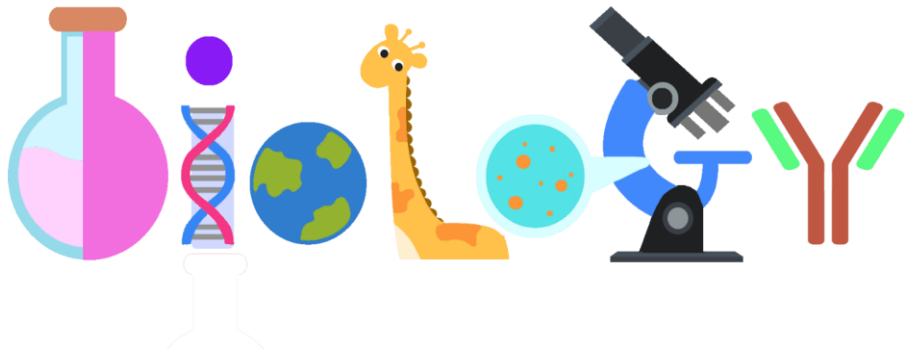
香港考試及評核局
Hong Kong Examinations and Assessment Authority

Seminar on School Based Assessment (Biology)



Objectives

- To enhance teachers' understanding of the assessment requirements and marking criteria of Area B1 of SBA

- To share some strategies teachers can use to support student learning in the new format of SBA

Outline of the seminar

❶ Background of the SBA initiative

❷ Discussion on the scoring of the student samples

❸ Strategies to support student learning in the SBA

❶ Background

Changes in format of SBA:

- Students do NOT need to write procedures in their investigative lab reports
- Specific guiding questions may be formulated to guide students to explain their experimental design decisions

Goals of the initiative:

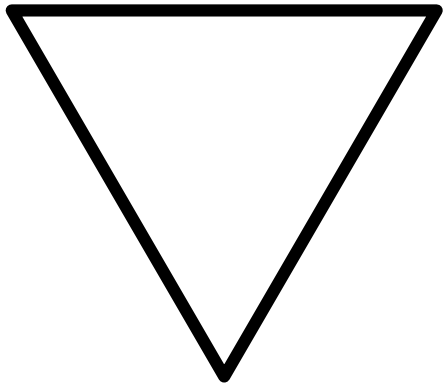
- SBA serves better formative functions in enhancing both teacher and student learning
- SBA becomes enjoyable learning experiences for students and experiences for teachers

❶ Background

Assessment Triangle

Observation

Interpretation



Cognition

(e.g., knowledge, skills, attitudes)

National Research Council. (2001). *Knowing what students know: The science and design of educational assessment*. National Academies Press.

❶ Background

A list of scientific thinking

33

	Procedural knowledge	Example
Preparing for the investigation	**Asking scientific questions** • Understanding what a meaningful scientific question that can be investigated within the scope of the school laboratory means	Link
	Appropriate design • Understanding different types of design for a (given) scientific question, e.g., experimental, field-based, fair testing, classifying, pattern-seeking	Link
	Hypothesis • Understanding the idea of (an explanatory) hypothesis, which is a tentative explanation or an initial model for a phenomenon/an investigable question that asks for an explanation of *why* something happens using biological principles/knowledge	Link
	Prediction • Understanding that predictions are the outcomes you would observe in relation to the hypothesis/model. Predictions are often written in the form of "*If… then…*"	Link

Variables

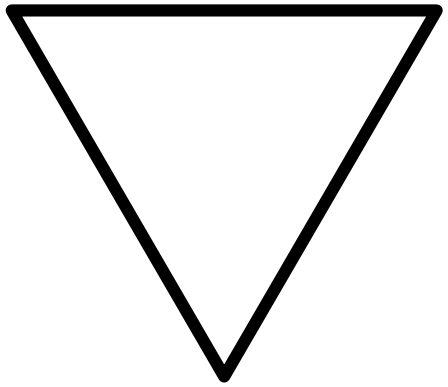
Hypothesis

Measurement

Assumptions

Alternative designs

Sampling



Cognition

Inter

	Basic Performance	Good Performance	Excellent Performance
Biological principle/ knowledge	B1. State briefly the overall experimental design and its underlying biological principles and/or concepts	G1. Explain how the overall experimental design is related to underlying biological principles and/or concepts	
Hypothesis & Prediction (if any)	B2. Identify the hypothesis tested	G2. State the predicted results based on the hypothesis	E1. Elaborate how the predicted results give/does not give support to the hypothesis
Sampling (if any)		G3. Identify errors/issues related to the sampling method(s) and a small sample size	E2. Suggest and explain ways to reduce sampling errors (e.g., random sampling) and average out effect of variations within a sample (e.g., increasing sample size)
Dependent variable (DV) & Independent variable (IV)	B3. Identify the DV and IV	G4. Explain why the variables are DV and IV in the investigation	
		G5. Identify multiple IV/DVs	
	B4. State the methods of measurement(s)/manipulation(s)	G6. Explain how variables are connected with the manipulation(s) and measurement(s)	E3. Explain the limitations related to the manipulation/measurement method(s)/ instrument(s) for the variable(s)
			E4. Discuss the strengths and limitations of the alternative measurement method(s)
	B5. State the predicted results based on the relationship(s) between the variables		
Control variables (CV)	B6. Identify some CVs	G7. Identify important CVs	E5. Explain why some important CVs need to be controlled
	B7. Identify the control set-up(s)	G8. Explain why the control set-up(s) (e.g., multiple control set-ups in some investigations) is/are needed	E6. Discuss the limitations of the control set-up(s)
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Assumption (if any)			E8. Identify the significant assumptions of the design
Others		G10. Explain why a specific step is conducted and its impact on the validity and reliability of the experimental design	E9. Discuss design decision(s) related to/ evaluate the overall validity and reliability of the experimental design
		G11. Suggest alternative designs	E10. Discuss the limitations and strengths of alternative designs (e.g., achieving the same investigation aim using different designs, within subject and between subject design)

National Research Council. (2001). *Knowing what students know: The science and design of educational assessment*. National Academies Press.

❶ Background

A list of scientific thinking

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		Procedural knowledge	Example
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	Basic Performance	Good Performance	Excellent Performance
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Hypothesis & Prediction (if any)	B2. Identify the hypothesis tested	G2. State the predicted results based on the hypothesis	E1. Elaborate how the predicted results give/does not give support to the hypothesis
Sampling (if any)			
ble (DV) variable	B3. I		
Depend & Inde	B5. S… on the …variables		
Control variables (CV)	B6. Identify some CVs	G7. Identify important CVs	E5. Explain why some important CVs need to be controlled
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Assumption (if any)			E8. Identify the significant assumptions of the design
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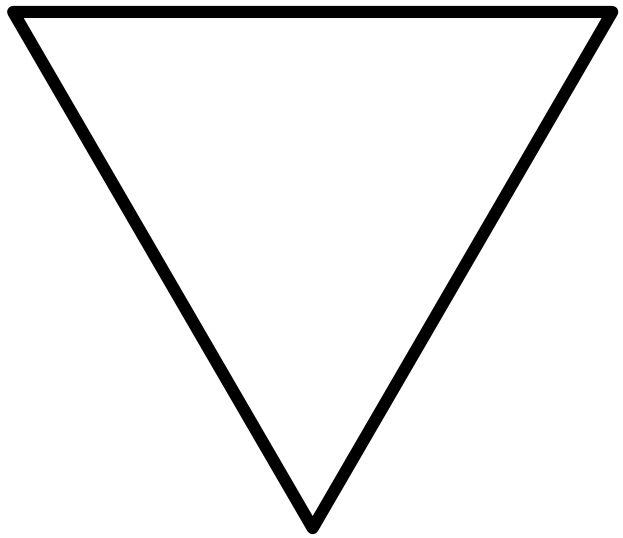
		G11. Suggest alternative designs	E10. Discuss the limitations and strengths of alternative designs (e.g., achieving the same investigation aim using different designs, within subject and between subject design)

What to assess in the B1 part of the investigative reports

❶ Background

Observation

(e.g., situations, tasks, activities)



Interpretation

Cognition

National Research Council. (2001). *Knowing what students know: The science and design of educational assessment*. National Academies Press.

❶ Background

Experimental question

How does the concentration of ethanol affect the membrane permeability of beetroot?

Design

The cells of beetroot have red pigment in the vacuoles. When the membranes of the vacuole and the cell membrane are damaged by ethanol, a kind of alcohol, pigment will leak out. With this information, design an experiment to answer the experimental question.

1. In this experiment, we are investigating how a factor (**independent variable, IV**) affects another factor (**dependent variable, DV**). What are the DV and IV of this experiment?

   IV is the concentration of ethanol. DV is the membrane permeability. (#1)

2. Explain how the membrane permeability of the beetroot cells can be measured based on the above information. Suggest an accurate and reliable method for the measurement.

   The membrane permeability can be measured by the amount of red pigment leaked out of the vacuoles. The amount of red pigment can be estimated from the intensity of red colour as judged by eyes or more accurately by colorimeter. (#11)

3. What do you predict the results when beetroot tissues are put into different concentrations of ethanol?

   The higher the concentration of the ethanol, the more the membrane is damaged. More red pigment will leak out from the vacuoles, producing darker red colour at higher ethanol concentrations. (#3)

4. Will you (1) put the **same** beetroot into different concentrations of ethanol **one after one**, or, (2) put **different** beetroot into different concentrations of ethanol? Discuss the strengths and drawbacks of each design.

   Design (1) has the problem that the membrane of beetroot ha… previous treatment of the ethanol and some red pigment has leaked out… of a concentration of ethanol. Design (2) avoids this problem, but the… concentrations of ethanol may be different… makes the comparison between different…

5. Your teacher stresses that the beetroot … concentration of ethanol. Explain why it …

   The shape and size of beetroot affect its… larger surface area will have faster leaka…

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SBA Sample Task 1

Sample Task 1

Investigating enzymatic activities of biological washing powders

Scenario:

Biological washing powders commonly contain enzymes to help remove stains. These enzymes may include amylase, proteases and/or lipases.

Richard found that he can measure the activity of amylase and proteases in biological washing powders, using starch agar plates and skimmed milk agar plates, respectively. He read the following information:

- When starch in the starch agar plate is broken down by amylase, a clear zone forms when the plate is flooded with iodine solution.
- The white colour of skimmed milk agar is caused by the protein casein. When casein is digested by proteases, a clear zone will form in the skimmed milk-agar plate.

Richard wanted to compare the activities of amylase and protease in three different brands of biological washing powder he found in the supermarket. He aimed to identify the brand that is most cost-effective in removing stains.

SBA Sample Task 2

SBA Sample Task 2

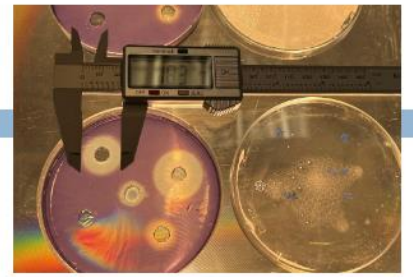
Investigating the effect of heavy metals on catalase activity of yeast beads

Scenario:

Hydrogen peroxide (H_2O_2) is widely used as a bleaching agent in textile industries. Hydrogen peroxide residues should be broken down to harmless substances before discharge to the environment.

Yeast cells contain catalases, which catalyse the breakdown of hydrogen peroxide into oxygen and water. Yeasts can be immobilized to form yeast beads

Students are given a scenario in this task sheet. This scenario appears more unfamiliar to students. Teachers may offer various kinds of support to students (e.g., preparatory tasks,



Measurements
Alternative designs

epetition and replicates

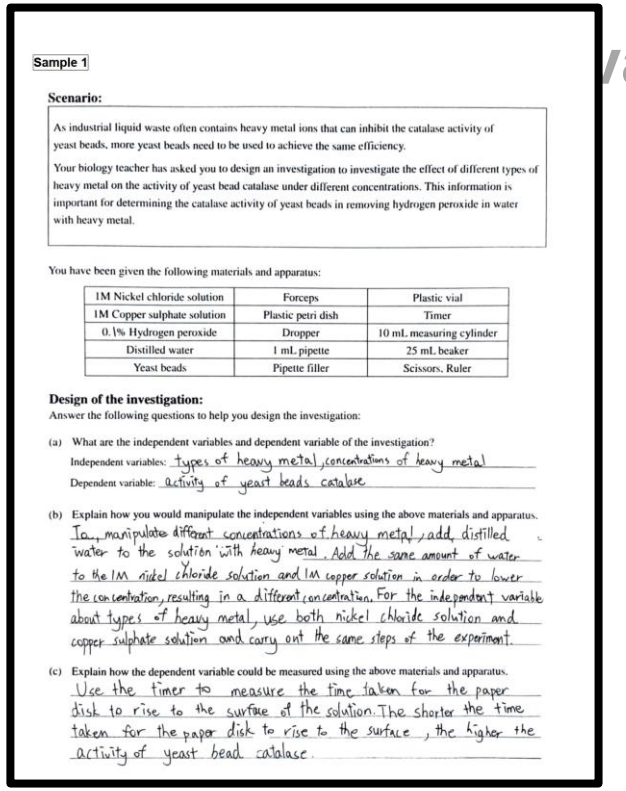
How to assess: Samples tasks to illustrate how to elicit student understandings related to the experimental designs

❶ Background

Notes:

- We do **NOT encourage using full report** as it may be limited in eliciting student understandings related to experimental designs
- Using a variety of guiding questions allows teacher to surface **targeted students' understandings** for both summative and formative functions
- If teachers think that full report is a better tool for differentiating the ability of their students in terms of their ability to design experiments, the **NEW assessment guidelines** should be followed.

❶ Background



Sample 1

Scenario:

As industrial liquid waste often contains heavy metal ions that can inhibit the catalase activity of yeast beads, more yeast beads need to be used to achieve the same efficiency.

Your biology teacher has asked you to design an investigation to investigate the effect of different types of heavy metal on the activity of yeast bead catalase under different concentrations. This information is important for determining the catalase activity of yeast beads in removing hydrogen peroxide in water with heavy metal.

You have been given the following materials and apparatus:

1M Nickel chloride solution	Forceps	Plastic vial
1M Copper sulphate solution	Plastic petri dish	Timer
0.1% Hydrogen peroxide	Dropper	10 mL measuring cylinder
Distilled water	1 mL pipette	25 mL beaker
Yeast beads	Pipette filler	Scissors, Ruler

Design of the investigation:

Answer the following questions to help you design the investigation:

(a) What are the independent variables and dependent variable of the investigation?

Independent variables: types of heavy metal, concentrations of heavy metal

Dependent variable: activity of yeast beads catalase

(b) Explain how you would manipulate the independent variables using the above materials and apparatus.

To manipulate different concentrations of heavy metal, add distilled water to the solution with heavy metal. Add the same amount of water to the 1M nickel chloride solution and 1M copper solution in order to lower the concentration, resulting in a different concentration. For the independent variable about types of heavy metal, use both nickel chloride solution and copper sulphate solution and carry out the same steps of the experiment.

(c) Explain how the dependent variable could be measured using the above materials and apparatus.

Use the timer to measure the time taken for the paper disk to rise to the surface of the solution. The shorter the time taken for the paper disk to rise to the surface, the higher the activity of yeast bead catalase.

vat

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Sampling (if any)		G3. Identify errors/issues related to the sampling method(s) and a small sample size	E2. Suggest and explain ways to reduce sampling errors (e.g., random sampling) and average out effect of variations within a sample (e.g., increasing sample size)
Dependent variable (DV) & Independent variable (IV)	B3. Identify the DV and IV	G4. Explain why the variables are DV and IV in the investigation	
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Interpretation

(e.g., making inference, judgments)

National Research Council. (2001). *Knowing what students know: The science and design of educational assessment*. National Academies Press.

❶ Background

Assessment Guidelines

- Biological principle/knowledge
- Hypothesis & Prediction
- Sampling
- DV, IV, CV
- Measurement
- Assumption
- Others (*design decisions, alternative designs*)

Unattained **Basic** **Good** **Excellent**

	Basic Performance	Good Performance	Excellent Performance
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❶ Background

- Assessment guidelines have taken into account
  - Aspects of understanding (e.g., control-of-variable, assumption)
  - Cognitive processes (e.g., describe, explain)

	Basic Performance	Good Performance	Excellent Performance
Control variables (CV)	B6. Identify some CVs	G7. Identify important CVs	E5. Explain why some important CVs need to be controlled
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❶ Background

Scoring

- should focus on whether the responses demonstrate the **performance described in the assessment guidelines**
- should focus on the **meaning, concepts and ideas** associated with the experimental design decisions
- should aim to produce ***correct rank order*** and differentiate students' responses

❶ Background

Scoring

- should **NOT** follow all-or-none principle (e.g., excellent or unattained)
- should **NOT** focus on trivial wordings and the presence of certain keywords only (rather than ideas)

	Basic Performance	Good Performance	Excellent Performance
Control variables (CV)	B6. Identify some CVs	G7. Identify important CVs	E5. Explain why some important CVs need to be controlled
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Outline of the seminar

❶ Background of the SBA initiative

❷ Discussion on the scoring of the student samples

❸ Strategies to support student learning in the SBA

❷ Discussion on the scoring

Questions

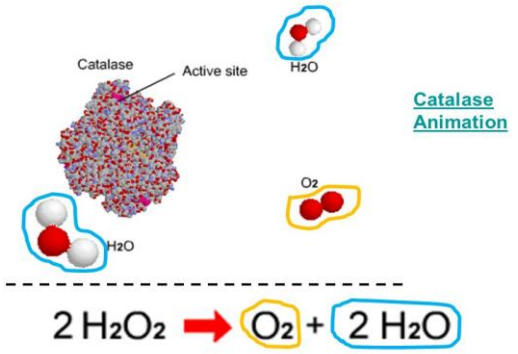
- What are your ***general impressions*** of the samples?
- Did you encounter ***any difficulties*** in scoring the samples?

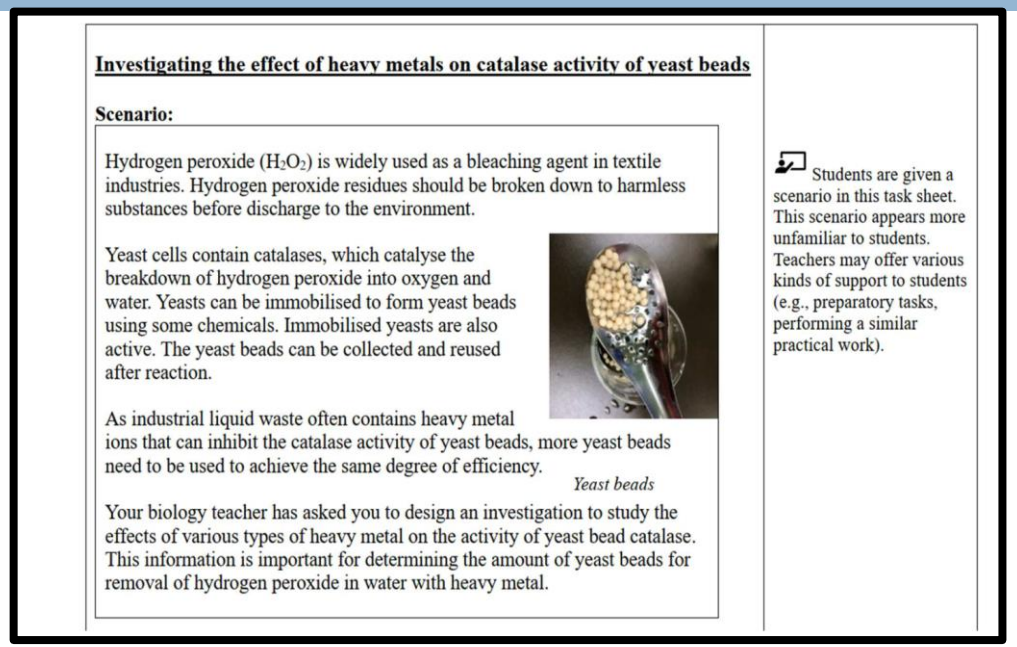
Sample Task

Yeast Bead Catalase Investigation

Context

- The samples were selected from two S.4 classes (n=52) in a Band 1 school.
- Students completed a preparatory task before working on the B1 task sheet in the lesson
- Students learned some basic ideas about experimental designs in Unit 1.





Investigating the effect of heavy metals on catalase activity of yeast beads

Scenario:

Hydrogen peroxide (H_2O_2) is widely used as a bleaching agent in textile industries. Hydrogen peroxide residues should be broken down to harmless substances before discharge to the environment.

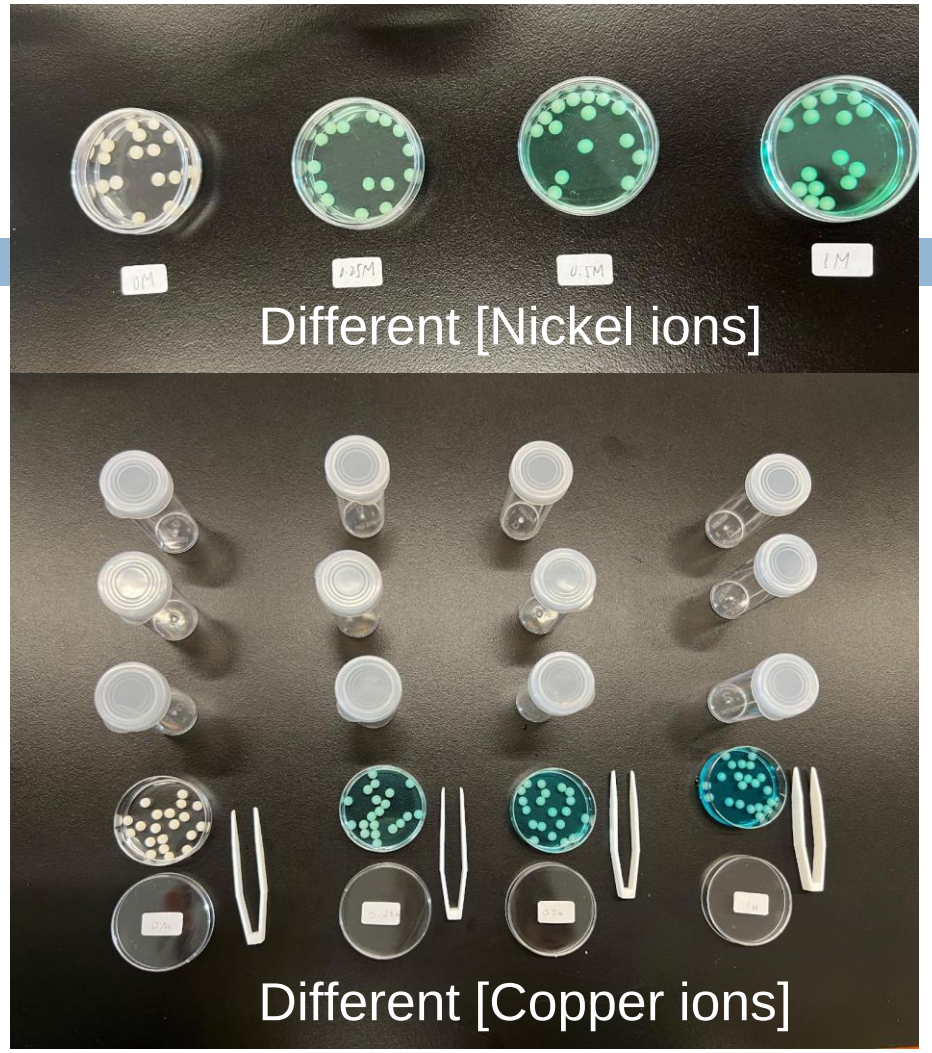
Yeast cells contain catalases, which catalyse the breakdown of hydrogen peroxide into oxygen and water. Yeasts can be immobilised to form yeast beads using some chemicals. Immobilised yeasts are also active. The yeast beads can be collected and reused after reaction.

Yeast beads

As industrial liquid waste often contains heavy metal ions that can inhibit the catalase activity of yeast beads, more yeast beads need to be used to achieve the same degree of efficiency.

Your biology teacher has asked you to design an investigation to study the effects of various types of heavy metal on the activity of yeast bead catalase. This information is important for determining the amount of yeast beads for removal of hydrogen peroxide in water with heavy metal.

Students are given a scenario in this task sheet. This scenario appears more unfamiliar to students. Teachers may offer various kinds of support to students (e.g., preparatory tasks, performing a similar practical work).



Multiple IVs

- ★ **Type** of heavy metal (Copper ions and Nickel ions)
- ★ **Concentration** of metal ions

Questions on how to manipulate the IVs

(A) Variables

Dependent variable (DV) & Independent variable (IV)			
	B3. Identify the DV and IV	G4. Explain why the variables are DV and IV in the investigation	
		G5. Identify multiple IV/DVs	
	B4. State the methods of measurement(s)/manipulation(s)	G6. Explain how variables are connected with the manipulation(s) and measurement(s)	E3. Explain the limitations related to the manipulation/measurement method(s)/ instrument(s) for the variable(s)
			E4. Discuss the strengths and limitations of the alternative measurement method(s)
	B5. State the predicted results based on the relationship(s) between the variables		

(a) What are the independent variables and dependent variable of the investigation?

Independent variables: types of heavy metal, concentrations of heavy metal

Dependent variable: activity of yeast beads catalase

Good

Basic

(a) What are the independent variables and dependent variable of the investigation?

Independent variables: Different types of heavy metal at different concentration

Dependent variable: The activity of yeast bead catalase

Good

Basic

(a) What are the independent variables and dependent variable of the investigation?

Independent variables: Types and concentration of heavy metal

Dependent variable: Activity of yeast bead catalase

Good

Basic

(B) Manipulation of IV

You have been given the following materials and apparatus:

1M Nickel chloride solution	Forceps	Plastic vial
1M Copper sulphate solution	Plastic petri dish	Timer
0.1% Hydrogen peroxide	Dropper	10 mL measuring cylinder
Distilled water	1 mL pipette	25 mL beaker
Yeast beads	Pipette filler	Scissors, Ruler

(b) Explain how you would manipulate the independent variables using the above materials and apparatus.

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	B5. State the predicted results based on the relationship(s) between the variables		

(b) Explain how you would manipulate the independent variables using the above materials and apparatus.

To manipulate different concentrations of heavy metal, add distilled water to the solution with heavy metal. Add the same amount of water to the 1M nickel chloride solution and 1M copper solution in order to lower the concentration, resulting in a different concentration. For the independent variable about types of heavy metal, use both nickel chloride solution and copper sulphate solution and carry out the same steps of the experiment.

Basic

(b) Explain how you would manipulate the independent variables using the above materials and apparatus.

Prepare four plastic petri dishes. One filled with nickel chloride solution, another with copper sulphate solution. Use the dropper and fill the plastic vial with distilled water and pour into beaker. Fill the plastic vial with Nickel chloride solution and pour into beaker and mix together with distilled water and fill the dish with the mixed solution. Repeat the steps but with copper sulphate solution and fill another dish.

Basic

(b) Explain how you would manipulate the independent variables using the above materials and apparatus.

Prepare beakers of same amount of 1M Nickel chloride solution and 1M Copper sulphate solution and use the 1mL pipette to add different amount of distilled water into the beakers to have different concentration of Nickel chloride and the copper sulphate solution.

Good

(C) Measurement of DV

You have been given the following materials and apparatus:

1M Nickel chloride solution	Forceps	Plastic vial
1M Copper sulphate solution	Plastic petri dish	Timer
0.1% Hydrogen peroxide	Dropper	10 mL measuring cylinder
Distilled water	1 mL pipette	25 mL beaker
Yeast beads	Pipette filler	Scissors, Ruler

- Tool
- Measurement related to DV

(c) Explain how the dependent variable could be measured using the above materials and apparatus.

Dependent variable (DV) & Independent variable (IV)	B3. Identify the DV and IV	G4. Explain why the variables are DV and IV in the investigation	
		G5. Identify multiple IV/DVs	
	B4. State the methods of measurement(s)/manipulation(s)	G6. Explain how variables are connected with the manipulation(s) and measurement(s)	E3. Explain the limitations related to the manipulation/measurement method(s)/ instrument(s) for the variable(s)
			E4. Discuss the strengths and limitations of the alternative measurement method(s)
	B5. State the predicted results based on the relationship(s) between the variables		

(C) Measurement of DV

Can we stop the timer when the bead starts to rise?

(c) Explain how the dependent variable could be measured using the above materials and apparatus.

Use the timer to measure the time taken for the paper disk to rise to the surface of the solution. The shorter the time taken for the paper disk to rise to the surface, the higher the activity of yeast bead catalase.

Basic

- ☐ Timer (tool)
- ☐ Paper disc

Good

- ☐ Timer (Tool)
- ☐ Yeast bead

(c) Explain how the dependent variable could be measured using the above materials and apparatus.

Soak the yeast beads in the petri dishes and use forceps to put the beads inside the hydrogen peroxide. Use the pipette and pipette filler connect it to a water trough and an inverted measuring cylinder. Use the timer to measure the time taken for colourless bubbles to appear.

Unattained

(c) Explain how the dependent variable could be measured using the above materials and apparatus.

Measure the time taken for the yeast beack rise to the surface of hydrogen peroxide solution.

Basic

(D) What is an assumption?

- An assumption is something *we think it is true*, though we *cannot be sure*.
- A significant assumption is the one that the experiment *cannot make any conclusion without assuming it to be true*.

(D) Assumptions

E8. Identify the significant assumptions of the design

How do you think student perform?
How can students achieve Excellent performance?

(d) State a significant assumption in this investigation.

Assume each yeast bead contains the same amount of catalase

Good

(d) State a significant assumption in this investigation.

Assume the rate of catalase activity of yeast beads remain the same throughout the experiment

Unattained

(d) State a significant assumption in this investigation.

Assume every yeast beads has the same amount of catalase.

Good

(D) Assumptions – Diff. Levels of Performance

Unattained:
❑ Environmental conditions are the same. ❑ Yeast beads have the same size and shape.
Basic:
❑ All catalases work the same.

(D) Assumptions – Diff. Levels of Performance

Good to Excellent:

- ❑ Amount of catalase in each yeast bead is the same.
- ❑ Catalase attains the same activity level initially.

Excellent:

- ❑ Oxygen release by yeast beads is ONLY contributed by activity of catalase but not other enzymes.
- ❑ The oxygen bubbles released do not dissolve in hydrogen peroxide solution.
- ❑ Heavy metal ions do not affect the density of the solution which affects the traveling time of the yeast beads moving up to the solution surface.
- ❑ Respiration of yeast cells does not affect the pH of the solution.

(E) Control of variables

Control variables (CV)	B6. Identify some CVs	G7. Identify important CVs	E5. Explain why some important CVs need to be controlled
	B7. Identify the control set-up(s)	G8. Explain why the control set-up(s) (e.g., multiple control set-ups in some investigations) is/are needed	E6. Discuss the limitations of the control set-up(s)

(e) Is it necessary to control the volume of 0.1% hydrogen peroxide solution in each sample? Explain why you think so.

Yes. Different amount of hydrogen peroxide solution will affect the rate for the paper disk to rise, as it takes a shorter time to float with a smaller amount of solution, and takes a longer time to rise with a larger amount of solution.

(e) Is it necessary to control the volume of 0.1% hydrogen peroxide solution in each sample? Explain why you think so.

Yes, the ~~if~~ higher volume of hydrogen peroxide have more substrates for catalase in the yeast bead to collide and form more products, thus increasing the rate of catalase activity. Therefore we need to control the volume

(e) Is it necessary to control the volume of ~~0.1%~~ 0.2% hydrogen peroxide solution in each sample? Explain why you think so.

Yes, because if the volume of hydrogen peroxide solution has increased or decreased, the time taken for yeast beads to rise to the surface of hydrogen peroxide solution will be affected. Thus, the activity of yeast beads catalase may be underestimated or overestimated.

How can students achieve Excellent performance?

Good

- Paper disc not yeast beads
- Double penalty?

Basic

- Able to relate substrate amount
- Wrong concept: Volume change but conc NOT!

Good

Excellent

(E) Control of variables

Control variables (CV)	B6. Identify some CVs	G7. Identify important CVs	E5. Explain why some important CVs need to be controlled
	B7. Identify the control set-up(s)	G8. Explain why the control set-up(s) (e.g., multiple control set-ups in some investigations) is/are needed	E6. Discuss the limitations of the control set-up(s)

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(e) Is it necessary to control the volume of ~~0.1%~~ 0.2% hydrogen peroxide solution in each sample?
Explain why you think so.

Yes, because if the volume of hydrogen peroxide solution has increased or decreased, the time taken for yeast beads to rise to the surface of hydrogen peroxide solution will be affected. Thus, the activity of yeast beads catalase may be underestimated or overestimated.

If student answers in part (c) that timer is stopped when the beads start to rise at the bottom, what would be the correct answer for part (e)?

(F) Sampling

Sampling (if any)		G3. Identify errors/issues related to the sampling method(s) and a small sample size	E2. Suggest and explain ways to reduce sampling errors (e.g., random sampling) and average out effect of variations within a sample (e.g., increasing sample size)

(f) Will you choose to use one single yeast bead or more than one yeast bead in each trial? Why?

More than one yeast bead. Different yeast bead may contain different amount of catalase. By using more than one yeast bead, the reliability of the results could be increased by minimizing the individual differences.

Excellent

(f) Will you choose to use one single yeast bead or more than one yeast bead in each trial? Why?

More than one yeast bead because the higher amount of yeast beads have a larger surface area for the catalase in the yeast beads to react and it can decrease the time needed

Unattained

(f) Will you choose to use one single yeast bead or more than one yeast bead in each trial? Why?

I will choose to ~~the~~ use more than one yeast bead. With a larger sample size of yeast beads and random allocation, the reliability of the results could be increased by minimizing the individual difference

Excellent

(G) Precautions

Others		G10. Explain why a specific step is conducted and its impact on the validity and reliability of the experimental design	E9. Discuss design decision(s) related to/ evaluate the overall validity and reliability of the experimental design
		G11. Suggest alternative designs	E10. Discuss the limitations and strengths of alternative designs (e.g., achieving the same investigation aim using different designs, within subject and between subject design)

(g) Your teacher advised you to put the yeast beads in the heavy metal solution for at least 5 minutes before you put the beads into the hydrogen peroxide solution. Explain why this is needed.

It is a precaution to ensure the yeast beads are being affected by the heavy metals.

Basic

(g) Your teacher advised you to put the yeast beads in the heavy metal solution for at least 5 minutes before you put the beads into the hydrogen peroxide solution. Explain why this is needed.

To ensure the yeast bead are affected by the heavy metal (catalase in the)

Basic

(g) Your teacher advised you to put the yeast beads in the heavy metal solution for at least 5 minutes before you put the beads into the hydrogen peroxide solution. Explain why this is needed.

To ensure the catalase activity of yeast beads are inhibitor and inhibited by the different concentration of heavy metal solution before the reaction starts.

Good

- **The impact of the specific step is clearly stated.**

(H) Precautions

Others		G10. Explain why a specific step is conducted and its impact on the validity and reliability of the experimental design	E9. Discuss design decision(s) related to/ evaluate the overall validity and reliability of the experimental design
		G11. Suggest alternative designs	E10. Discuss the limitations and strengths of alternative designs (e.g., achieving the same investigation aim using different designs, within subject and between subject design)

(h) Discuss the importance of using a suitable concentration of hydrogen peroxide in relation to the overall validity of the investigation.

(H) Precautions

(h) Your teacher advised you not to use hydrogen peroxide that is too concentrated (>5% hydrogen peroxide). Discuss the importance of using a suitable concentration of hydrogen peroxide in relation to the overall validity of the investigation.

As hydrogen peroxide is acidic, a too concentrated hydrogen peroxide will affect the action of catalase by denaturing it. A suitable concentration of hydrogen peroxide ensures the catalase in the yeast beads are able to work in a suitable pH.

Unattained

- Wrong: Hydrogen peroxide does not form acid to denature enzyme

(h) Your teacher advised you not to use hydrogen peroxide that is too concentrated (>5% hydrogen peroxide). Discuss the importance of using a suitable concentration of hydrogen peroxide in relation to the overall validity of the investigation.

Catalase works best in a certain concentration of hydrogen peroxide. Too concentrated hydrogen peroxide will affect the rate of catalase activity and affect the overall validity of the investigation.

Unattained

- Not specifying how the catalase activity be affected by [H_2O_2]

(H) Precautions

(h) Your teacher advised you not to use hydrogen peroxide that is too concentrated (>5% hydrogen peroxide). Discuss the importance of using a suitable concentration of hydrogen peroxide in relation to the overall validity of the investigation.

Because too concentrated hydrogen peroxide will lead to higher rate of catalase reaction. So, the rate of yeast bead to reach the surface will be too fast and it will be too hard to measure the difference of rate of reaction between different solutions. Suitable concentration can ensure the result is obvious to compare.

Excellent

(I) Application of biological knowledge

(I) Using your biology knowledge, suggest two ways you can speed up the investigation by using the same materials provided. Explain why it can work.

	Basic Performance	Good Performance	Excellent Performance
Biological principle/ knowledge	B1. State briefly the overall experimental design and its underlying biological principles and/or concepts	G1. Explain how the overall experimental design is related to underlying biological principles and/or concepts	

(I) Application of biological knowledge

(i) **Using your biology knowledge, suggest two ways you can speed up the investigation by using the same materials provided. Explain why it can work.**

raise the temperature of the hydrogen peroxide solution to around 37°C as catalase will work best and faster. The reactions will be completed faster.
Use a larger amount of yeast beads. The reactions will be completed faster with a larger amount of catalase.

Basic

- 1: correct, but lacks explanation
- 2: not correct, same conc. of substrate

(i) Using your biology knowledge, suggest two ways you can speed up the investigation by using the same materials provided. Explain why it can work.

Increase the amount of yeast beads. So more catalase can collide with hydrogen peroxide and forming more products, and decreasing the amount of time needed. Increase the temperature of hydrogen peroxide solution and yeast beads. So more kinetic energy of the substrate and catalaze, and they move faster and collide with each other more frequently to have a higher chance of forming enzyme-substrate complexes and form products faster.

Basic

- 1: partially correct, same [substrate], same time needed for beads to rise.
- 2: partially correct, correct explanation, but not infinitely increasing temperature

(I) Application of biological knowledge

(i) Using your biology knowledge, suggest two ways you can speed up the investigation by using the same materials provided. Explain why it can work.

Increase the surface area of yeast beads by cutting yeast beads into smaller pieces, as the larger surface of yeast beads can increase the rate of reaction of catalase. Second, the volume of hydrogen peroxide solution should be decreased. The lower the water level, the higher the rate for yeast beads to rise to the surface of hydrogen peroxide solution.

Basic

Good

- 1: not correct, smaller bead have higher surface area to volume ratio, but smaller total surface area
- 2: correct

How can students achieve Good performance?

Assessment Guidelines

- ☐ Biological principle/knowledge
- ☐ Hypothesis & Prediction
- ☐ Sampling
- ☐ DV, IV, CV
- ☐ Measurement
- ☐ Assumption
- ☐ Others (*design decisions, alternative designs*)

	Basic Performance 1	Good Performance 5	Excellent Performance 4
Biological principle/ knowledge	B1. State briefly the overall experimental design and its underlying biological principles and/or concepts	G1. Explain how the overall experimental design is related to underlying biological principles and/or concepts	
Hypothesis & Prediction (if any)	B2. Identify the hypothesis tested	G2. State the predicted results based on the hypothesis	E1. Elaborate how the predicted results give/does not give support to the hypothesis
Sampling (if any)		G3. Identify errors/issues related to the sampling method(s) and a small sample size	E2. Suggest and explain ways to reduce sampling errors (e.g., random sampling) and average out effect of variations within a sample (e.g., increasing sample size)
Dependent variable (DV) & Independent variable (IV)	B3. Identify the DV and IV	G4. Explain why the variables are DV and IV in the investigation	
		G5. Identify multiple IV/DVs	
	B4. State the methods of measurement(s)/manipulation(s)	G6. Explain how variables are connected with the manipulation(s) and measurement(s) X 2	E3. Explain the limitations related to the manipulation/measurement method(s)/ instrument(s) for the variable(s)
			E4. Discuss the strengths and limitations of the alternative measurement method(s)
	B5. State the predicted results based on the relationship(s) between the variables		
Control variables (CV)	B6. Identify some CVs	G7. Identify important CVs	E5. Explain why some important CVs need to be controlled
	B7. Identify the control set-up(s)	G8. Explain why the control set-up(s) (e.g., multiple control set-ups in some investigations) is/are needed	E6. Discuss the limitations of the control set-up(s)
Measurement	B8. Identify important measurement errors	G9. Suggest ways to reduce measurement errors (e.g., using an instrument with a higher sensitivity)/enhance reliability (e.g., repeated measurements, using different measurement methods/instruments)	E7. Explain why some procedures can reduce measurement errors (e.g., repeated/averaging measurements for reducing random errors; calibration for reducing systematic errors; involving multiple observers to minimize individual bias; choosing an instrument that has a higher sensitivity to reduce measurement errors)
Assumption (if any)			E8. Identify the significant assumptions of the design
Others		G10. Explain why a specific step is conducted and its impact on the validity and reliability of the experimental design	E9. Discuss design decision(s) related to/ evaluate the overall validity and reliability of the experimental design
		G11. Suggest alternative designs	E10. Discuss the limitations and strengths of alternative designs (e.g., achieving the same investigation aim using different designs, within subject and between subject design)

Overall Rating

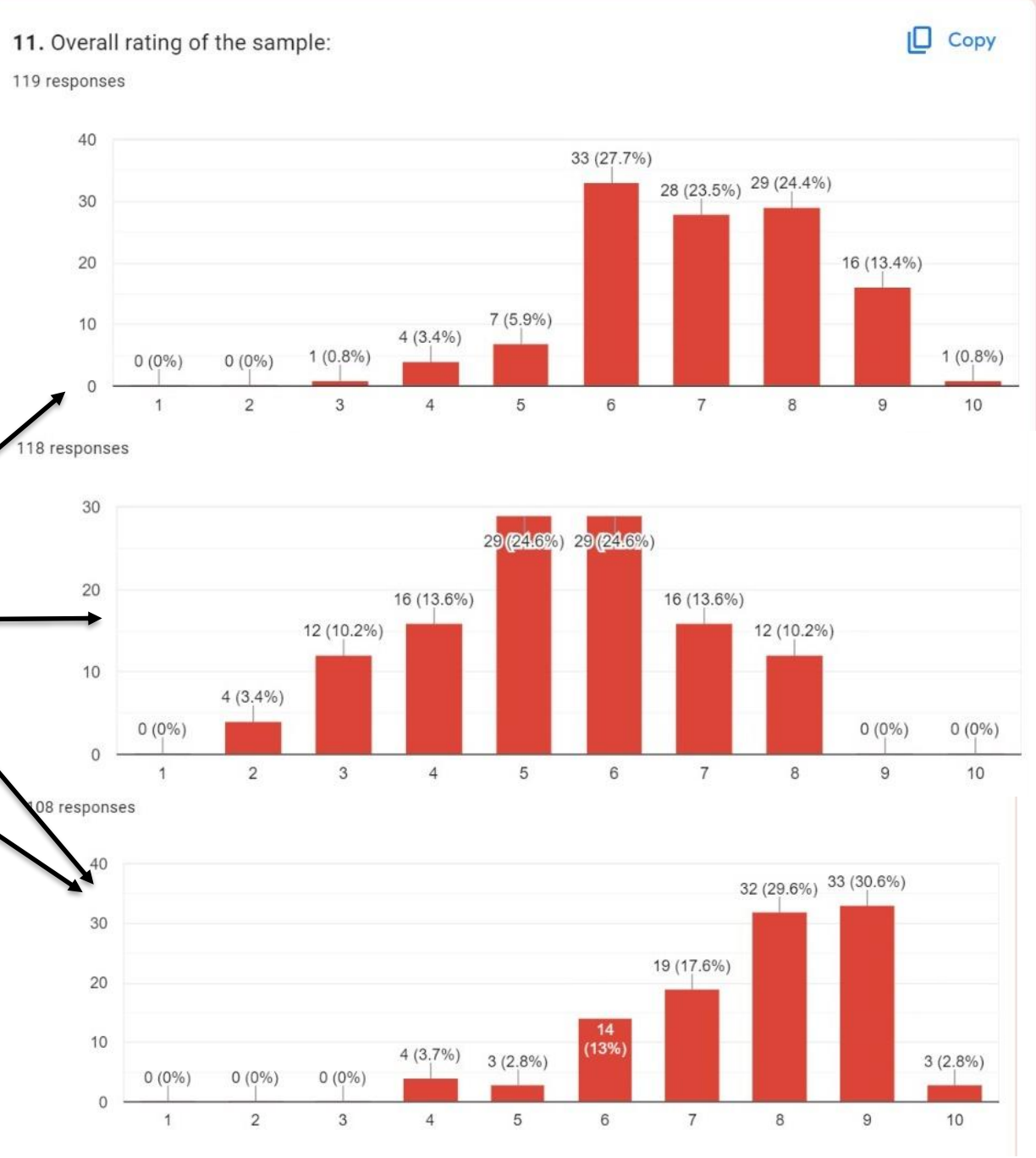
Assessment Guidelines for Experimental Design (B1)

Mark range	Quality of work	Performance
9-10	Excellent	The report shows most of the good performances and a few excellent performances.
6-8	Good	The report shows most of the basic performances and some good performances.
3-5	Fair	The report shows some basic performances and a few good performances.
1-2	Poor	The report shows a few basic performances.

	Unattained	Basic	Good	Excellent	Mark range	Quality of work
Sample 1	1	5	3	1	6 – 8	Good
Sample 2	4	5	1	0	3 – 5	Fair
Sample 3 V1	0	3	5	2	9 – 10	Excellent
Sample 3 V2	0	2	5	3	9 – 10	Excellent

Overall Rating

	Unattained	Basic	Good	Excellent	Mark range	Quality of work
Sample 1	1	5	3	1	**6-8**	**Good**
Sample 2	4	5	1	0	**3-5**	**Fair**
Sample 3 V1	0	3	5	2	**9-10**	**Excellent**
Sample 3 V2	0	2	5	3	**9-10**	**Excellent**



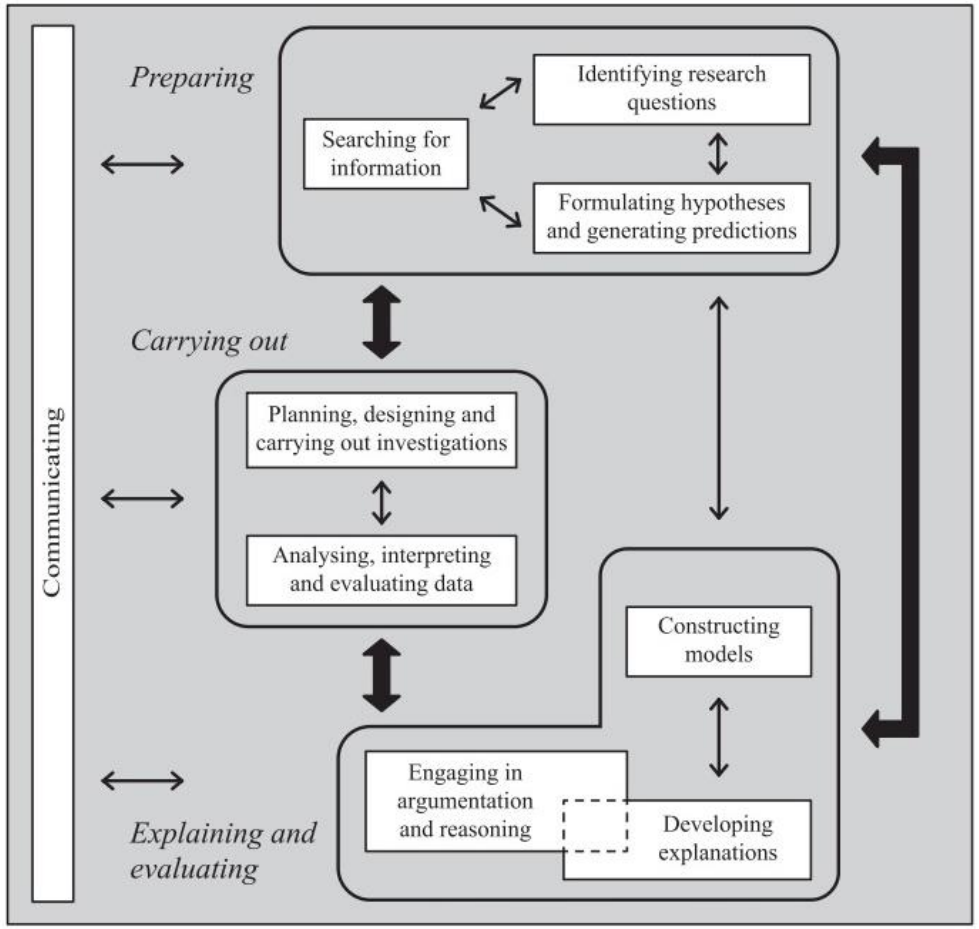
Outline of the seminar

❶ Background of the SBA initiative

❷ Discussion on the scoring of the student samples

❸ Strategies to support student learning in the SBA

❸ Strategies to support student learning in the SBA



Not controlling variables

Lack of repetition of measurement

Working without a control condition

Lack of determination of test times

Not knowing what a hypothesis is

……

Kranz, J., Baur, A. & Möller, A . (2022) Learners' challenges in understanding and performing experiments: A systematic review of the literature, *Studies in Science Education*, DOI:10.1080/03057267.2022.2138151

❸ Strategies to support student learning in the SBA

Investigating the effect of temperature on the activity of catalase

Introduction

Hydrogen peroxide is a metabolic by-product in our body. Catalase is an enzyme that breaks down hydrogen peroxide into oxygen and water. The activity of catalase is influenced by temperature. In this investigation, you are going to investigate the effect of temperature on the activity of catalase.

Materials and apparatus

Liver catalase extract	Boiling tube
Water bath	Glass tubing
Measuring cylinder	Delivery tubing
Water tough	One-hole stopper
0.1% hydrogen peroxide solution	Thermometer

Task

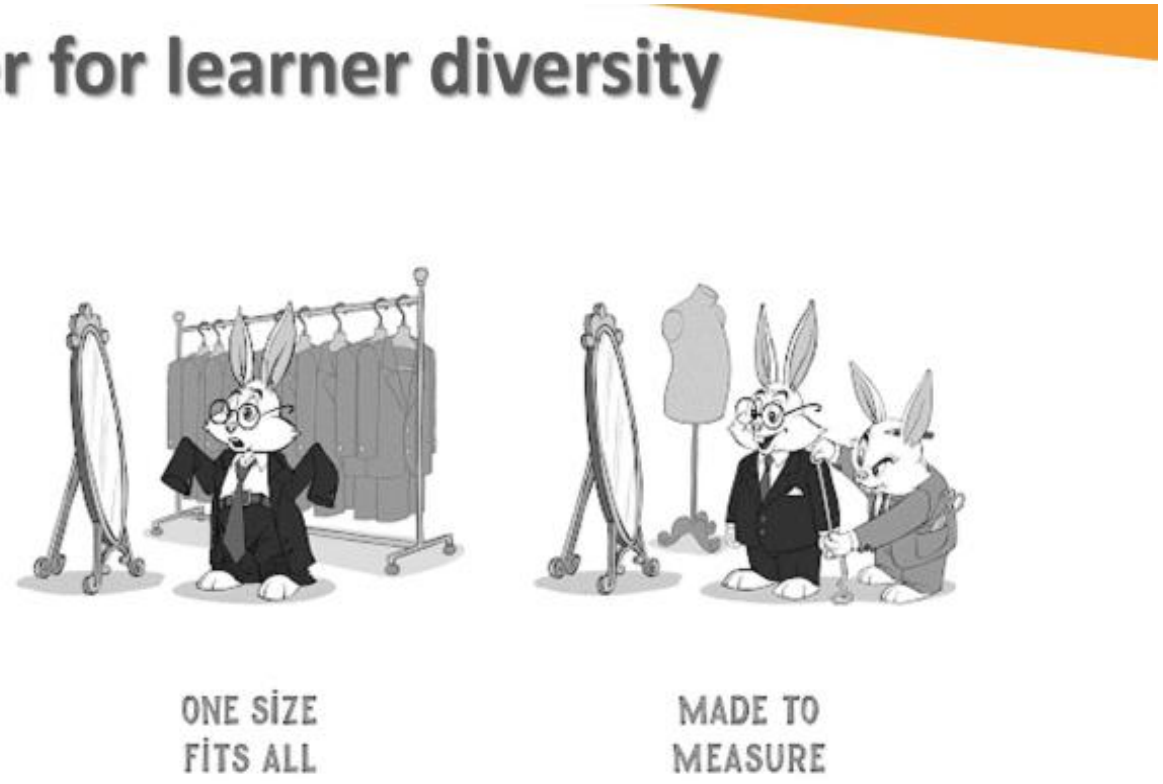
Design an investigation to study the effect of temperature on the activity of catalase. Write a full report that describes your experimental design, procedures, findings, and conclusion.

❸ Strategies to support student learning in the SBA

- High-quality assessment tasks provide a **delicate balance** between providing ***sufficient structures*** for students to express their thinking and ***allowing for space*** to illuminate what students know (Fine & Furtak, 2020).

❸ Strategies to support student learning in the SBA

- Assessment task
  - Assessment items
- Task implementation



Investigating the effect of heavy metal ions on catalase activity of yeast beads

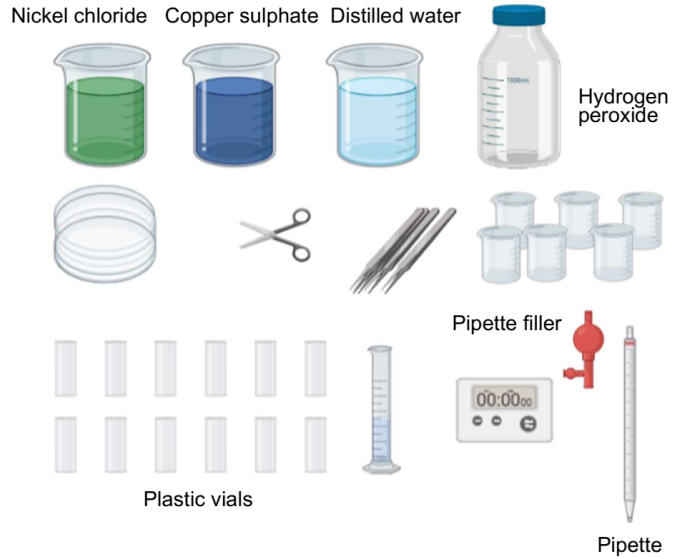
Scenario

Hydrogen peroxide (H_2O_2) is widely used as a bleaching agent in textile industries. Hydrogen peroxide residues should be broken down to harmless substances before discharge to the environment.

Baker's yeast (*Saccharomyces cerevisiae*) is a rich source of catalase. Catalase is an enzyme that catalyzes the breakdown of hydrogen peroxide into oxygen and water. Scientists make use of yeasts to remove hydrogen peroxide residues in wastewater. However, industrial liquid waste often contains heavy metal ions that can inhibit catalase activity of yeast beads. More yeast beads need to be used to achieve the same efficiency.

Yeast beads

Your biology teacher has asked you to design an investigation to investigate the effect of different types of heavy metal ions on the activity of yeast bead catalase under different concentrations. This information is important for determining the catalase activity of yeast beads in removing hydrogen peroxide in water with heavy metal.



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Aim of the investigation:

- To investigate the effect of different types of heavy metal ions on the activity of yeast bead catalase under different concentrations

Design of the investigation:

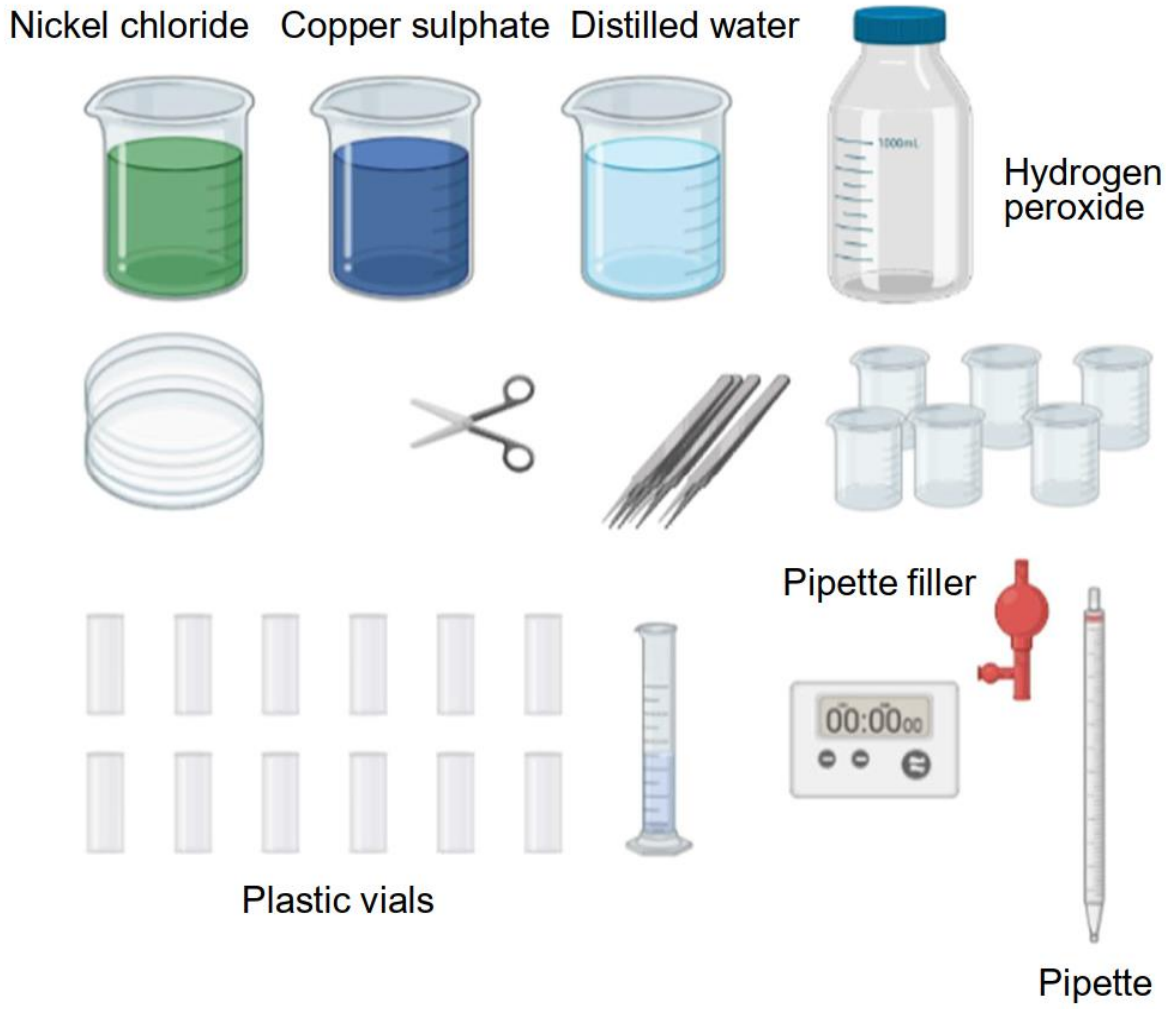
- You have been given the following materials and apparatus:

1M Nickel chloride solution	Forceps	Plastic vial
1M Copper sulphate solution	Petri dish	Timer
0.1% Hydrogen peroxide	1 mL pipette	10 mL measuring cylinder
Distilled water	Pipette filler	25 mL beaker
Yeast beads	Scissors	

- Answer the following questions to explain your experimental design decisions:

1. What are the **independent variables** (i.e., factor(s) that we change) and **dependent variable(s)** (i.e., the factor(s) that we measure) of the investigation? Independent variable(s): Dependent variable(s):	*G5. Identify multiple IVs* *B3. Identify the DV*
2. Describe how you would manipulate the independent variable(s) using the above materials and apparatus *(You may supplement your description with a diagram to represent your ideas).*	*G6. Explain how variables are connected with the manipulation(s)*
3. State how the dependent variable can be measured using the above materials and apparatus. *Hints:* Make sure that you include the following parts in your answers: □ the measurement tools and the methods of measurement. □ the relationship between the measurement and the dependent variable	*G6. Explain how variables are connected with the manipulation(s)*

❸ Strategies to support student learning in the SBA



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❸ Strategies to support student learning in the SBA

Visual scaffolds

- Addition of visual aids (e.g., photographs/diagrams /graphic organizers) in the question prompts
- Provision of real objects (e.g., experimental apparatus) or multimedia

❸ Strategies to support student learning in the SBA

2. 描述如何使用上述材料和儀器測量酵母凝膠珠中過氧化氫酶的活性。你可以畫出你的實驗設計。

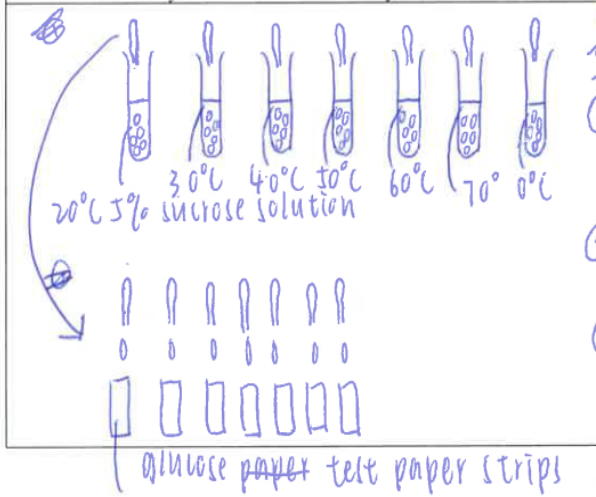
(2) State the DV and briefly describe how you will measure the DV with the given materials.

Dependent variable (DV): The colour change of the glucose paper test strips which are added the drops of the solution tested. with different temperature

Description of how you will measure the DV:

Notes:

- *You may support your description with a drawing*
- *Make sure you describe the tool you will use and how your measurement is related to the DV*



① wait 5 minutes
② add ~~a~~ ~~the~~ a drop of the solution on the glucose paper test strips by using the dropper
③ repeat the same action for every 1 minutes.
④ draw a table to mark down the colour change

collect the samples first and then test ~~the~~ all them with the glucose ~~pat~~ paper test strips at the same time.

(b) State another method to measure the DV if other materials are available.

The Benedict's test.

❸ Strategies to support student learning in the SBA

Effect of concentration of ethanol on membrane permeability

Experimental question
How does the concentration of ethanol affect the membrane permeability of beetroot?

Design

The cells of beetroot have red pigment in the vacuoles. When the membranes of the vacuole and the cell membrane are damaged by ethanol, a kind of alcohol, pigment will leak out. With this information, design an experiment to answer the experimental question.

1. In this experiment, we are investigating how a factor (**independent variable, IV**) affects another factor (**dependent variable, DV**). What are the DV and IV of this experiment?

B3. Identify the DV
B3. Identify the IV

❸ Strategies to support student learning in the SBA

Linguistic scaffolds

- Allowing students to draw ***in combination with*** writing
- Defining key terms
- Provision of sentence starters/frames
- Providing a word bank
- Using bullet points/shorter sentences
- Simplify vocabulary and grammar
- Use active voice

❸ Strategies to support student learning in the SBA

(c) State how the dependent variable can be measured using the above materials and apparatus.

Hints: Make sure that you include the following parts in your answers:

- the measurement tools and the methods of measurement.
- the relationship between the measurement and the dependent variable

G6. Explain how variables are connected with the manipulation(s)

❸ Strategies to support student learning in the SBA

(j) *Using the same materials provided*, suggest ***two*** modifications in the experimental design to speed up the investigation. Use your biological knowledge to explain why these modifications can work.

G1. Explain how the overall experimental design is related to underlying biological principles and/or concepts

Modification in the design	Explanation based on the biological principle
1	
2	

❸ Strategies to support student learning in the SBA

2. 分析探究實驗結果

指引：

I. 根據實驗結果的數據，描述及解釋實驗結果。

II. 如有需要，辨認數據的趨勢和模式，並加以分析。

III. 如有，請列出並討論異常的數據及觀察。

4. 結論

指引：

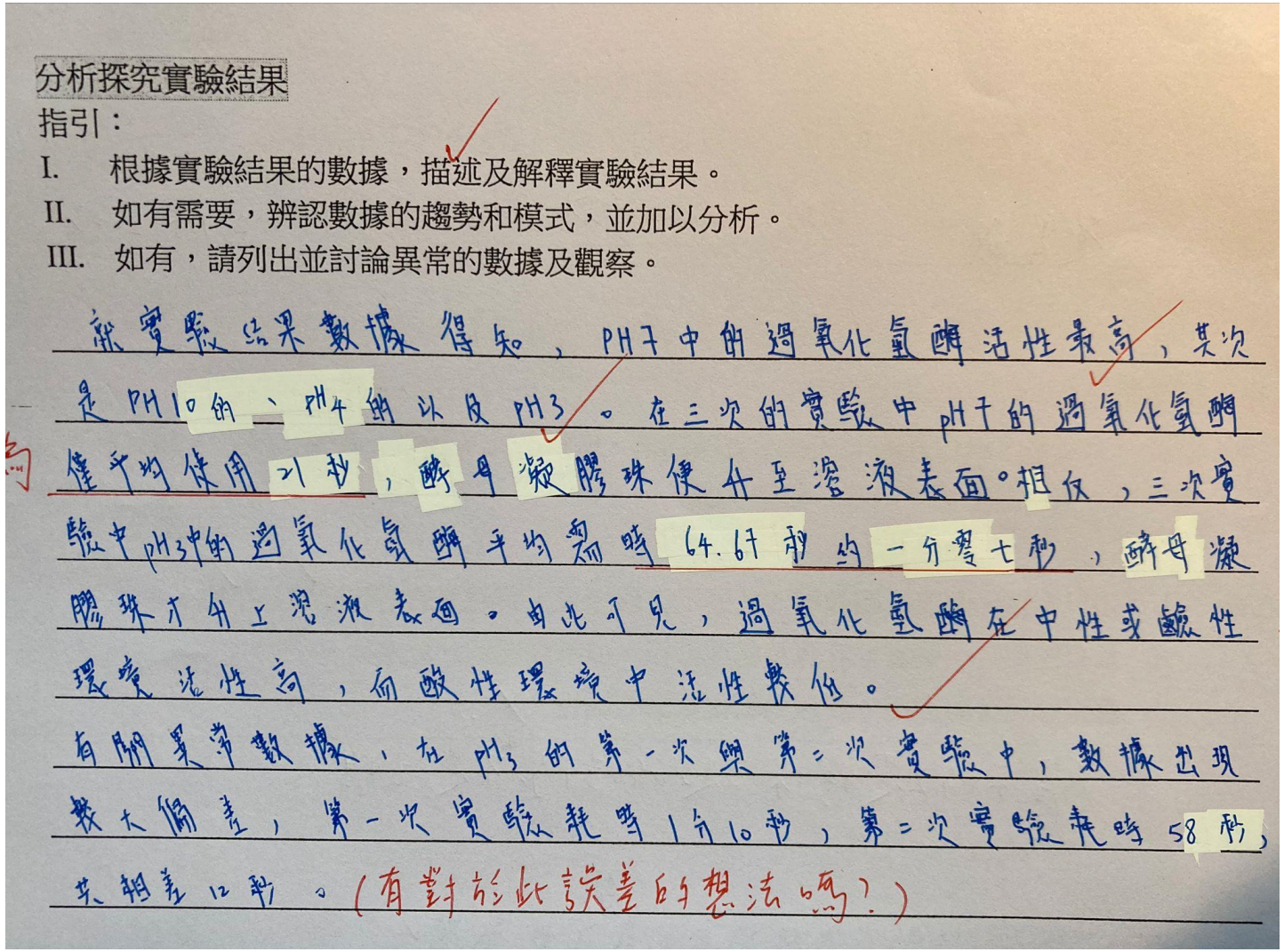
I. 按實驗結果回應探究問題。

II. 討論數據的有效度和可信度。

III. 討論實驗設計的限制。

IV. 討論與實驗相關的理論。

❸ Strategies to support student learning in the SBA



分析探究實驗結果

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II. 如有需要，辨認數據的趨勢和模式，並加以分析。

III. 如有，請列出並討論異常的數據及觀察。

就實驗結果數據得知，PH7中的過氧化氫酶活性最高，其次是PH10的、PH4的以及PH3。在三次的實驗中pH7的過氧化氫酶僅平均使用21秒，酵母凝膠珠便升至溶液表面。相反，三次實驗中PH3的過氧化氫酶平均需時64.67秒約一分零七秒，酵母凝膠珠才升上溶液表面。由此可見，過氧化氫酶在中性或鹼性環境活性高，而酸性環境中活性較低。

有關異常數據，在PH3的第一次與第二次實驗中，數據出現較大偏差，第一次實驗耗時1分10秒，第二次實驗耗時58秒，共相差12秒。(有對於此誤差的想法嗎?)

❸ Strategies to support student learning in the SBA

Conceptual assistance

- Providing a checklist
- Using rubrics
- Division of the prompts into smaller units
- Use of parallel task

❸ Strategies to support student learning in the SBA

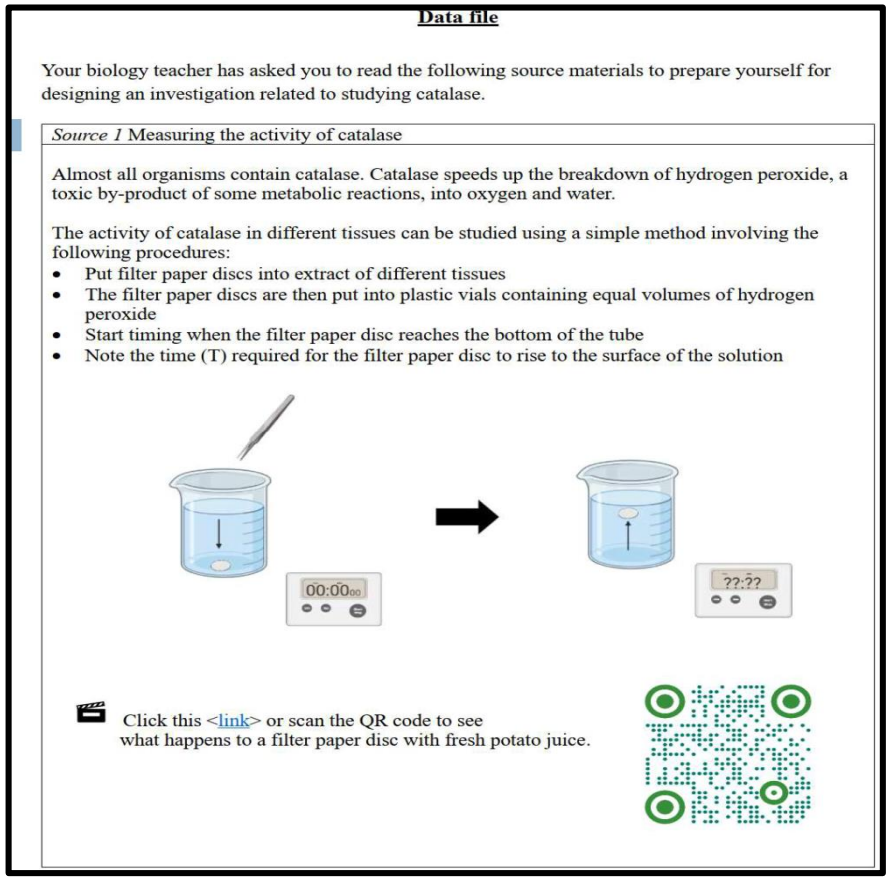
Scaffolding strategies

Sensory support	Linguistic support	Conceptual support	Interactive/social support
• Real objects • Multimedia • Graphs • Tables • Graphic organisers	• Defining key terms within sentences • Modifying sentence patterns • Providing sentence starters and frames	• Providing a checklist • Using rubrics • Dividing the prompts into smaller units	• Discussion with peers/teacher • Working in pairs or small groups with peers • Working with technological tools

❸ Strategies to support student learning in the SBA

Alternative ways of task implementation

- Initiate a class discussion *before* the B1 assessment
- Provide opportunities for trial run
- Distribute the task sheet *before* the assessment
- Conduct a similar task (parallel task) *before* the assessment
- Use pre-lesson task to activate the necessary prior knowledge



Data file

Your biology teacher has asked you to read the following source materials to prepare yourself for designing an investigation related to studying catalase.

Source 1 Measuring the activity of catalase

Almost all organisms contain catalase. Catalase speeds up the breakdown of hydrogen peroxide, a toxic by-product of some metabolic reactions, into oxygen and water.

The activity of catalase in different tissues can be studied using a simple method involving the following procedures:

- Put filter paper discs into extract of different tissues
- The filter paper discs are then put into plastic vials containing equal volumes of hydrogen peroxide
- Start timing when the filter paper disc reaches the bottom of the tube
- Note the time (T) required for the filter paper disc to rise to the surface of the solution

Click this <link> or scan the QR code to see what happens to a filter paper disc with fresh potato juice.

❸ Strategies to support student learning in the SBA

Alternative ways of task implementation

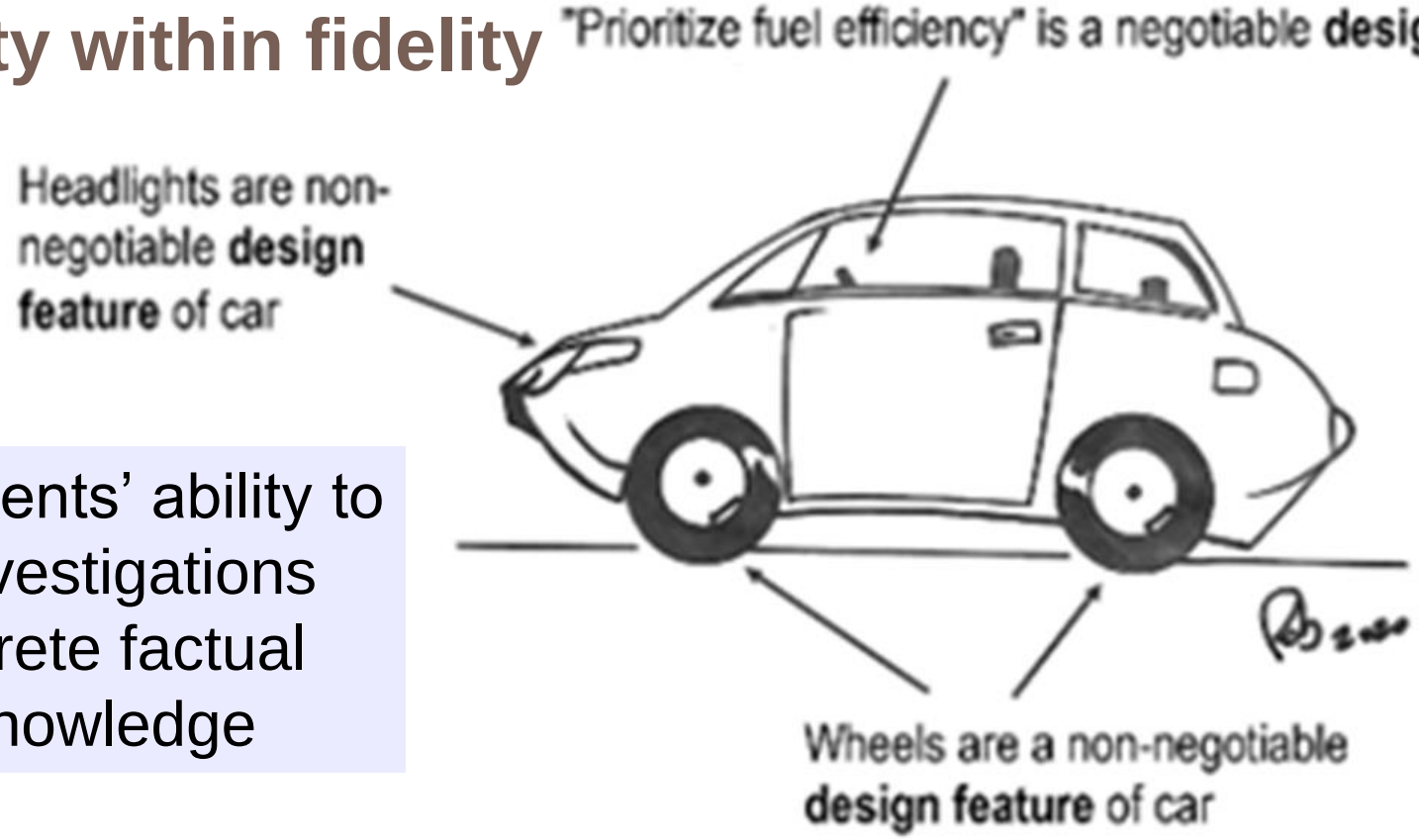
- Have students identify the most challenging questions *immediately* after completing B1 questions
- Provide exemplars of varying performance
- Have students self-assess their understanding associated with designing investigations
- Have students revise and refine their reports

2. 這個實驗中的自變量 (IV) 是什麼？我們如何操縱這個自變量？(B3) (B4)
What is the independent variable (IV) of this experiment? How can we manipulate the independent variable

B3 B4	自變量 IV: 不同成熟度的香蕉	如何操縱 將香蕉分作五份，分別於室內放置不同時間後放入 雪櫃中停止香蕉 繼續成熟，以保証有五個不同熟度的樣本。
B3 B4	Independent variable IV: degree of ripeness of the bananas	How to manipulate One bananas put into the refrigerator, another banana just put outside until it turn yellow and ripened
½ B3 ½ B4	Independent variable IV: The duration their bananas placed.	How to manipulate Put the individual of bananas with different duration.
B3	Independent variable IV: Ripeness of banana	How to manipulate Put the bananas in room temperature with same days.
B4	自變量 IV: 溫度	如何操縱 透過學樓和普通室溫作出對比，可以把兩條未成熟的香蕉分別放進雪櫃和桌子上。

❸ Strategies to support student learning in the SBA

Flexibility within fidelity



- Exact tasks used
- Questions set
- Targeted scientific thinking and its progression

Elicit students' ability to design investigations NOT discrete factual content knowledge

Figure 1. Non-negotiable design features versus negotiable design principles.

Miller, E. C., Severance, S., & Krajcik, J. (2021). Motivating teaching, sustaining change in practice: Design principles for teacher learning in project-based learning contexts. *Journal of Science Teacher Education*, *32*(7), 757-779.

❸ Strategies to support student learning in the SBA

Investigating the effect of temperature on the activity of catalase

Introduction

Hydrogen peroxide is a metabolic by-product in our body. Catalase is an enzyme that breaks down hydrogen peroxide into oxygen and water. The activity of catalase is influenced by temperature. In this investigation, you are going to investigate the effect of temperature on the activity of catalase.

Materials and apparatus

Liver catalase extract	Boiling tube
Water bath	Glass tubing
Measuring cylinder	Delivery tubing
Water tough	One-hole stopper
0.1% hydrogen peroxide solution	Thermometer

Task

Design an investigation to study the effect of temperature on the activity of catalase. Write a full report that describes your experimental design, procedures, findings, and conclusion.

- We do **NOT encourage using full report** as it may be limited in eliciting student understandings related to experimental designs
- If teachers think that full report is a better tool for differentiating the ability of their students in terms of their ability to design experiments, the **NEW assessment guidelines** should be followed

Assessment guideline

SBA Assessment guideline	English version	Chinese version
1. Area B1	<link>	<link>
2. Area B2	<link>	<link>

Sample task

Sample task	English version	Chinese version
1. Effect of concentration of ethanol on membrane permeability 乙醇濃度對膜通透性的影響	<link>	<link>
2. A comparison of the stomatal density of upper and lower epidermis of leaves using leaf temperature 利用葉溫比較葉片上、下表皮的氣孔密度	<link>	<link>
3. A comparison of the fat content of different types of milk 不同類型牛奶的脂肪含量比較	<link>	<link>
4. Investigating enzymatic activities of biological washing powders 探究生物洗衣粉的酶活性	<link>	<link>
5. Investigating the effect of heavy metal ions on catalase activity of yeast beads 探究重金屬離子對酵母凝膠珠中過氧化氫酶活性的影響	<link>	<link>
6. Investigation on the effect of pH on the invertase activity of the yeast beads 探究 pH 值對酵母珠的轉化酶活性的影響	<link>	<link>

- Please note that these sample tasks are intended to support teachers when planning their SBA. Teachers are STRONGLY encouraged to adapt and modify these sample tasks to better support the learning needs of their students.

- Sample tasks for teachers to modify and adapt for their own needs.

❸ Strategies to support student learning in the SBA

Possible modifications of assessment tasks and items:

(a) Varying question formats

(b) Modifying the questions

(c) Changing the factor(s) under investigation

Changes in implementation

Mini-exams → Formative assessment interactions

Support and feedback
before and after the SBA task

Summary

- Principles of scoring SBA samples in the new SBA format
- New SBA format provides teachers with more flexibility to support student learning of experimental designs
- Small changes in
  - how we design assessment tasks
  - implement the SBA tasks

  can lead to changes in how students learn from the experiences and teacher learning from their students

Contact information

Faculty of Education
The University of Hong Kong
香 港 大 學 教 育 學 院

Kennedy Chan
(kennedyckh@hku.hk)

Dickson Ho
(hts@cfss.edu.hk)

Interim Resumption Arrangements (IRA) for 2024 DSE Biology

- Teachers are encouraged to carry out **MORE THAN** the minimum number of assessments for each student.

- The final SBA marks of a candidate includes
  - The best **ONE** mark obtained in **Area A** regardless of the types (8%);
  - The best **ONE** mark obtained in **Area B1** (6%);
  - The best **ONE** mark obtained in **Area B2** (6%).