



香港教育大學

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How to create my own science experiments?

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and Environmental Studies

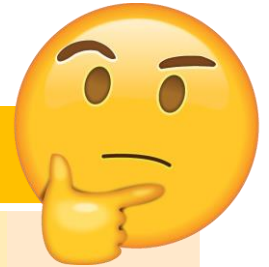
Motivations and Objectives



- Due to pandemic, all courses are delivered online;
science courses with experiments face extra challenges
- Since science experiments require special apparatus, chemicals, laboratory spaces, etc., it can be **difficult or dangerous for learners to conduct experiments at home in online lessons**
- In this project, we aim
 1. To **identify problems encountered by learners** in online science courses with experimental components
 2. To **identify strategies**, mechanism or platforms which enable **learners experience experimental components** and acquire experimental skills in online science courses
 3. To identify and **devise good practices** of conducting experimental components with learners for non-face-to-face course delivery

Simulations VS Animations/Videos

- Although they look similar, there are indeed difference between simulations and animations/videos:



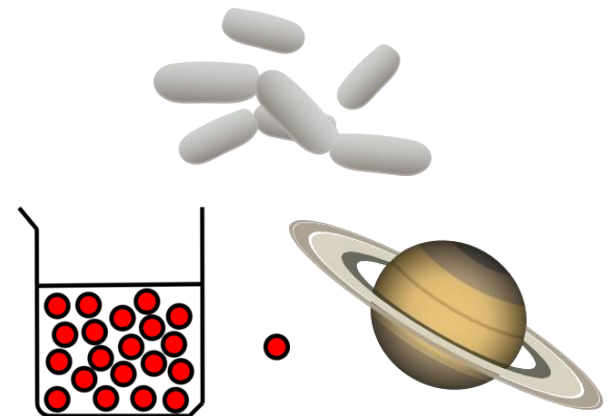
Animations/Videos	Simulations
<ul style="list-style-type: none">•	<ul style="list-style-type: none">•
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Advantages of simulation in science ed.

- Simultaneous **different representation** of the same concepts (e.g. movie, graph, etc.)
- **Visualize** and **understand** abstract science concepts
- **Replace** dangerous/infeasible/expensive experiments
- Change in **time-scale, size-scale**
- Active, hands-on learning
- Group-collaboration

Applications:

- **Lectures** (visualization, demonstrations, **experiments**, discussions)
- **Pre-lab**
- **Group projects**

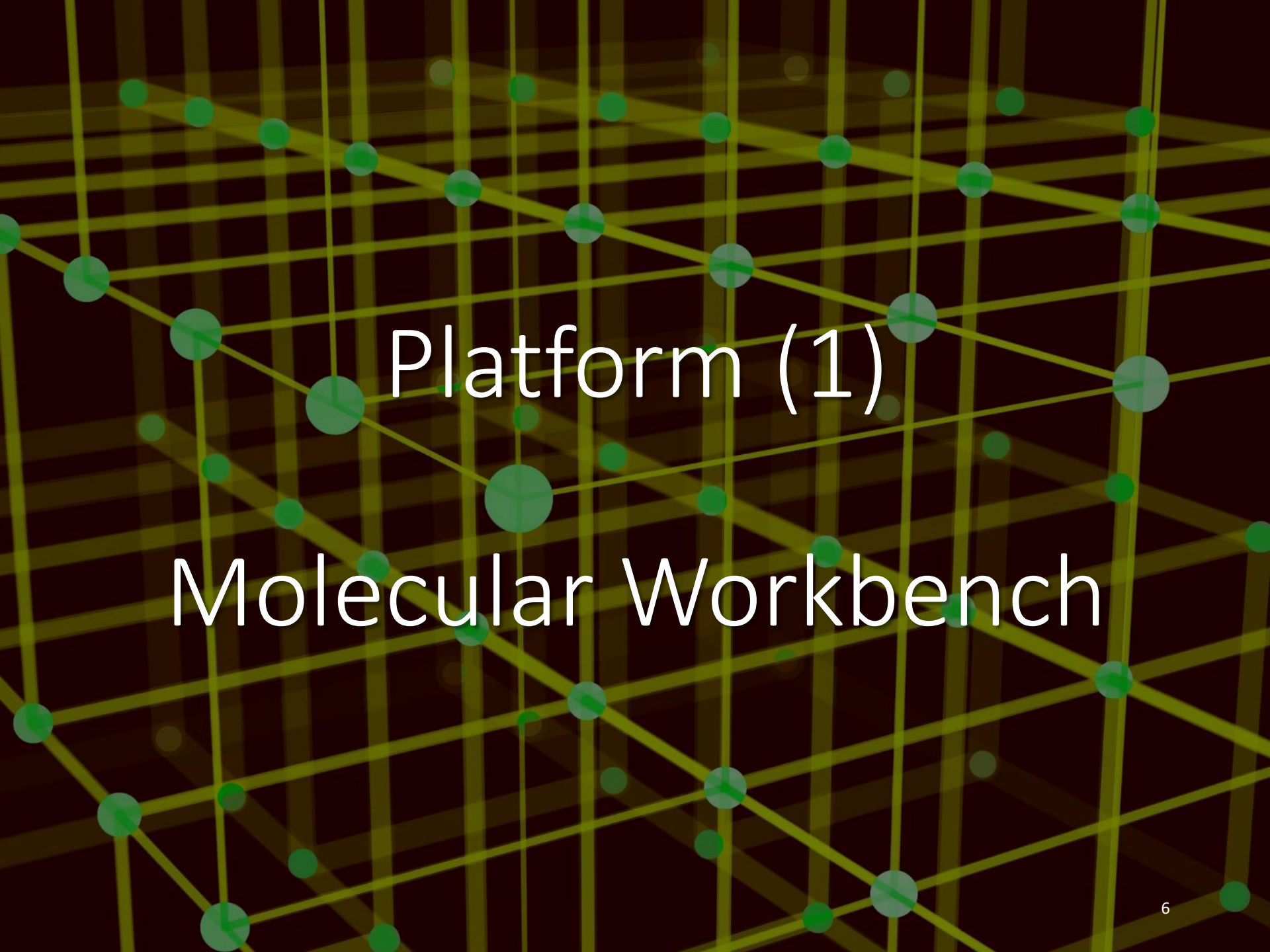


Reference

R. Lindgre , Spatial learning and computer simulations in science (2009)
D. Gende, Science Simulations: A Virtual learning environment (2011)

Method 1

Adopting existing
simulations in your own way



Platform (1)

Molecular Workbench

(1) Molecular Workbench (free)

- **Molecular Workbench** is **free and open software** – “a modeling tool for teachers and students to create their own simulations and share them with collaborators”:

<http://mw.concord.org/modeler/>

<http://mw.concord.org/nextgen/>

- Developed **Concord Consortium**, a non-profit educational research and development organization based in Concord, Massachusetts



Visual, Interactive Simulations for Teaching & Learning Science
FREE AND OPEN SOURCE



Hundreds of Simulations

Explore physics, chemistry, biology, biotechnology, and nanotechnology.



Embedded Assessments

Real-time reports provide a complete view of student learning progression.



Create and Customize

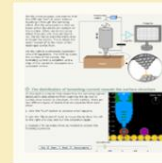
Customize any model or create one with powerful modeling tools.

Selected Curriculum Modules

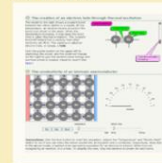
Transistor



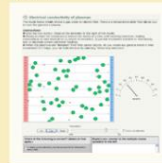
STM



Semiconductor



Plasma



Molecular Rover



Chemical Bonding



Chemical Resp.



Diffusion



How teachers use it?

- Teachers can set up online learning platform (e.g. google sites), **embed the simulated experiments**, and incorporate questions for students to adjust parameters

- Example:**



S1 UNIT6: MATTER AS PARTICLES

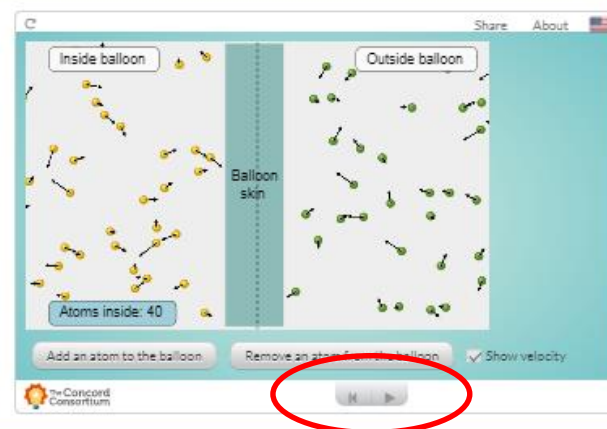
6.5 Gas Pressure

Class overview

In this online module, we will adjust parameters in the following simulated experiments, and investigate the relationship between **temperature**, **volume** and **pressure** of gas.

Experiment 1

Let's blow up a balloon!



Experiment 1

Let's blow up a balloon!

Click the "run button (the triangle)" under the simulated experiment, without adding or removing atoms from the balloon, does the balloon skin move? 1 point

Yes, it moves

No, it does not move

When we blow and add atoms to the balloon, what happens to the balloon skin? 1 point

move inside

move outside

8

How to make it?

- It is indeed very simple:

Molecular workbench next-generation

A screenshot of the Molecular Workbench interface. A 'Share' dialog box is open, showing options to share via email or IM, and to embed on a website or blog. The 'Embed' section is highlighted with a red circle, showing the following HTML code:

```
<iframe width="618px" height="418px" frameborder="no" scrolling="no" allowfullscreen="true" webkitallowfullscreen="true" mozallowfullscreen="true" src="https://lab.concord.org/embeddable.html#interactives/jsmol/jsmol-dna.json">
```


 The 'Share' button in the top right of the dialog is also circled in red. The background shows a DNA model and various controls.

A screenshot of the Google Sites 'Embed from the web' dialog box. The 'By URL' tab is selected, and the 'Embed code' button is circled in red. Below the button is a text area with the placeholder text 'html code goes here'. The dialog also includes 'Cancel' and 'Next' buttons. The background shows the Google Sites editor interface with the 'Insert' menu open and the 'Embed' option circled in red.

Google site

A screenshot of the Google Sites editor. The 'Insert' menu is open, and the 'Forms' option is circled in red. A blue arrow points from the 'Forms' option in the 'Insert' menu to the 'Forms' section in the 'Recent' list. The 'Forms' section in the 'Recent' list is also circled in red, showing two form templates: 'Experiment 2' and 'Balloon'.

Insert form in Google



Method 2

Creating your own
experiments in feasible
platforms

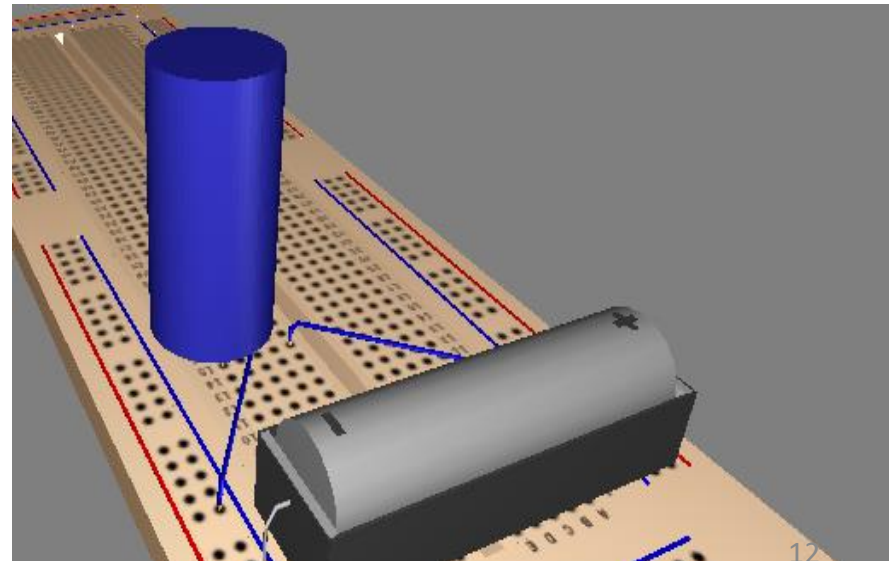
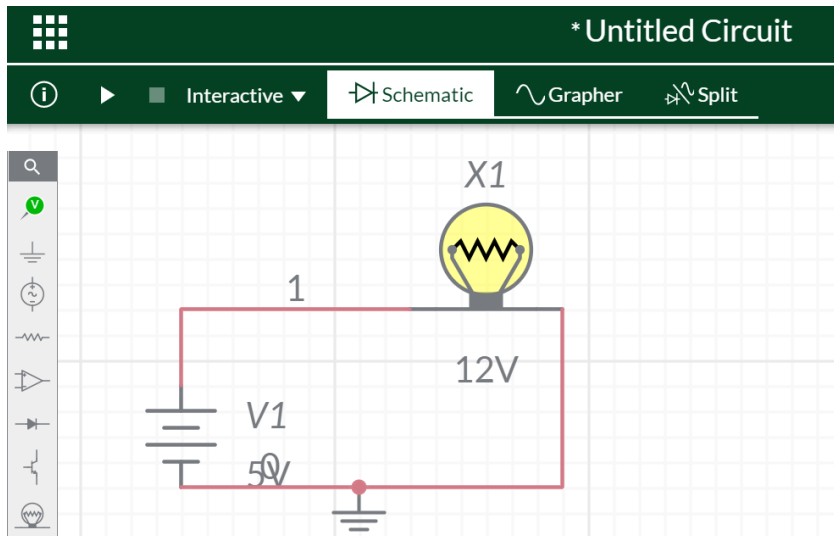


Platform (2)

MultiSim Live

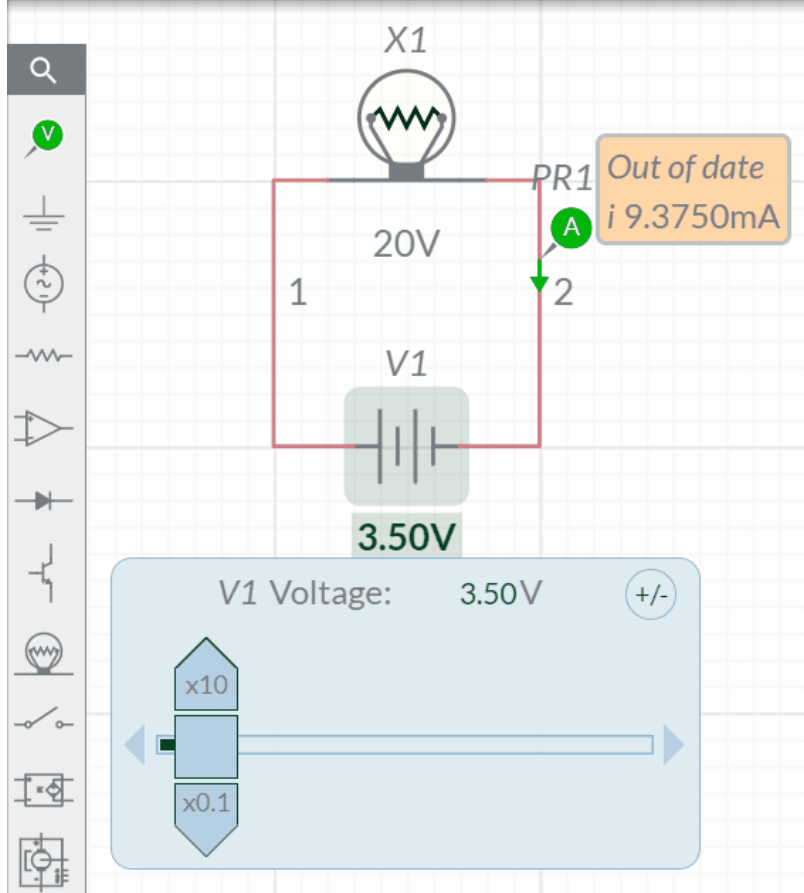
(2) MultiSim Live (free)

- **Developer:** Originally Electronic Workbench, now National Instruments (NI)
- **Goal:** circuit simulation and design program
- **Origin:** the software SPICE released in 1973 developed by UC Berkeley
- MultiSim is widely used in Universities, high school as well as the industry to design circuit; **MultiSim Live is free!**



Simulated Circuit Experiments (1)

▶
■ Interactive ▼
▶ Schematic
~ Grapher
▶ Split



SCP 2015 Electricity and Energy
Experiment 1 – Simple Circuits
 Dr. YEUNG Chi Ho Bill

Due to pandemic, the following experiment will be conducted through online circuit simulation platform "Multisim Live". Since this is a web-based simulation platform, so there is no need for you to download any software to your computer. You can also conduct the experiment without account registration, but if you want to save your simulated file, you need to register an account.

Part 1 – Ohmic and non-Ohmic electronic components
Part 1a – A circuit with a light bulb

Figure 1 The "Multisim Live" simulation platform with a simple circuit consisting of a set of batteries and a light bulb

- Open the above simple circuit with a set of batteries and a light bulb by clicking the following hyperlink or scan the QR code:
https://www.multisim.com/content/DKnebAmw4bEC89/Sb/20d4/experiment1_part1a/
- Click the "Run simulation" icon on the row above the simulation platform:
- Move your cursor to point to "5V" in Figure 1, click the setting icon on the top right hand corner, and a grey panel on the right (like the one in Figure 1) will pop up

4. Change the voltage of the batteries from 5V to 1V, by either changing the number "5V" in the grey panel on the right, or by dragging the blue panel underlying "5V".

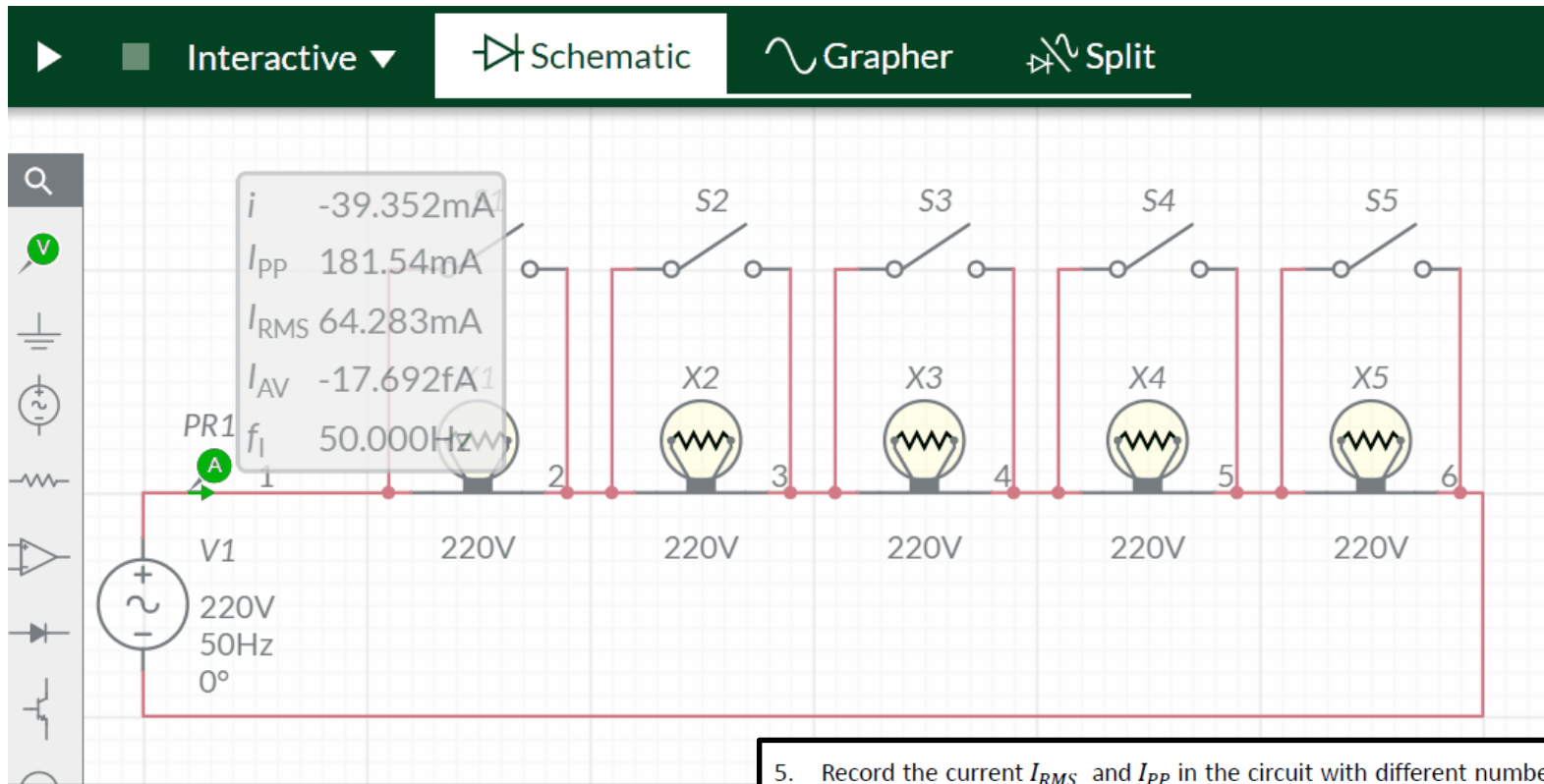
5. The current of the circuit is found here next to the symbol .

6. Record the current of the circuit with different voltage of the batteries as shown in the table below, and observe how brightness of the light bulb changes with voltage of the batteries:

Voltage of the batteries (V)	Current of the circuit (Unit =)
1	
2	
3	
5	
10	
15	
20	

Table 1a

Simulated Circuit Experiments (2)



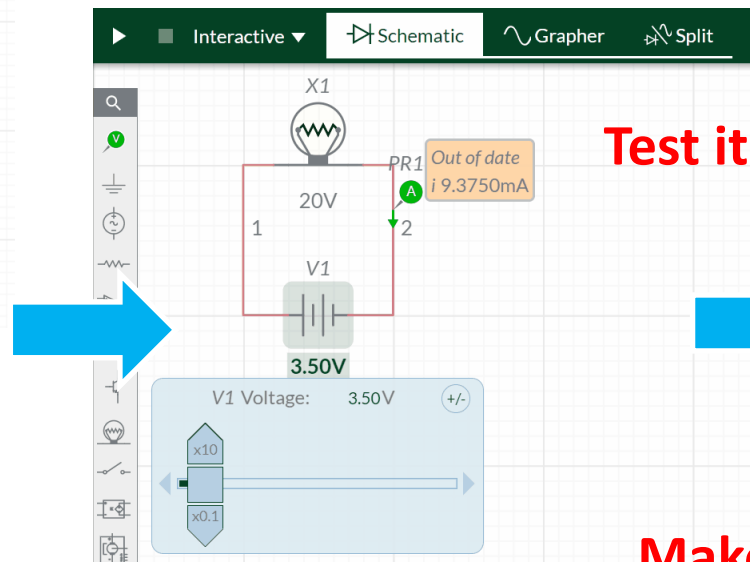
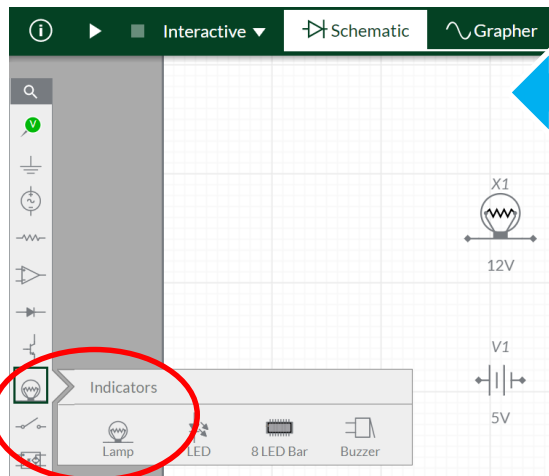
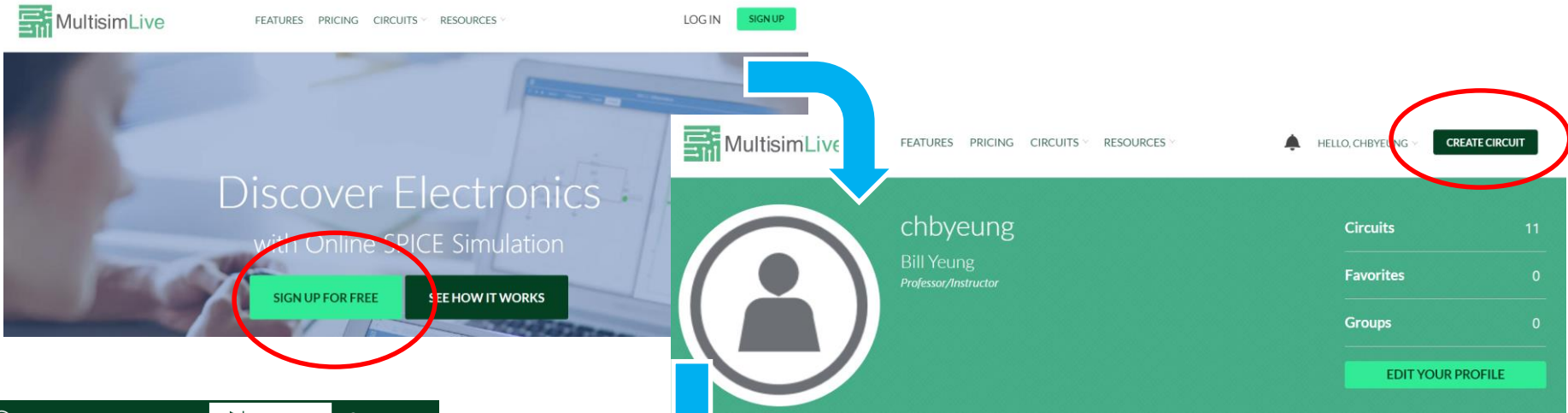
5. Record the current I_{RMS} and I_{PP} in the circuit with different number of closed switches as shown in the table below, and **observe how brightness of the switched-on light bulbs changes with the number of closed switches:**

Number of closed switches	I_{RMS} (Unit =)	I_{PP} (Unit =)
1		
2		
3		
4		
5		

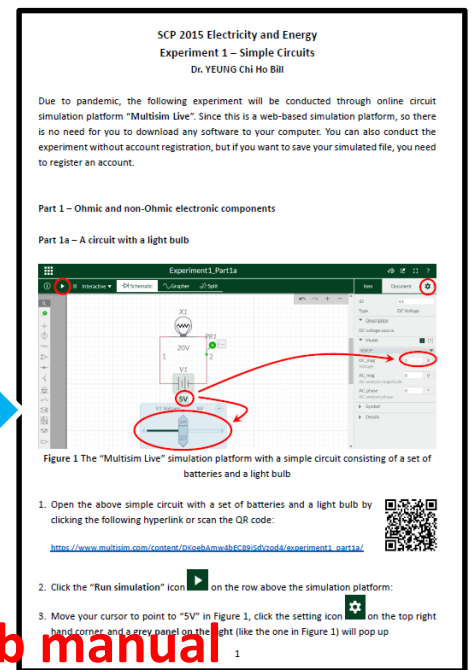
Table 2a

How to make it?

- It is again very simple:



Test it!



Make lab manual



Platform (3)

Model ChemLab

(3) Model Chemlab



- **Developer:** Model Science Software
- **Goal:** allow students to perform chemistry operations and experiment via the simulated platform
- Teachers can **tailor-make chemicals and chemical reactions**, to allow students mixing the chemicals and observe the reaction in the simulated platform

ChemLab - (untitled) - Heat of Neutralization

File Edit Equipment Chemicals Procedures Arrange Options Help

Market 12 B / U

Introduction:

In this lab you will examine the heat of neutralization for the reaction of hydrochloric acid with sodium hydroxide. The heat of neutralization is defined as the quantity of heat evolved when one mole of acid or base is exactly neutralized. When an acid and a base react, the net result is the production of a salt and water. In this experiment, NaOH will neutralize the HCl in a reaction that produces sodium chloride (salt) and water.

$$\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{heat}$$

Most chemical reactions will have a heat transfer associated with them. If the reaction gives off heat it is exothermic and if it absorbs heat from its surroundings it is endothermic. The heat of reaction is usually defined as the amount of heat released or absorbed in a chemical reaction per mole of reacting substance.

First Law of Thermo-dynamics is the law of conservation of energy. "Energy can neither be created nor destroyed, only changed from one form into another."

For a closed constant mass system the first law of thermo-dynamics is often expressed as:

$$\Delta U = Q - W$$

Where ΔU is the change of internal energy, Q is the heat added to the system and W is the work done by the system.

Enthalpy (H) is a property of a system and is equal to $U + PV$, where U is the internal energy of the system, P is the pressure, and V is the volume.

$$H = U + PV$$

In a chemical reaction, the enthalpy change is equal to the total enthalpy of the products minus the enthalpy of the reactants. This is known as Hess's Law. The following

ChemLab File Edit Equipment Chemicals Procedures Arrange Options Font Window Help

Acid-Base Titration - untitled.lab

Introduction Procedure Observation

Acid-Base Titration Introduction:

Water dissociates (self-ionizes) into H^+ (hydrogen ion) and OH^- (hydroxide ion) ions naturally to a very small extent:

$$\text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^-$$

In a neutral solution the concentration of $[\text{H}^+]$ and $[\text{OH}^-]$ are equal at $1.0 \times 10^{-7} \text{ M}$. An acidic solution is one in which the concentration of $[\text{H}^+] > [\text{OH}^-]$, and in an basic solution the $[\text{H}^+] < [\text{OH}^-]$. pH is a measure of the concentration of $[\text{H}^+]$ and is defined as:

$$\text{pH} = -\log[\text{H}^+]$$

In a neutral solution $\text{pH} = 7$. A $\text{pH} < 7$ indicates an acidic solution and $\text{pH} > 7$ signifies a basic solution.

An acid-base reaction is one in which H^+ ions are transferred from an acid to a base:

$$\text{HA} + \text{B} \rightarrow \text{A}^- + \text{BH}^+$$
, where HA is an acid and B is an base

In this experiment we will explore the use of titration, adding small quantities of a base to an acid and recording the rise of pH. We can plot the pH against the amount of base added producing a titration curve. The steepest point on the curve occurs at the equivalence point, when the acid is exactly neutralized. Because the titration curve is so steep, any equivalence only a small amount

Titration

pH: 12.4725

Titration Data

ml of titrant	pH
0	1.0
5	1.0
10	1.0
15	1.0
20	1.0
25	1.0
30	1.0
35	1.0
36	2.0
37	4.0
38	7.0
39	10.0
40	12.0
45	12.0

Simulated Physics/Chemistry Experiments (3)

File Edit Equipment Chemicals Procedures Arrange Options Help

Marlett 12 **B** *I* U

Introduction Procedure Observations

Specific Heat Lab Introduction:

Specific Heat is the amount of heat required to raise the temperature of a unit mass by one degree. It can be expressed in terms of calories/gm-°C or Joules/ kg -°K. Water has a relatively high specific heat of 1cal/gm-°C. Metals usually have a low specific heat, for example lead has a specific heat of .03 cal/gm-°C.

A calorimeter is an instrument for determining the amount of heat evolved, transferred or absorbed. In our case it will consist of a closed insulated vessel with a thermometer.

The amount heat "Q" transferred to or from a mass

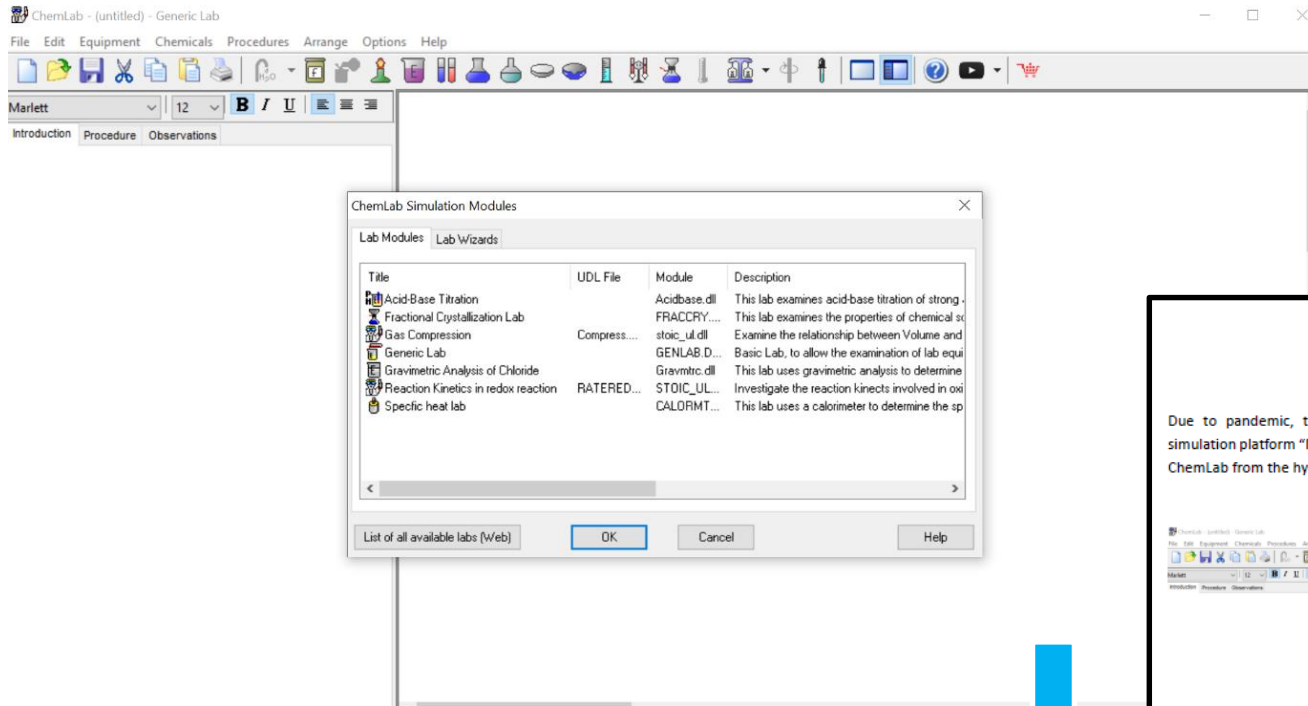
18

15. Record the final temperature of the mixture in the following table

	50g water	100g water	200g water
The final temperature of the mixture of 100°C iron (100g) + 20°C water (different amount)			

Table 1

How to make it?



SCP 2015 Electricity and Energy
Experiment 2 – Specific Heat Capacity
Dr. YEUNG Chi Ho Bill

Due to pandemic, the following experiment will be conducted through online circuit simulation platform "Model ChemLab". Please download the free evaluation version of Model ChemLab from the hyperlink below:

<https://www.modelscience.com/software.html>

ChemLab - (untitled) - Generic Lab

File Edit Equipment Chemicals Procedures Arrange Options Help

Marlett 12 B I U

Introduction Procedure Observations

ChemLab Simulation Modules

Lab Modules Lab Wizards

Title	UDL File	Module	Description
Acid-Base Titration		AcidBase.dll	This lab examines acid-base titration of strong...
Fractional Crystallization Lab		FRACCRY...	This lab examines the properties of chemical s...
Gas Compression	Compress...	stoic_ul.dll	Examine the relationship between Volume and...
Generic Lab		GENLAB.D...	Basic Lab, to allow the examination of lab equi...
Gravimetric Analysis of Chloride		Gravmtic.dll	This lab uses gravimetric analysis to determine...
Reaction Kinetics in redox reaction	RATERED...	STOIC_UL...	Investigate the reaction kinetics involved in oxi...
Specific heat lab		CALORMT...	This lab uses a calorimeter to determine the sp...

List of all available labs (Web) OK Cancel Help

Figure 1 Simulation platform of Model ChemLab

Part 1 – Specific heat capacity of iron

1. Open ChemLab, and in the pop-up window with different experiments, choose "Specific heat lab"; or alternatively, open ChemLab, select "Options" → "Labs" → "Specific heat lab"
- NOTE: Most of the following procedures can be found in the "Procedures" column on the left hand side [1]
2. Add a test tube by using the test tube button
3. Add 100g of iron to the test tube by right-clicking the test tube and choose chemical; select 100g iron shot; a label "Fe" can be added to the test tube
4. Add a thermometer by right-clicking the test tube and select "thermometer"
5. Add a 250ml beaker by selecting "equipment" at the top toolbar; add 150ml of water into the beaker
6. Select both the test tube and the beaker and right-click to select "combine"

Make lab manual

Method 3

Creating your own new experiments

(1) Molecular Workbench (free)

- **Molecular Workbench** is **free and open software** – “a modeling tool for teachers and students to create their own simulations and share them with collaborators”:

<http://mw.concord.org/modeler/>

<http://mw.concord.org/nextgen/>

- Developed **Concord Consortium**, a non-profit educational research and development organization based in Concord, Massachusetts



Visual, Interactive Simulations for Teaching & Learning Science
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Embedded Assessments

Real-time reports provide a complete view of student learning progression.



Create and Customize

Customize any model or create one with powerful modeling tools.

Selected Curriculum Modules

Transistor 	STM 	Semiconductor 	Plasma
Molecular Rover 	Chemical Bonding 	Chemical Resp. 	Diffusion

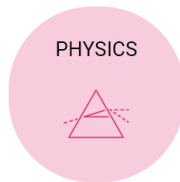
(2) PhET Interactive Simulations

- A completely free platforms with **many existing simulations**

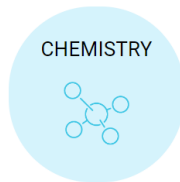


- Users can create a completely new simulations using html5

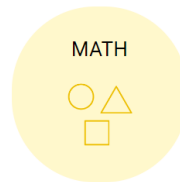
Over **1.1 billion** simulations delivered



PHYSICS



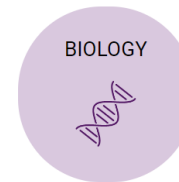
CHEMISTRY



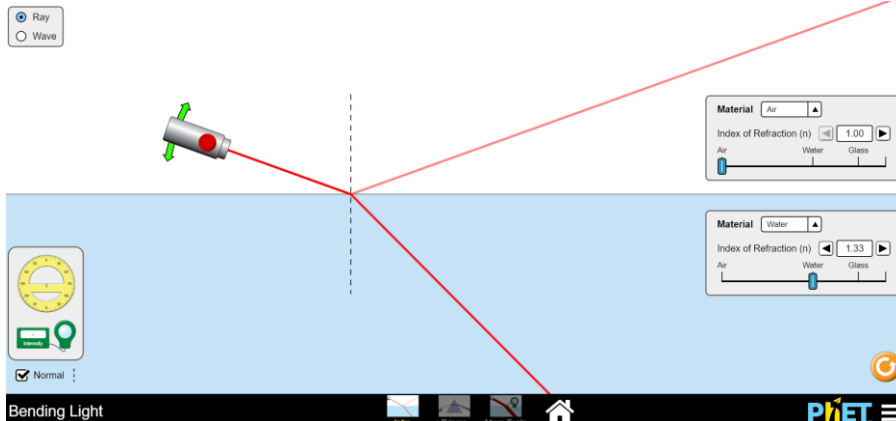
MATH



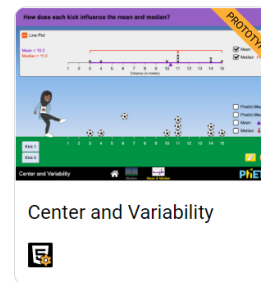
EARTH SCIENCE



BIOLOGY



HTML5 Prototype X



Can simulations replace hands-on experiments in teaching science?

	Simulations	Hands-on experiment
Pros	Please refer to the points listed on the last page	<ul style="list-style-type: none">••
Cons	<ul style="list-style-type: none">••	<ul style="list-style-type: none">••

- Simulations are **good complement** to hands-on experiments, **not replacement**



Summary

- **The following platforms of simulated experiments are shown**
 1. Molecular Workbench
 2. MultiSim Live
 3. Model ChemLab
 4. PhET
- Instead of just playing with this online module, **students are required to record data like real experiments**, and submit homework or lab reports
- Students have **mostly positive feedback** on the simulated experiments