USING STUDENTS' MISTAKES TO PROMOTE LEARNING IN SCIENCE

HANDOUTS FOR TEACHERS

Contents

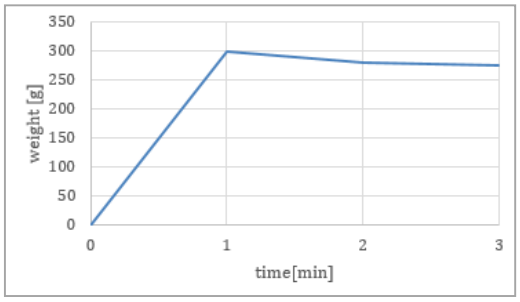
Handout 1(1): Sample student work

Constructing a graph

Bahri and Sandra took an apple to school for lunch. Both of them don't like the bitter skin, so their apples are peeled. Sandra's mother, however, has cut her peeled apple into bite-sized pieces, while Bahri has brought the peeled apple as a whole. During a hot day with temperatures of 35°C in the shade, both students ask themselves: "Who is going to have the juiciest apple in the afternoon?".

Paul performed an experiment regarding this question and constructed this graph from his results.

Paul's graph:



What is Paul trying to illustrate? How do you know?

List the errors and difficulties that are revealed by Paul's graph.

Try to identify the thinking that lies behind Paul's error.

What feedback would you give to Paul?

Handout 1(2): Sample student work

Formulating a hypothesis

Bahri and Sandra took an apple to school for lunch. Both of them don't like the bitter skin, so their apples are peeled. Sandra's mother, however, has cut her peeled apple into bite-sized pieces, while Bahri has brought the peeled apple as a whole. During a hot day with temperatures of 35°C in the shade, both students ask themselves: "Who is going to have the juiciest apple in the afternoon?".

Formulate a hypothesis for this question, which can be tested with an experiment.

Justin's response

"If you cut the apple into bite-sized pieces, it dries out because it has contact with more air."

What does Justin appear to understand? How do you know?

List the errors and difficulties that are revealed by his response.

Try to identify the thinking that lies behind each error.

What feedback would you give Justin? Write down your comments on his work.

Handout 2(1): Sample follow-up questions

Common issues	Suggested questions and prompts
Student chooses an inappropriate diagram type For example: Student chooses a pie chart	• *Which type of diagram can represent your information appropriately?* • *Can this type of diagram be used to display the relation between time and weight?*
Student is unable to assign the variables to the axis For example: Student assigns the time to the y-axis and the weight to the x-axis	• *Which axis is assigned to which variable?*
Student is unable or fails to label the axis (clearly) For example: Student forgets the measurement units or uses indistinct information	• *Check if a reader can reconstruct the experiment if only your diagram is available with no additional information.* • *How can you withdraw from the diagram which units were used to record the data?*
Student fails to choose an appropriate scaling For example: Student selects very large/ small intervals between measurement points Or: Uses different sized intervals	• *How did you choose the distance between the data points?* • *How does the reader withdraw the intervals of your measurements from the diagram?* • *How should the initial and final value of the axes be chosen so that all data fit in this diagram?*
Student is unable to plot the data For example: Student wants to maintain a linear or constant diagram form	• *How do you create a coordinate system to enter the value pairs of your experiment?* • *How do you plot the data into the diagram?*
Student creates a separate diagram for each test approach	• *How can you implement the different test approaches in one diagram?*
Student fails to draw connecting lines	• *In which case may the individual values be connected with lines?*
Student fails to hypothesize For example: Student defines variable wrong Or: limits the hypotheses too much Or: forms unstructured hypotheses	• *What do you want to observe in your Experiment? How can you measure it?* • *What can be varied in your experiment? What are the different states of the variable?* • *What is a hypothesis? If I change the variable, what changes can I observe?*

Handout 3: Handling students' errors

There are two common ways of reacting to pupils' errors and misconceptions:

- **Avoid them** whenever possible:
  "If I warn pupils about the misconceptions as I teach, they are less likely to happen. Prevention is better than cure."
- **Use them** as learning opportunities:
  "I actively encourage students not to hide mistakes when they make them, and to learn from them."

Which approach resonates with your own practice?

Can you give an example of you reacting to a student's mistake in one of your lessons?

What kind of challenges are there to using students' mistakes in a classroom?

Handout 4: Principles to discuss

The following principles are backed up by research evidence:

Explore misconceptions through discussion

Teaching approaches that encourage the exploration of misconceptions through discussions result in deeper, longer-term learning than approaches that try to avoid mistakes by explaining the 'right way' to see things from the start.

Focus on known difficulties

It is helpful if discussions focus on known difficulties. Rather than posing many questions in one session, it is better to focus on a challenging question and encourage a variety of interpretations to emerge, so that learners can compare and evaluate their ideas.

Use cognitive conflicts

Questions can be juxtaposed in ways that create a tension (sometimes called a 'cognitive conflict') that needs resolving. Contradictions arising from conflicting methods or opinions can create awareness that something needs to be learned.

> For example, asking students whether tomatoes are fruits or vegetables. Some students might connect the definition of 'fruit' with the sweet taste. Although tomatoes are colloquial assigned to vegetables, they are botanically speaking, fruits. This can lead to the need to talk about definitions and characteristics of fruits and vegetables.

Provide opportunities for meaningful feedback

Activities should provide opportunities for meaningful feedback. This does not mean providing summative information, such as the number of correct or incorrect answers. More helpful feedback is provided when learners compare results obtained from alternative methods until they realise *why* they get different answers.

Include whole group discussions

Sessions include time for whole group discussion in which new ideas and concepts are allowed to emerge. This requires sensitivity so that learners are encouraged to share tentative ideas in a non-threatening environment.

Allow opportunities to consolidate

Opportunities should be provided for learners to consolidate what has been learned through the application of the newly constructed concept.

What do you think of this advice?

What would you like to add?

Is there anything you would remove?