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

Workshop on Desigining e-Learning Activities using "DragGame" for Enhancing Learning and Teaching in Science (S1-3)

April 28, 2023

Outline

- Explain why modelling is important for students' academic success at higher class levels using DragGame as an example

- Discuss different designs of DragGame e-learning activities to support student understanding at the submicroscopic worlds

- Hands-on experience in constructing e-learning activities using DragGame

Why DragGame?

A curriculum coherence perspective

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

1. 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.

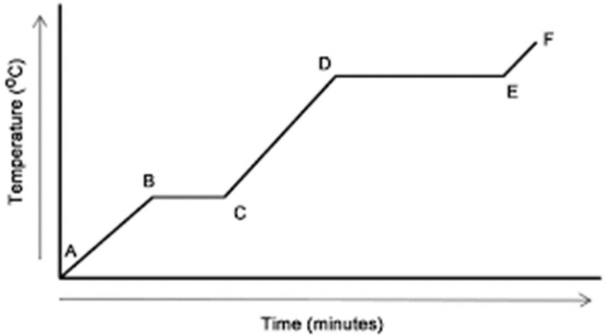
Interfacing with Chemistry (S4 - 6)

Science (S1-3)		Chemistry	
6.1	Particle theory	II.	Microscopic world I
6.2	Particle model for the three states of matter	VI.	Microscopic world II
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**



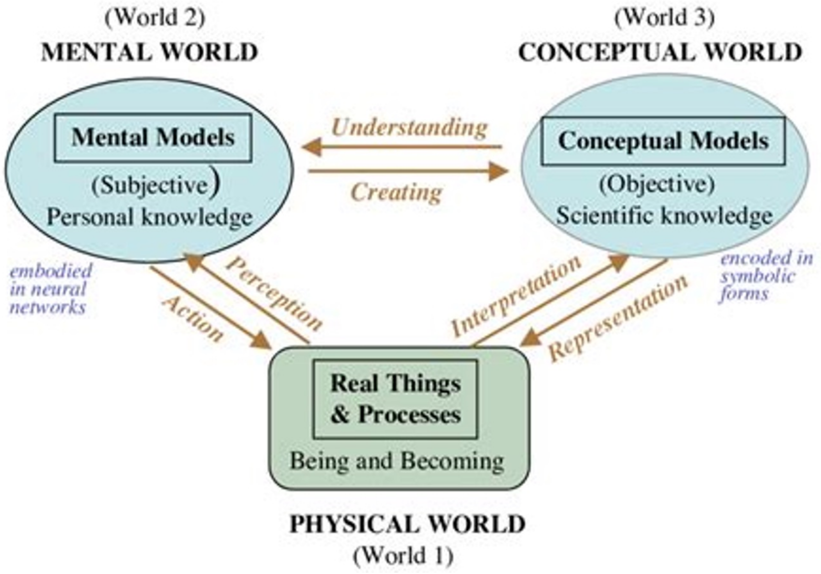
Curriculum Development Council and The Hong Kong Examinations and Assessment Authority. (2017). *Physics Curriculum and Assessment Guide (Secondary 4 - 6)*. HKSAR Government.

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)

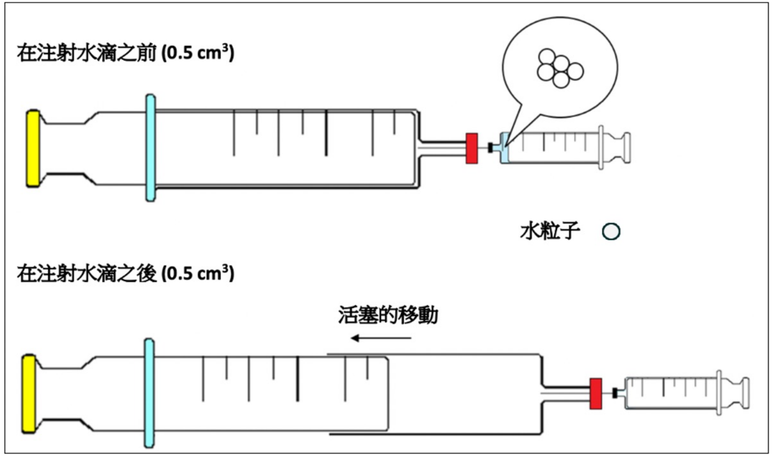
Hestenes, D. (2006). Notes for a Modeling Theory of Science, Cognition and Instruction. *Proceedings of the 2006 GIREP conference: Modelling in Physics and Physics Education.* http://modeling.asu.edu/R&E/Notes_on_Modeling_Theory.pdf

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

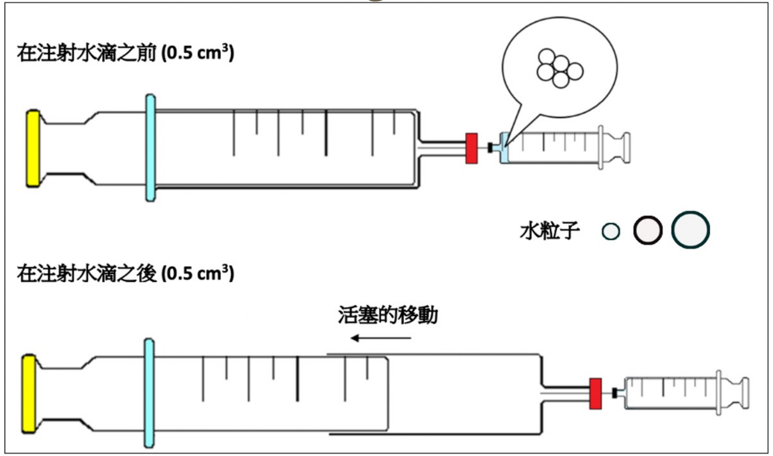
Exploring different designs of DragGame e-learning activities

Different physical states of matter

Design A



Design B



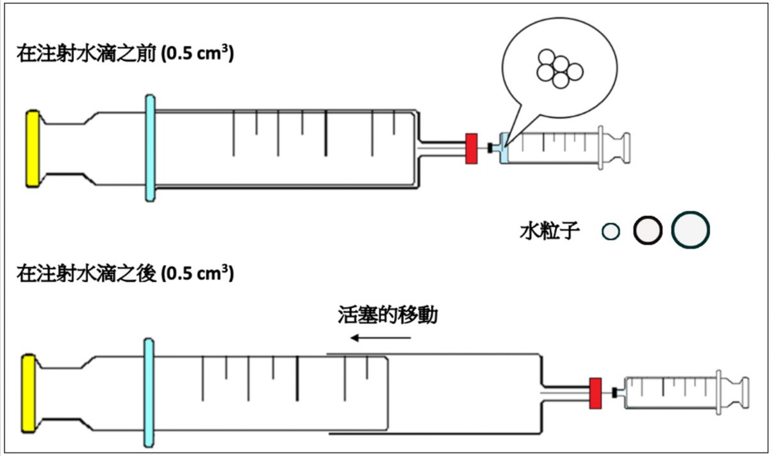
- The glass plunger is pre-heat to 140°C
- What are the observations?
- What ideas can be discussed with students using the two different designs?
- How does the purpose of teaching differ in the two designs?

Different physical states of matter

Discussion (Group Activity)

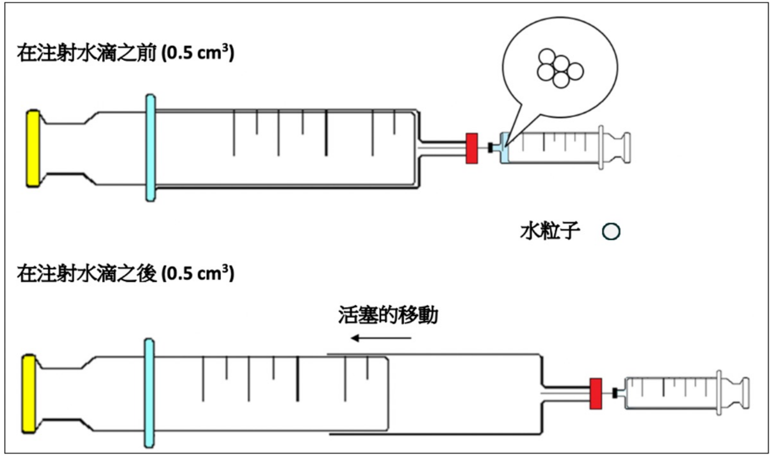
- Use the activity to produce a possible student's representation which reflect alternative idea(s)
- Insert the representation in the Google doc
- Write down the alternative idea(s) reflected in the representation

Design B

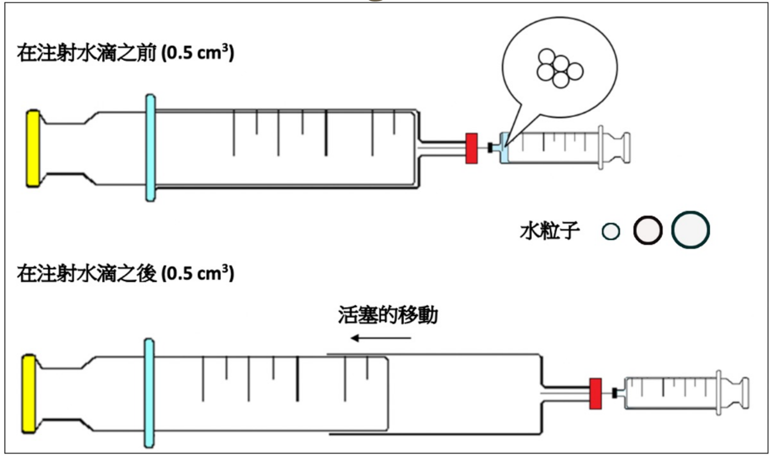


Different physical states of matter

Design A

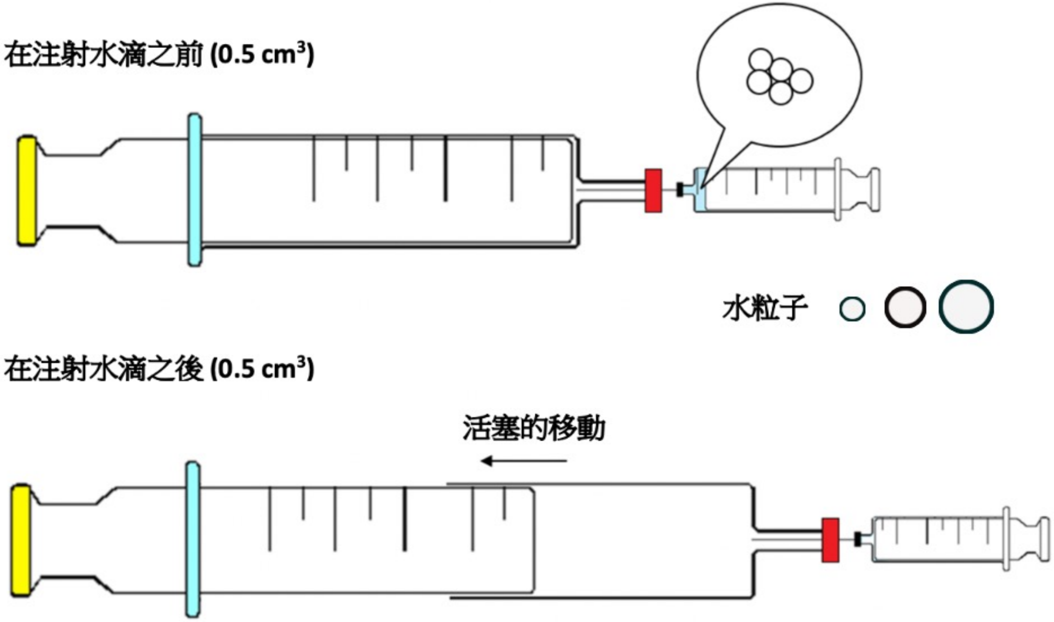


Design B



- Visualization of particles
- Elicitation of possible alternative ideas
- Construction of explanation

Layout of DragGame Example

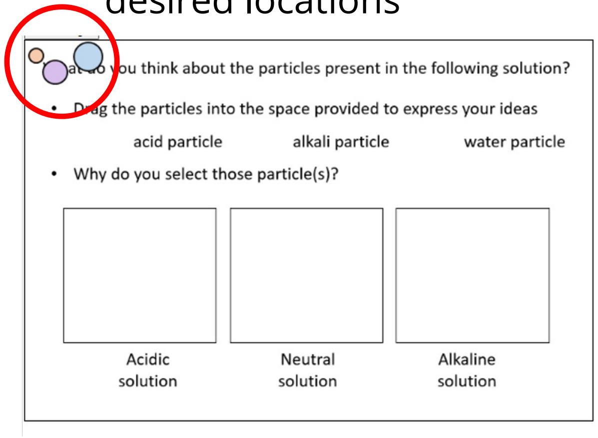


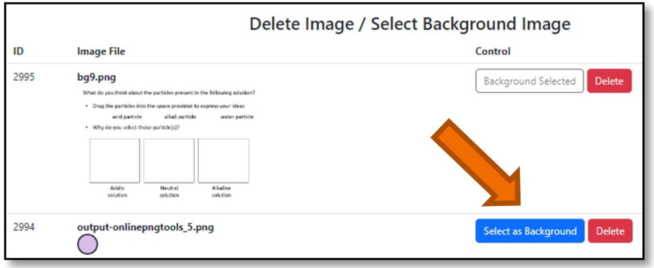
https://draggame.e-learning.hk/en/templates/312/view/

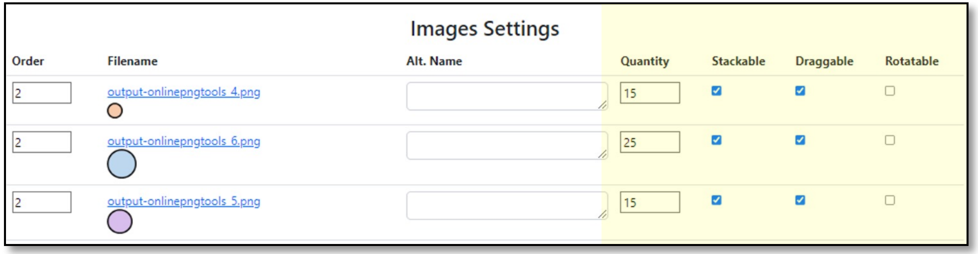
Using DragGame to generate the e-learning activity

- https://draggame.e-learning.hk/
- WS01, WS02, WS03, WS04, WS05
- PW: 20230317

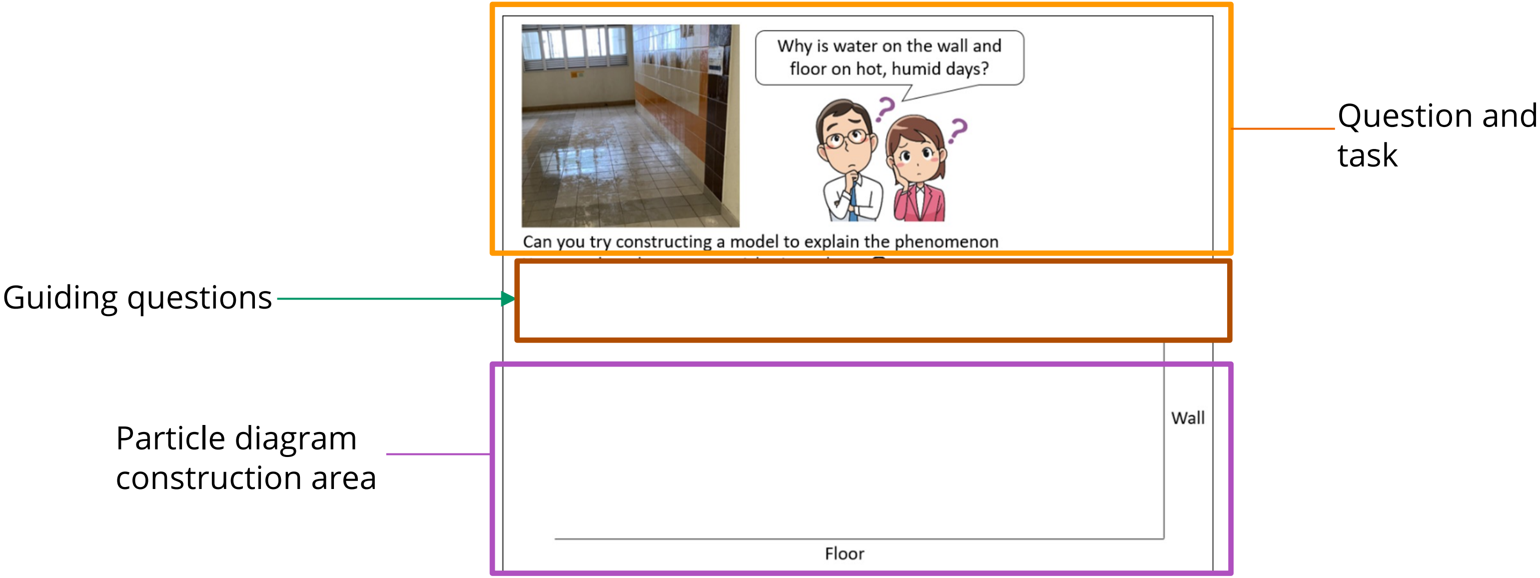
Place the draggable entities to desired locations





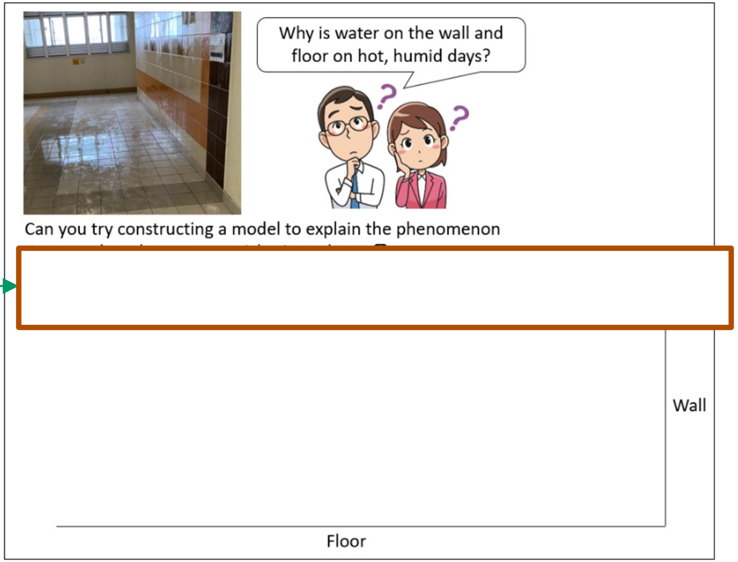


Designing DragGame e-learning activity background



Designing DragGame e-learning activity background

Design the instruction and guiding questions



- Use the background template ppt for your design
- Export the slide as picture

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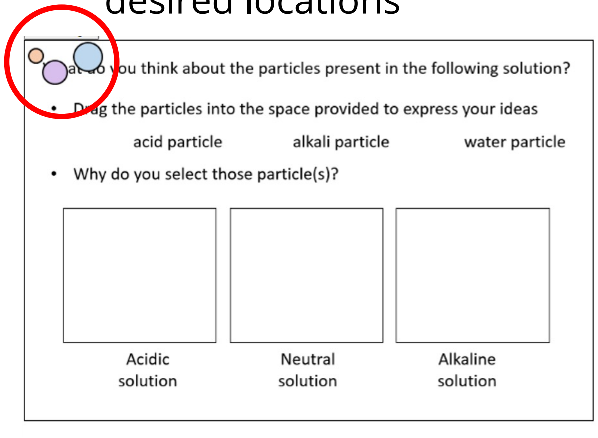
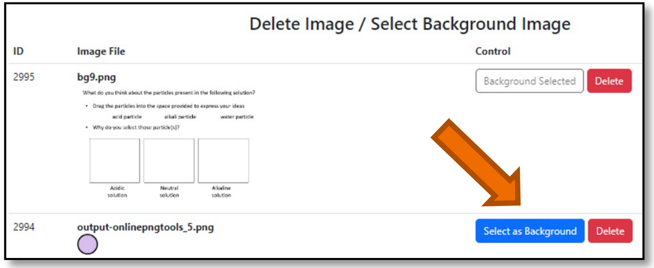
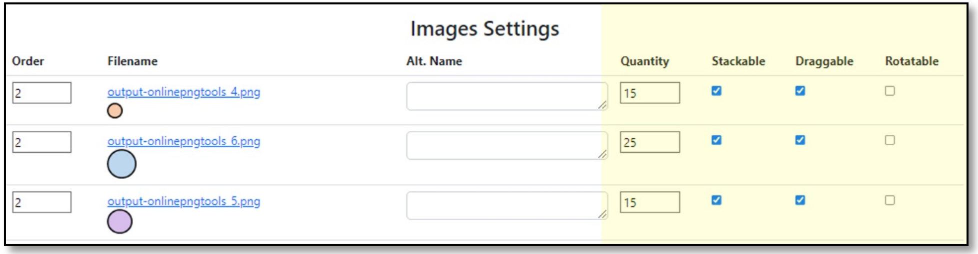






Integrating knowledge in daily life

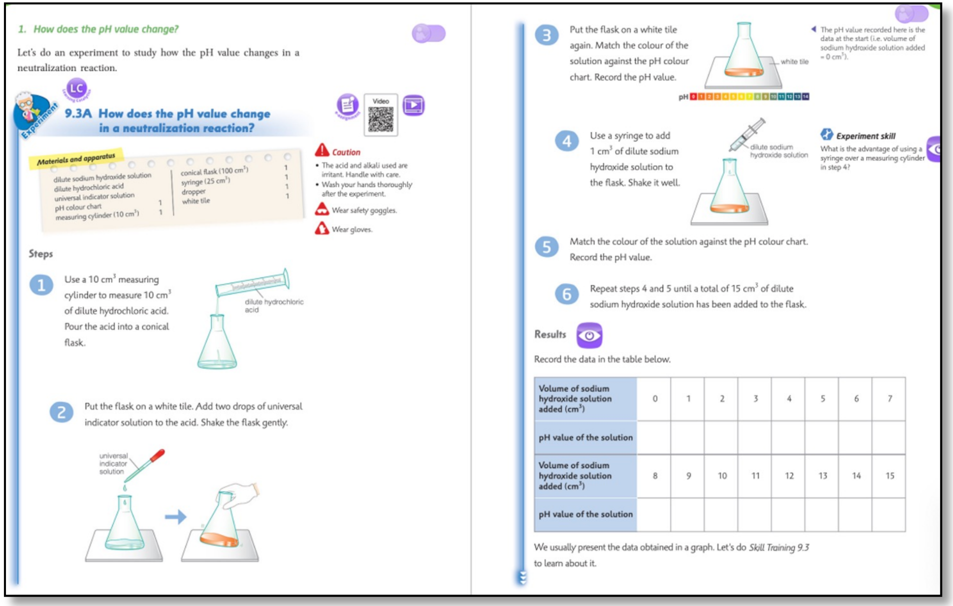
Discussion (Group Activity)

- Construct two representations (1. alternative vs 2. scientific)

- What are the ideas missing/alternative in representation (1)?

- What is the idea(s) that cannot be represented in the representation (2) but is involved in reasoning about the phenomenon?

Enhancing understanding at the minds-on level



1. How does the pH value change?

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

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

Experiment

LC

Video

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.

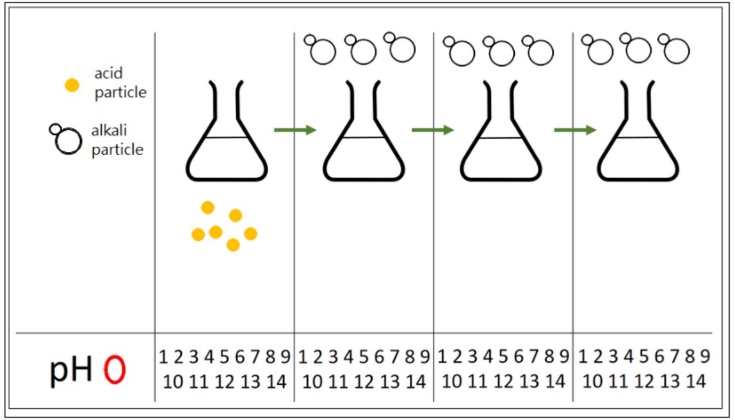
6. Repeat steps 4 and 5 until a total of 15 cm^3 of dilute sodium hydroxide solution has been added to the flask.

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.



(https://draggame.e-learning.hk/en/templates/236/view/)

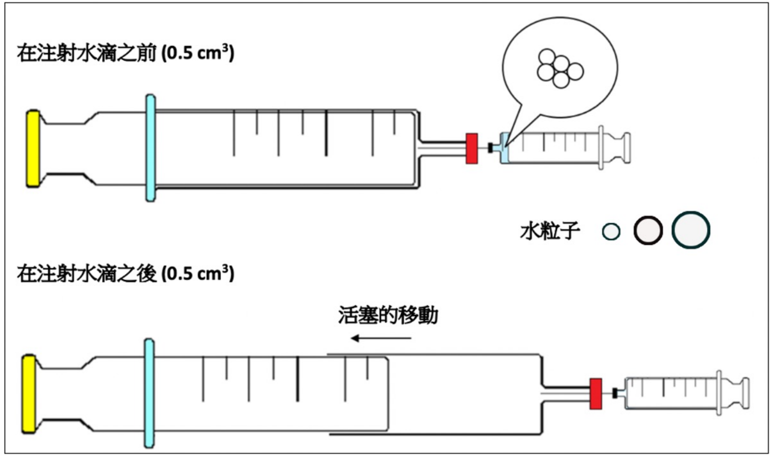
Affordance of DragGame e-learning activities

- Develop consensus on the meaning of representations
- Student works are comparable
- Students can revise their work immediately after discussion/learning
- Less time consuming than drawing diagrams
- The same activities can be administered before/during/after lessons with different teaching purposes.

Key messages

- Smooth transitions between different Key Stages are needed
- Curriculum coherence ensures aligned students' learning experiences & good transitions
- DragGame e-learning activities should be designed with clear teaching purposes

Acknowledgement



This DragGame e-learning activity is prepared by Mr. Ka Yeung Poon and his teams at St. Paul’s School (Lam Tin)

Workshop Materials

Different physical states of matter
https://draggame.e-learning.hk/en/templates/312/view/

Design materials and Group Activity:
https://bit.ly/44mOTXe

Water in hot humid day
https://draggame.e-learning.hk/en/templates/275/view/

Neutralization
https://draggame.e-learning.hk/en/templates/236/view/