondary 1: Unit 6 Matter as Particles

- State that all matter is made up of **particles**
- Recognise that **particles** are in random motion
- Recognise that there are empty spaces between **particles**
- Give examples of **atoms** and simple **molecules**
- Recognise that different **particles** have different sizes and masses
- Recognise the arrangement of **particles** in the three states of matter
- Describe the process of dissolving using the **particle** theory
- Explain the change in volume when a solid is dissolved in water using the **particle** theory
- State the effect of temperature change on the movement of **particles**
- Explain thermal expansion and contraction using the **particle** theory
- *Recognise that the existence of gas pressure is due to gas **particles** hitting against the walls of a container*
- *Explain the change in gas pressure at different temperatures using the **particle** theory*
- *Explain the effect of temperature change on the density of a substance using the **particle** theory*

The Curriculum Development Council. (2017). *Supplement to the Science Education Key Learning Area Curriculum Guide: Science (Secondary 1-3)*. HKSAR Government.

Interfacing with Physics (S4 - 6)

Science (S1–3)		Physics	
Unit	Title	Topic	Title
6.1	States of matter	I	Heat and Gases
6.2	Illustrations for the support of the claims of the particle theory		
6.3	Particle model for the three states of matter		
6.4	Gas pressure		

Curriculum Development Council and The Hong Kong Examinations and Assessment Authority. (2017). *Physics Curriculum and Assessment Guide (Secondary 4 - 6)*. HKSAR Government.

"Particle"-related objectives in KS3 Science (2)

Secondary 3: Unit 13 From Atoms to Materials

- Recognise that all matter is composed of small particles called **atoms**
- Be aware of the relationship between elements and **atoms**
- Describe the structure of an **atom** in terms of protons, neutrons and electrons
- Be aware that atomic number represents the number of protons in the nucleus of an **atom**
- Recognise that the mass number of an **atom** is the sum of the number of protons and the number of neutrons
- Be aware that scientists in the past organise elements according to the mass of **atoms** and their chemical properties
- Recognise crude oil as a mixture of hydrocarbon **molecules** of different sizes
- *Relate the physical properties of the hydrocarbons to their [molecular] sizes*
- Recognise that plastics are macromolecules made by joining up many hydrocarbon **molecules**

The Curriculum Development Council. (2017). *Supplement to the Science Education Key Learning Area Curriculum Guide: Science (Secondary 1-3)*. HKSAR Government.

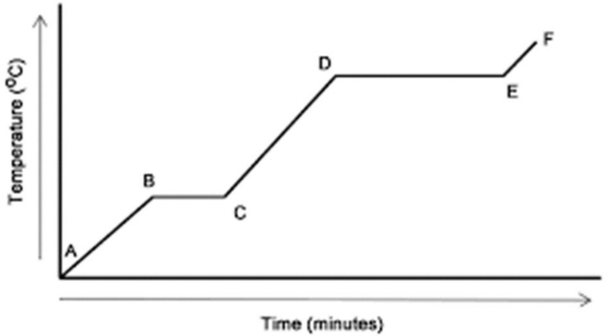
Interfacing with Chemistry (S4 - 6)

Science (S1-3)		Chemistry	
6.1	Particle theory	II. VI.	Microscopic world I Microscopic world II
6.2	Particle model for the three states of matter		
6.3	Dissolving		
13.1	Atoms and elements	II.	Microscopic world I
13.2	Periodic Table		
13.3	Mixtures and compounds	I.	Planet earth

Curriculum Development Council and The Hong Kong Examinations and Assessment Authority. (2017). *Chemistry Curriculum and Assessment Guide (Secondary 4 - 6)*. HKSAR Government.

An example: Cooling curve (Topic I a & c in DSE Physics)

- interpret temperature as a quantity associated with the average kinetic energy due to the **random motion** of **molecules** in a system
- describe the effect of mass, temperature and **state** of matter on the internal energy of a system
- relate internal energy to the sum of the kinetic energy of **random motion** and the potential energy of **molecules** in the system
- realise latent heat as the energy transferred during the **change of state** without temperature change
- interpret latent heat in terms of the change of potential energy of the **molecules** during a **change of state**



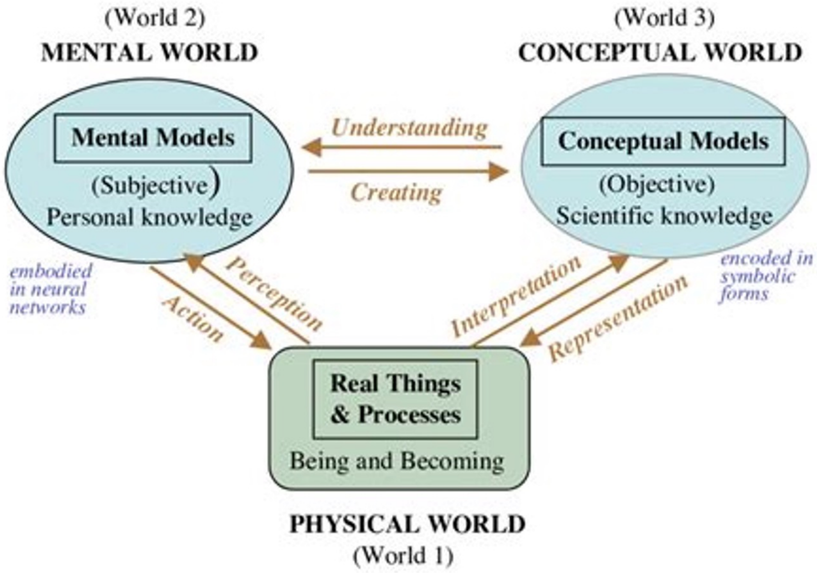
Curriculum Development Council and The Hong Kong Examinations and Assessment Authority. (2017). *Physics Curriculum and Assessment Guide (Secondary 4 - 6)*. HKSAR Government.

Does the particle model explain your observations?

“Yes, the **particle model can explain the phase changes from solid → liquid → gas**. In this example of the ice, the application of the model is straightforward. When ice is heated, the energy transferred to the ice increases the vibration of the water particles. This increased vibration breaks down some of the attractive forces between the water particles in the solid. The solid melts to give liquid water where the water particles can slide past each other easily.” (Royal Society of Chemistry, n.d.)

Royal Society of Chemistry. (n.d.) Develop and use models in your teaching: Evaluate the particle model of matter. *Education: Inspiring your teaching and learning*. https://edu.rsc.org/resources/use-the-particle-model-of-matter/2387.article

Deep learning of the particle model?



“Students' experiences with scientific models help them to develop their own mental models of scientific concepts.” (Treagust *et al.*, 2002)

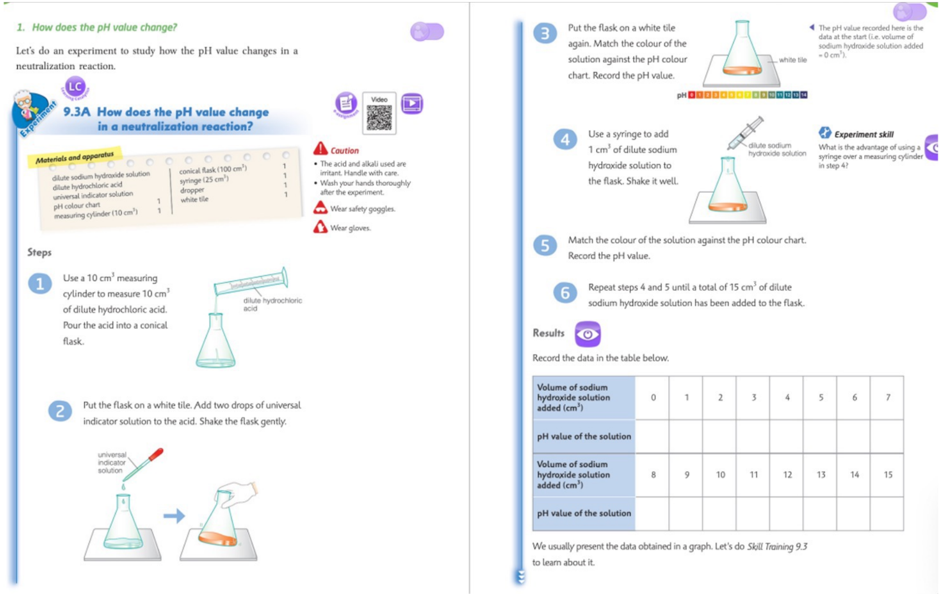
Hestenes, D. (2006). Notes for a Modeling Theory of Science, Cognition and Instruction. *Proceedings of the 2006 GIREP conference: Modelling in Physics and Physics Education*. http://modeling.asu.edu/R&E/Notes_on_Modeling_Theory.pdf

Treagust, D. F., Chittleborough, G., & Mamiala, T. L. (2002) Students' understanding of the role of scientific models in learning science. *International Journal of Science Education*, *24*(4), 357-368. doi: 10.1080/09500690110066485

Co-construction of learning experiences

Examination of textbook section (15 min)

- Read the textbook section about neutralization
- Identify the learning objective(s) of the practical work activity



1. How does the pH value change?

Let's do an experiment to study how the pH value changes in a neutralization reaction.

Experiment 9.3A How does the pH value change in a neutralization reaction?

Materials and apparatus

dilute sodium hydroxide solution		conical flask (100 cm^3)	1
dilute hydrochloric acid		syringe (25 cm^3)	1
universal indicator solution		dropper	1
pH colour chart	1	white tile	1
measuring cylinder (10 cm^3)	1		

Caution
- The acid and alkali used are irritant. Handle with care.
- Wash your hands thoroughly after the experiment.

Wear safety goggles.

Wear gloves.

Steps

1. Use a 10 cm^3 measuring cylinder to measure 10 cm^3 of dilute hydrochloric acid. Pour the acid into a conical flask.
2. Put the flask on a white tile. Add two drops of universal indicator solution to the acid. Shake the flask gently.
3. Put the flask on a white tile again. Match the colour of the solution against the pH colour chart. Record the pH value.

The pH value recorded here is the data at the start (i.e. volume of sodium hydroxide solution added = 0 cm^3).

4. Use a syringe to add 1 cm^3 of dilute sodium hydroxide solution to the flask. Shake it well.

Experiment skill: What is the advantage of using a syringe over a measuring cylinder in step 4?

5. Match the colour of the solution against the pH colour chart. Record the pH value.
6. Repeat steps 4 and 5 until a total of 15 cm^3 of dilute sodium hydroxide solution has been added to the flask.

Results

Record the data in the table below.

Volume of sodium hydroxide solution added (cm^3)	0	1	2	3	4	5	6	7
pH value of the solution								
Volume of sodium hydroxide solution added (cm^3)	8	9	10	11	12	13	14	15
pH value of the solution								

We usually present the data obtained in a graph. Let's do *Skill Training 9.3* to learn about it.

Neutralization

Discussion (8 min)

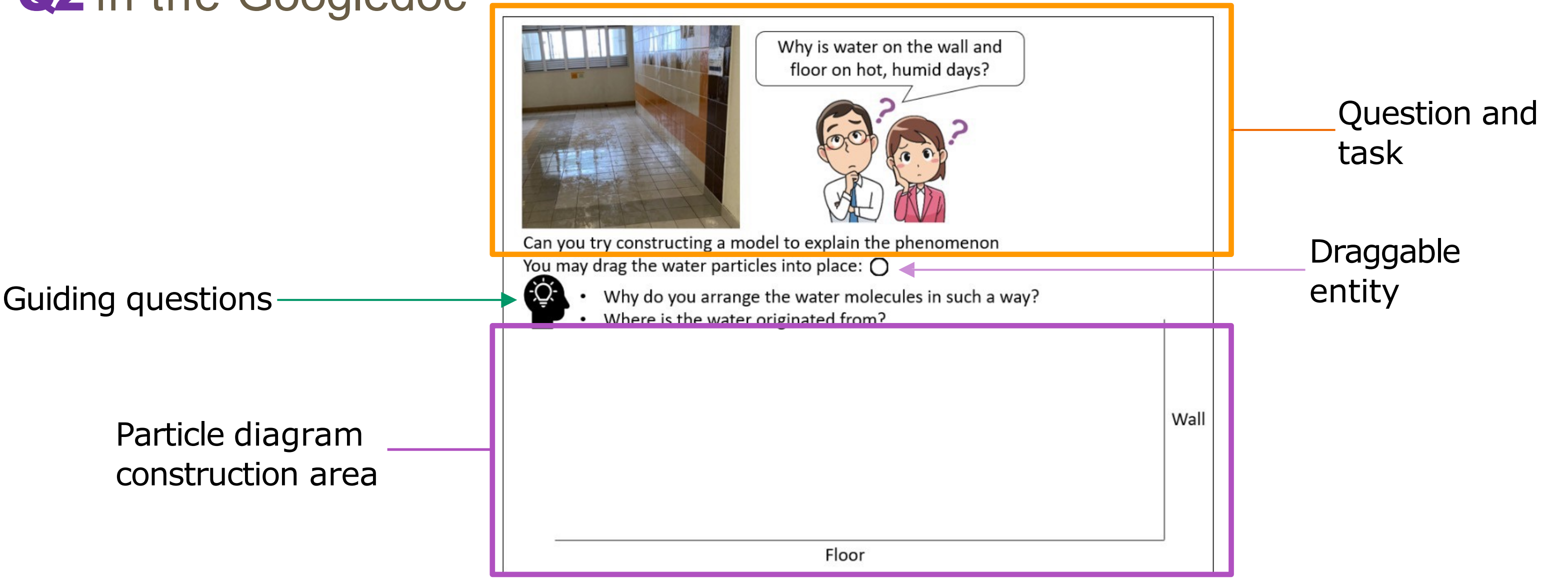
- How would you revise the LOs and/or the activity to facilitate students understanding of neutralization at the particle level?

- Answer the question by completing **Q1** in the Googledoc

Neutralization

DragGame e-learning activity design (20 min)

- Use PowerPoint to design a slide that represents the activity layout
- Answer **Q2** in the Googledoc



Use the DragGame to generate your e-learning activity

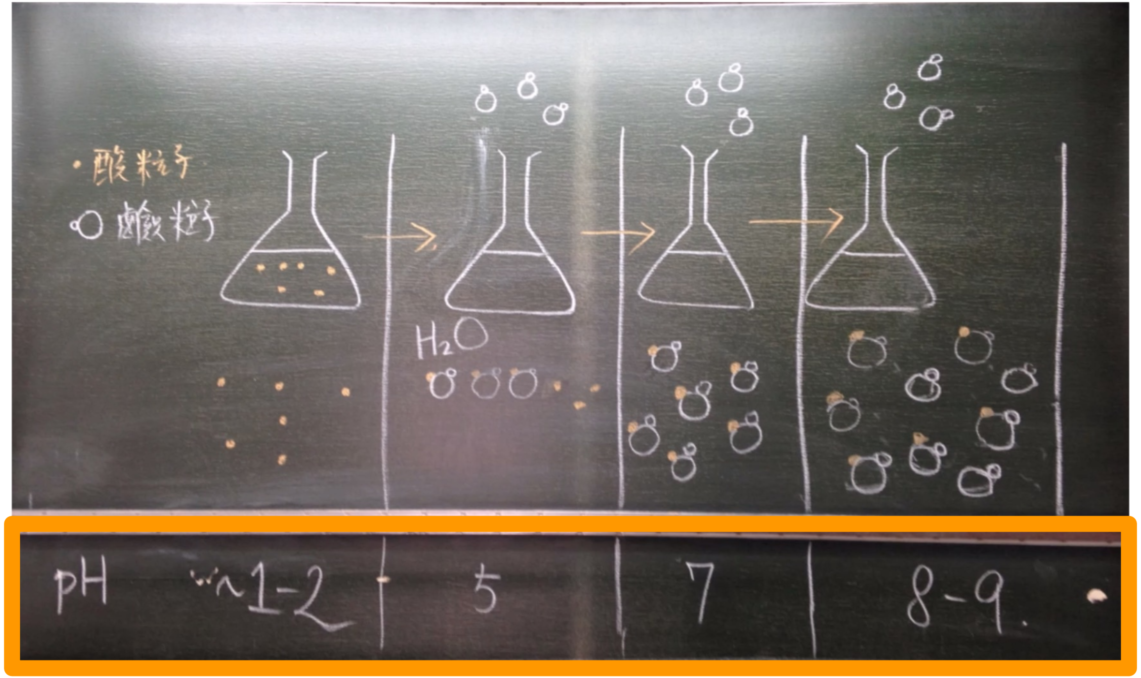
- Preparing pictures (background and draggable entities) for import
  - Duplicate the slide and remove the draggable entities

    (this serves as the background picture)
  - Save the draggable entities as individual pictures

    (they serve as draggable entities that you can set the quantity in the platform)

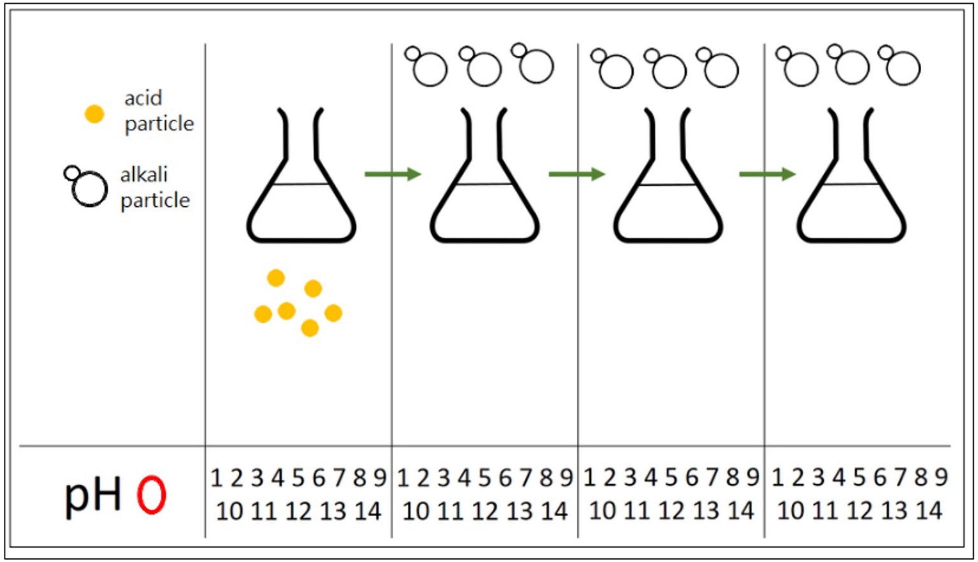
- https://draggame.e-learning.hk/
- WS01, WS02, WS03, WS04, WS05
- PW: 20230317
- Complete Q3 in the Googledoc

Student-generated diagrams



Data from the practical

Affordance of the DragGame e-learning activity



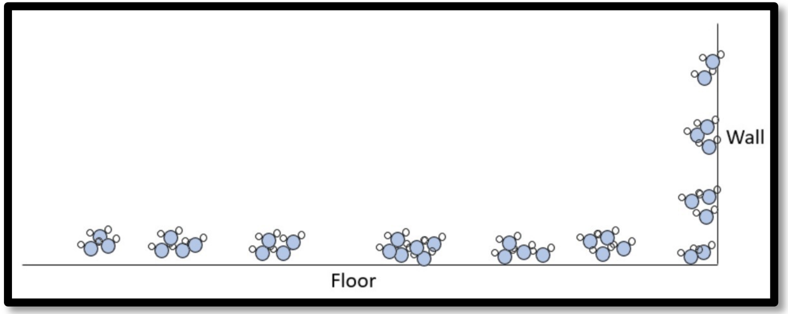
Eliciting student ideas

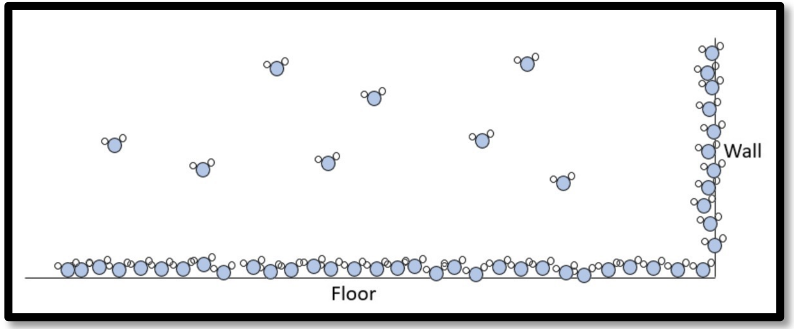
Can you try constructing a model to explain the phenomenon
You may drag the water particles into place: ○

- Why do you arrange the water molecules in such a way?
- Where is the water originated from?

Wall

Floor


Wall
Floor


Wall
Floor

Key messages

- Smooth transitions between different Key Stages are needed

- Curriculum coherence ensures aligned students' learning experiences & good transitions

- Creating visualised models facilitate students' development of mental models