Using multiple choice questions to identify student misconceptions

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Using multiple choice questions

Purpose:

- To gain an insight into the writing of multiple choice questions
- Learn how to use statistical evidence to reveal areas of misconception and error
- Explore how to use multiple choice questions in the classroom to identify and address specific areas for development
- Share ideas for activities involving multiple choice questions to suit different learning styles
Writing multiple choice questions
Why multiple choice questions?

- In summative assessment:
  - For wide syllabus coverage
  - Contribute to reliability
  - Quick and easy to mark electronically
  - Easy to create similar but different questions (sibling items)

- In formative assessment
  - To reinforce learning
  - To identify misconceptions
  - Easy to create sibling items to re-test misconceptions
  - Quick and easy to mark
The circuit of a motor racing track is 3.0 km in length. In a race, a car goes 25 times round the circuit in 30 minutes.

What is the average speed of the car?

A 75 km / hour   B 90 km / hour   C 150 km / hour   D 750 km / hour
Sibling – a closely related item

The circuit of a motor racing track is 3.0 km in length. In a race, a car goes 25 times round the circuit in 30 minutes.

What is the average speed of the car?

A 75 km / hour  B 90 km / hour  C 150 km / hour  D 750 km / hour

The circuit of a motor racing track is 7.0 km in length. In a race, a car goes 12 times round the circuit in 36 minutes.

What is the average speed of the car?

A 84 km / hour  B 252 km / hour  C 140 km / hour  D 432 km / hour
What makes a good multiple choice item?

- There is a unique correct answer that is on syllabus
- The key is correct no matter how much science is known beyond the syllabus
- All options are plausible
- All distractors are on syllabus
- It is neither too easy nor too difficult
- The language is clear and technical terms are on the syllabus
- There is no trickery, or gender, racial or cultural bias of any kind
Distractors – non-calculation questions

Distractors for non-calculation items are all reasonable choices given incomplete knowledge.

When dilute sulfuric acid is electrolysed using inert electrodes, two gases are produced.

What are these two gases?

A hydrogen and oxygen
B hydrogen and sulfate
C hydrogen and sulfur dioxide
D oxygen and sulfur dioxide
Distractors – calculation questions

- Distractors for calculations can all be reached using the data given, ideally with just one mistake in the process

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
</table>

A 2.0 g sample of sodium chloride is dissolved in water to give a solution of volume 80 cm³.

What is the concentration of this solution in g/dm³?

- Key: $80 \div 1000 = 0.08\text{ dm}^3, \quad 2.0 \div 0.08 = 25\text{ g/dm}^3$

- What could be good distractors?
  - not converting to dm³ = 0.025 (g/cm³)
  - fraction wrong way up = 0.04 (dm³/g)
  - multiplying instead of dividing = 0.16 (g dm³)
Distractors – calculation questions

A 2.0 g sample of sodium chloride is dissolved in water to give a solution of volume 80 cm$^3$.

What is the concentration of this solution in g/dm$^3$?

A

B 25

C

D

Other possible distractors

- not converting to dm$^3$ and wrong way up = 40 (cm$^3$/g)
- multiplying 80 x 2 = 160
- adding 80 + 2 = 82
- random answer e.g. 33
Distractors – calculation questions

Distractors for calculations can all be reached using the data given, ideally with just one mistake in the process.

The potential difference across a resistor is 6.0 V, and the current in it is 3.0 A.

What is the resistance of the resistor?

A 0.50 Ω  
B 2.0 Ω  
C 9.0 Ω  
D 18 Ω

Ohm’s Law: \( V = I \times R \)

where \( V \) is voltage, \( I \) is current in amperes (A) and \( R \) is the resistance in ohms (Ω)

Rearrange: \( R = \frac{V}{I} = \frac{6.0}{3.0} = 2.0 \ \Omega \)
Statistics
Facility = the proportion of students that answered correctly

Target range is 0.25 – 0.80

An extremely high value indicates the question is too easy

An extremely low value indicates the question is too hard

0.25 is the “guessing rate” in a four-option question
Statistics

- Proportion endorsing = the proportion choosing each option

The diagram shows a ray of light striking a plane mirror.

What is the angle of reflection?

- **A** 20°
- **B** 40°
- **C** 70°
- **D** 140°
Statistics

- Look at the proportion of candidates in the upper 27% of the test score distribution who gave the correct answer to the item, and the same proportion in the lowest 27% group.
- Should find that the proportion endorsing the key is greater for the stronger group than for the weaker group.
- AND the proportion endorsing for the distractors is greater for the weaker group than for the stronger group.
Statistics

Statistics for the question:

<table>
<thead>
<tr>
<th>Proportion correct</th>
<th>Option</th>
<th>Proportion endorsing</th>
<th>Key</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>Low</td>
</tr>
<tr>
<td>0.36</td>
<td>A</td>
<td>0.56</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
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<td>C</td>
<td>0.36</td>
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<tr>
<td></td>
<td>D</td>
<td>0.04</td>
<td>0.06</td>
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</tbody>
</table>

PE report: This question on reflection of light proved challenging. The majority of candidates chose option A; it should be noted that the angle of reflection is always measured between the ray and the normal.
Using the statistics

- Use the facility to identify which topics are generally well understood and which are less well understood.
- Use the proportion endorsing to identify specific misconceptions and identify which topics weaker candidates struggle with.
Using multiple choice questions in the classroom
Use in the classroom

- At the beginning of the topic to assess prior knowledge
- During a topic to assess progress
- During a lesson to check understanding
- As homework
- At the end of a topic to plan targeted revision
Sources of questions

- Past papers
- Test-maker
- Text books
- Online
- Write your own
Writing multiple choice questions - tips

- Keep notes of ideas as teaching
- Identify topic/learning outcome to test
- Start by writing a question with correct answer
- Consider distractors to test common misconceptions/mistakes
- Ask someone else to review
Learning styles
Small amounts of sodium chloride and sand are shaken with separate samples of water in two test-tubes. The test-tubes are left to stand for 24 hours.

Which diagram shows how the test-tubes appear after leaving them to stand for 24 hours?
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Which diagram shows how the test-tubes appear after leaving them to stand for 24 hours?
Learning styles

A A
A A
B B
B B
C C
C C
D D
D D
Learning styles
Learning styles

- Further ideas…
- Students to write their own
- Using paper/mini white boards to hold up what they think it is – gives quick idea whether they are getting it
- Yes/no/maybe – traffic lights or smiley faces, to vote on each choice
- A, B, C, D stations around the classroom
Summary
Using multiple choice questions

Outcomes:

- Gained an insight into the writing of multiple choice questions
- Learned how to use statistical evidence to reveal areas of misconception and error
- Explored how to use multiple choice questions in the classroom to identify and address specific areas for development
- Shared ideas for activities involving multiple choice questions to suit different learning styles
Assessment

We recognise that assessment has two important roles: to prove and improve – to prove what students are learning, and to suggest how they can improve their understanding and skills.
Thank you
Any questions?
Learn more!
Getting in touch with Cambridge is easy

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