

Examining Assessment Equity →

Connecting
MCQ
Assessment to
Experiential
Learning
Outcomes

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Experiential learning is a term used to describe...

- a) The process of making meaning from direct experience
- b) The process of learning through experimentation
- c) The process of using metacognitive strategies to reflect and 'think about thinking'
- d) All of the above

Past experience

New activity

Reflection
& Metacognition

Examples:

Field work, land-based learning, apprenticeship, internship, presentation, experiment, laboratory exercises, problem-based learning, embodied instruction, peer teaching & more!

Kiskiaumatowin is a Cree/Nihewin word that best translates to “learning” and contains the root words ‘*ki*’ and ‘*iski*’, which refer to ‘people’ and ‘earth’. This suggests that Niheyawin view knowledge as something that arises from interactions with...

- a. Fish that swim in schools
- b. Books and Internet resources
- c. Other people, as well as the land and its other-than-human inhabitants
- d. Zeegers et al. (2011)

Truth & Reconciliation Calls to Action

Situated on Treaty 6 Territory in the Homeland of the Métis Nation, our university is called in the spirit of Truth and Reconciliation to ensure that Indigenous peoples have equitable access to educational opportunities (TRC 92.ii) through changes that welcome both Indigenous peoples and their ways of knowing into our colleges.

Reconciliation in STEM disciplines includes working to ameliorate a long history of systemic and institutional racism that has limited the cultural-relevance of, and tangible access to, STEM for Indigenous learners.

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- **How do traditional assessment strategies interact with experiential pedagogies?**
- **Can MCQs reward and reflect outcomes of experiential learning?**
- Are MCQs assets or barriers to increasing equity and accessibility in our STEM disciplines? When, why, and how?



A Learning Experience

ALL:

Step 1 – put 1 metal flake in a cup

Step 2 – add acetic acid to a depth
of 10 mm

Step 3 – observe

Think about/discuss: when have you
seen bubbles form in solutions
before?

MCQs – a bit of a bad rep!

Multiple Choice Questions (MCQs)...

- a) Test arbitrary recall rather than deep processing
- b) Send students away from exams with fresh (prompted) misconceptions about tested material
- c) Are perceived by students as ‘tricky’
- d) Don’t allow students to demonstrate alternate understandings or apply personal insights or academic strengths
- e) Culturally-biased: school culture, cultural attitudes toward risk taking and approaches to problem-solving
- f) **Worst Case Scenario: privilege assumed prior knowledge and base literacies (jargon level) rather than mastery of course content**

We've been using them for a while, there must be redeeming features!

Multiple Choice Questions (MCQ)

- a) Can cue improved content mastery during experiential learning
- b) Produce best 'student performance' when well aligned to course content and paired with quality instruction
- c) Are used as a component of assessment in ~ 20% of courses that explicitly incorporate experiential learning
- d) Can help students to identify and dismiss competitive incorrect answers
- e) MCQ tests can promote productive retrieval and enhance later recall building disciplinary knowledge banks

All of the above!

- a) Sadowski & Gulgoz (1996) Elaborative Processing Mediates the Relationship Between Need for Cognition and Academic Performance
- b,c) Wilson, Yates & Purton (2018) Performance, Preference, and Perception in Experiential Learning Assessment
- d) VanSchenk Hof, Houseworth, McCord & Lannin (2018) Peer evaluations within experiential pedagogy: Fairness, objectivity, retaliation safeguarding, constructive feedback, and experiential learning as part of peer assessment
- e) Little, Bjork, Bjork & Angello (2012) Multiple-Choice Tests Exonerated, at Least of Some Charges: Fostering Test-Induced Learning and Avoiding Test-Induced Forgetting

FIRST THINGS FIRST... Assessing the Quality of MCQs and MCQ exams

- Student performance
 - Difficulty (0-1): $0.3 < p < 0.8$, i.e. 30-80% of students get item correct
 - Point bi-serial index (-1 to +1): < 0.2 revise item, 0.3-0.39 good, 0.4-0.7 very good)
 - Point bi-serial index of question components: negative for distractors, positive for keyed answer
 - Test statistics: KR-20, KR-21 (> 0.5), Cronbach Alpha (> 0.8) scores
- Peer review within SoTL practice
- Alignment with course learning objectives / materials covered
- Feedback solicited through bonus questions and/or spontaneous feedback

Question		Summary Statistics				Reliability	
Question	Points	Graded	Correct	Incorrect	No Response	Point Biserial	Percent Correct
Question68	1.00	222	104	118	0	0.52	46.85

Test Reliability

Kuder-Richardson Formula 20	0.92
Kuder-Richardson Formula 21	0.90
Coefficient (Cronbach) Alpha	0.92

Question68

Response	Frequency	Percent	Point Biserial	Graph
A	41	18.47	-0.09	
B	66	29.73	-0.40	
C	11	4.95	-0.18	
*D	104	46.85	0.52	
E	0	0.00	-	
F	0	0.00	-	
G	0	0.00	-	
H	0	0.00	-	
I	0	0.00	-	
J	0	0.00	-	

McBeth 2019 (unpublished data)

Philosophical dilemmas with MCQs:

- a) Optimal question design requires a certain proportion of students (the students who have the hardest time with the material) misunderstand and demonstrate that misunderstanding
- b) Depending on students' common misunderstandings to ensure test questions function in a statistically effective way



“Lies, damned lies,
statistics...”

[Twain, PM Benjamin Disraeli and co]

Shouldn't I be figuring out what those misunderstandings are, and leverage that knowledge to improve my teaching and my students' understanding of the material?

7. New ocean basins form through _____, and ocean basins close through _____.

(A) subduction / continental rifting

(B) continental collision / continental rifting

(C) continental rifting / subduction

(D) oceanic rifting / isostatic rebound

111. For 1 bonus mark: explain how you arrived at your answer for question 7. I encourage you to use a drawing to help illustrate your answer to this bonus question if it is helpful for your explanation.

113. For 1 bonus mark: Please share something creative (e.g., geologically themed drawing, haiku, pun) and/or something you've learned in this course (e.g., diagram, something that will stick with you), and/or anything else you want to share with me. I will be very generous with marks on this question. I would love to see you stretch yourself and draw or share something more complicated or creative, it doesn't have to be perfect.

Note: obtained ethics exemption prior to test and provided option to participate in study or not (identical bonus questions for those who opted out)

7. New ocean basins form through _____, and ocean basins close through

_____.

- (A) subduction / continental rifting (B) continental collision / continental rifting
- (C) continental rifting / subduction (D) oceanic rifting / isostatic rebound

Question	Points	Graded	Correct	Incorrect	Response	Biserial	Correct
Question7	1.00	222	112	110	0	0.22	50.45

Question7

Response	Frequency	Percent	Point Biserial	Graph																						
A	26	26.53	-0.24	<table border="1"> <caption>Data for Graph</caption> <thead> <tr> <th>Response</th> <th>Frequency</th> </tr> </thead> <tbody> <tr><td>A</td><td>26</td></tr> <tr><td>B</td><td>6</td></tr> <tr><td>C</td><td>52</td></tr> <tr><td>D</td><td>13</td></tr> <tr><td>E</td><td>0</td></tr> <tr><td>F</td><td>0</td></tr> <tr><td>G</td><td>0</td></tr> <tr><td>H</td><td>0</td></tr> <tr><td>I</td><td>0</td></tr> <tr><td>J</td><td>0</td></tr> </tbody> </table>	Response	Frequency	A	26	B	6	C	52	D	13	E	0	F	0	G	0	H	0	I	0	J	0
Response	Frequency																									
A	26																									
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H	0																									
I	0																									
J	0																									
B	6	6.12	-0.07																							
*C	52	53.06	0.24																							
D	13	13.27	0.07																							
E	0	0.00	-																							
F	0	0.00	-																							
G	0	0.00	-																							
H	0	0.00	-																							
I	0	0.00	-																							
J	0	0.00	-																							

7. New ocean basins form through _____, and ocean basins close through _____.

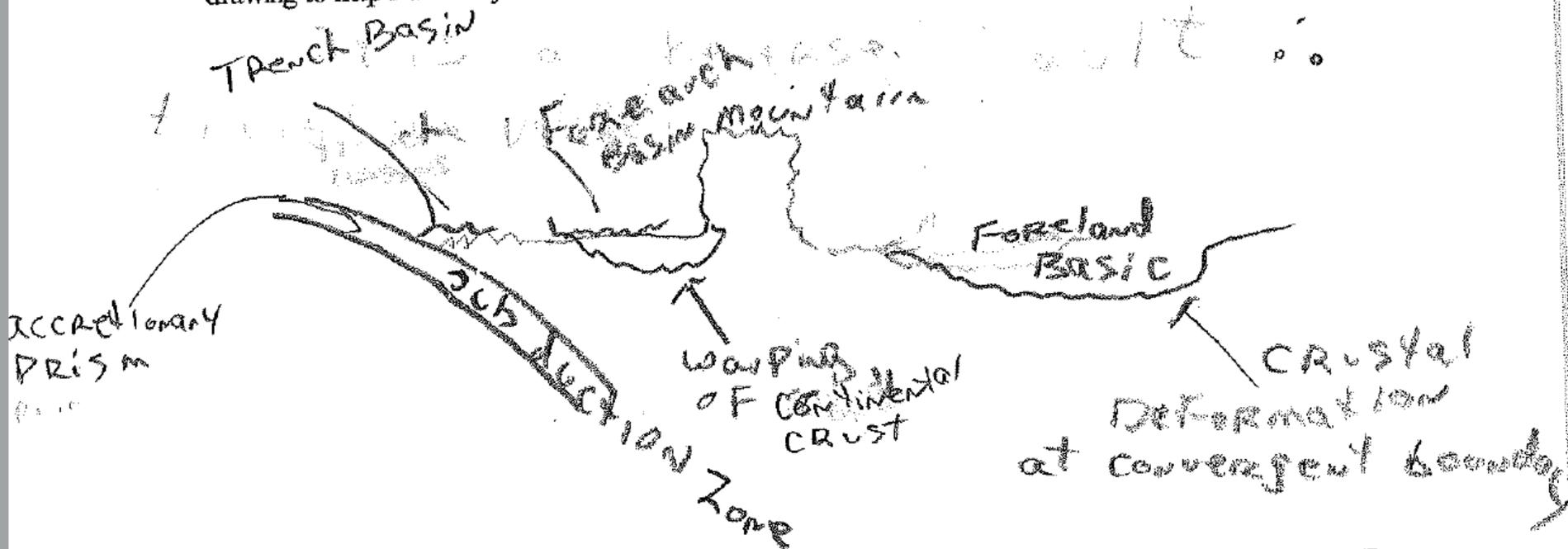
- (A) subduction / continental rifting (B) continental collision / continental rifting
 (C) continental rifting / subduction (D) oceanic rifting / isostatic rebound

Question	Points	Graded	Correct	Incorrect	Response	Biserial	Correct
Question7	1.00	222	82	140	0	0.09	36.94

Question7

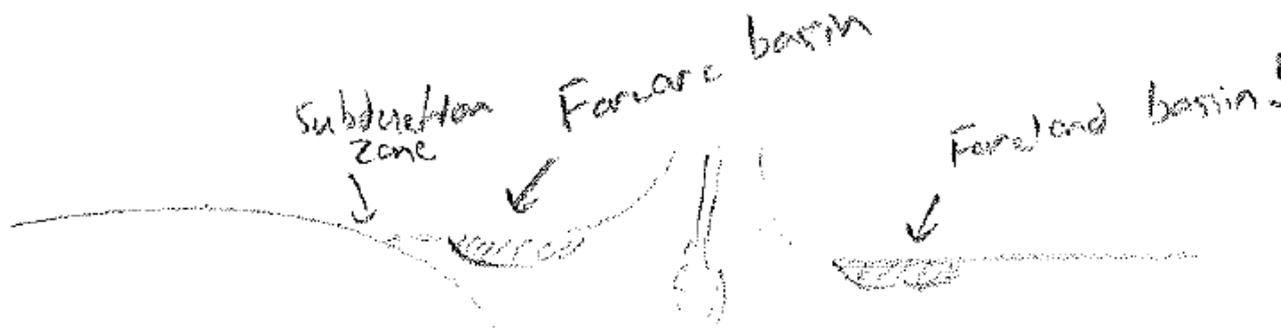
Response	Frequency	Percent	Point Biserial	Graph
A	81	36.49	-0.23	
B	5	2.25	-0.05	
*C	82	36.94	0.09	
D	54	24.32	0.17	
E	0	0.00	-	
F	0	0.00	-	
G	0	0.00	-	
H	0	0.00	-	
I	0	0.00	-	
J	0	0.00	-	

111. For 1 bonus mark: explain how you arrived at your answer for question 7. I encourage you to use a drawing to help illustrate your answer to this bonus question if it is helpful for your explanation.



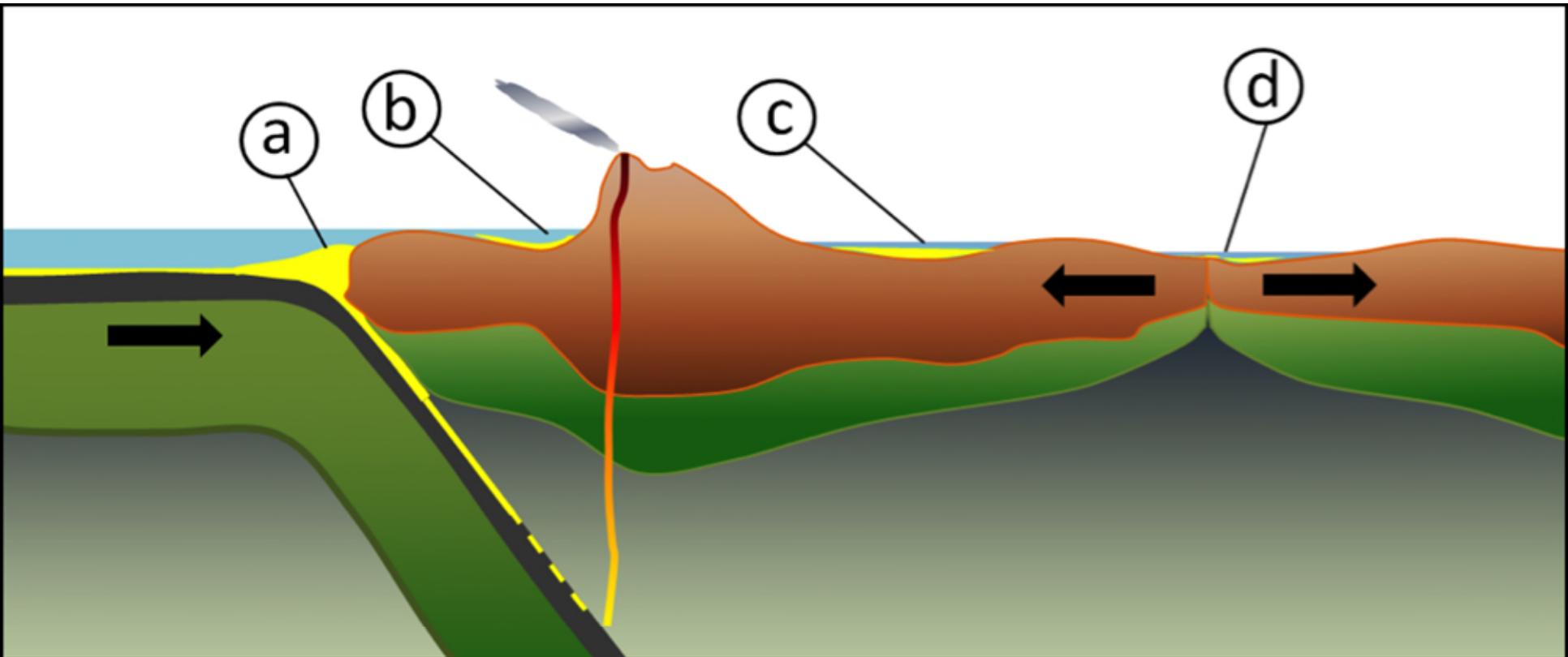
111. For 1 bonus mark: explain how you arrived at your answer for question 7. I encourage you to use a drawing to help illustrate your answer to this bonus question if it is helpful for your explanation.

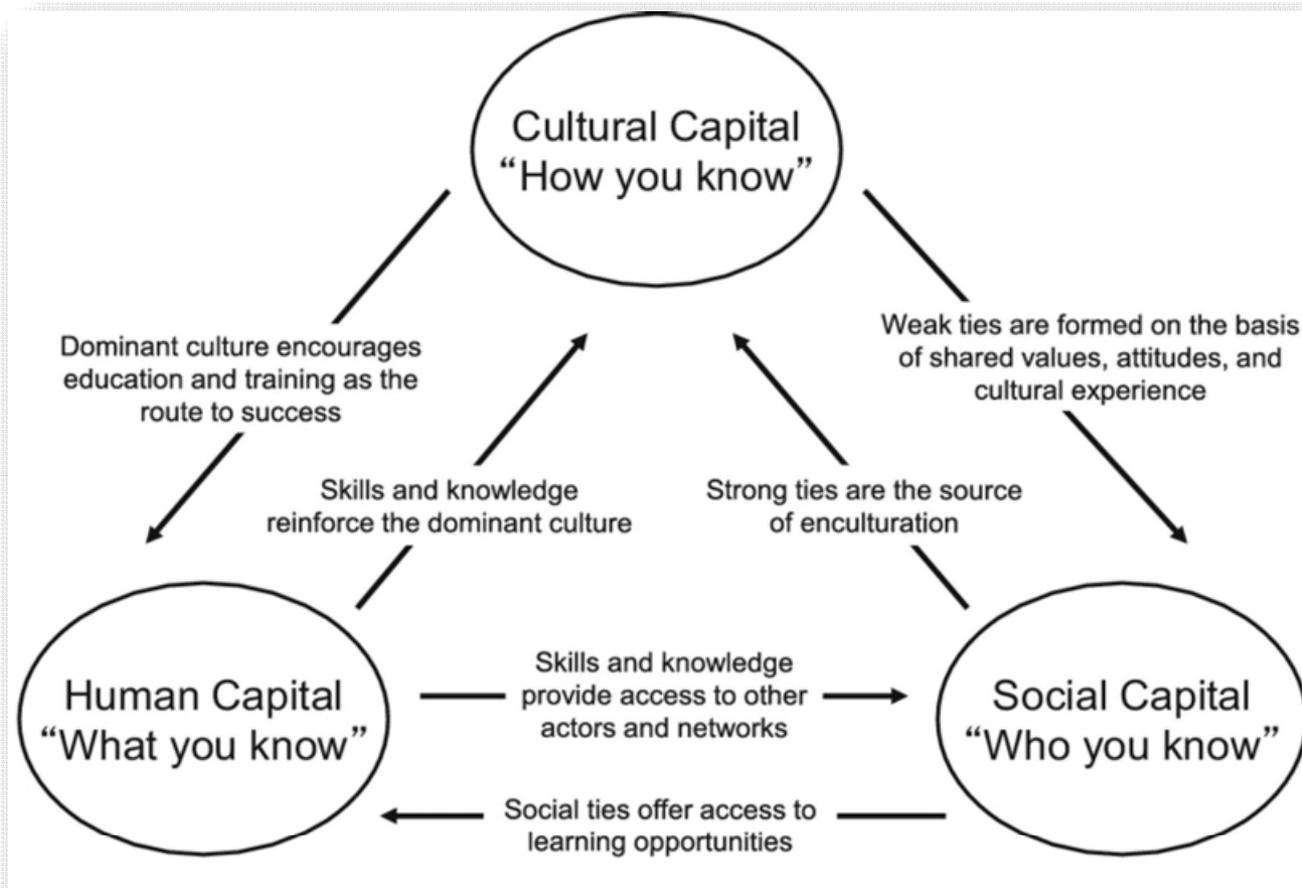
I somewhat guessed on Q7 but I remember this diagram



Tectonically-produced basins:

- (a) trench basin (b) forearc basin
(c) foreland basin (d) rift basin





“... students built multidimensional social ties with faculty, peers, and others, yielding social capital that can be drawn upon for information, resources, and support. They reported developing cultural capital in the form of learning to think and work like a scientist—a scientific *habitus*.”

INTS 102 – Hacking Problematic MCQs

Justification of MCQ answer selection can...

- a) Benefit the academic motivation of students high in ‘need for cognition’
- b) Improve learning (delayed factual recall) impact of post-evaluation feedback
- c) Promotes mastery of “normative scientific reasoning” in STEM courses
- d) Decreases the likelihood of guessing and encourages re-organization of knowledge
- e) Increase student perception of evaluative objectivity
- f) Aid instructors by flagging instances where students select ‘correct’ answers through inappropriate or incorrect reasoning
- g) Decrease inequity by reducing the influence of assumed skillsets in assessment (e.g. English language proficiency)

All of the above!

- a) Sadowski & Gulgoz (1996) Elaborative Processing Mediates the Relationship Between Need for Cognition and Academic Performance
- b) Levant, Zuckert & Paolo (2018) Post-exam feedback with question rationales improves re-test performance of medical students on a multiple-choice exam
- b) Ernst & Steinhäuser (2012) Feedback-related brain activity predicts learning from feedback in multiple-choice testing
- c,d,f) Koretsky, Brooks & Higgins (2016) Written Justifications to multiple-choice concept questions during active learning in class
- e) Wilson, Yates & Purton (2018) Performance, Preference, and Perception in Experiential Learning Assessment
- g) Basset (2016) Teaching Critical Thinking without (Much) Writing: Multiple-Choice and Metacognition

INTS 102 – Hacking Problematic MCQs

Which of the following statements is false?

- a. water molecules are polar
- b. all living things contain water
- c. ice is more dense than liquid water
- d. none: all of these statements are true

A large molecule made up of many similar subunits is called a:

- a. functional group
- b. helix
- c. monomer
- d. polymer

$10^4 = ?$

- a. $10+10+10+10$
- b. $10 \times 10 \times 10 \times 10 \times 10$
- c. 10,000
- d. $\log_4(10)$

When I tie my shoelaces, I have performed an 'operation'.
When I untie my shoelaces, I am performing an 'inverse operation'.
What operation is the inverse of multiplying a number by 3?

answer: _____

INTS 102 – Student-generated MCQs as assessment

Stereotype threat is a tendency for members of a stereotyped group to underperform on a task when performance expectations generate cognitive dissonance. This threat can be relieved by...

- a. directly addressing stereotypes in task environments
- b. building task environments that do not provoke stereotype threat
- c. encouraging individuals to affirm their own values and goals before and during the task
- d. all of the above

True or False – “diversity in science is important”

- a. True—white males have been carrying the burden of creating knowledge for too long
- b. True—diversity of beliefs, skillsets, and cultures of knowing will broaden the questions that science can both ask, and answer
- c. False—the more similar members of a group are, the more quickly they will generate new ideas
- d. False—the scientific method is objective; it does not matter who is doing research

In healthcare delivery (and many other fields) individuals must provide “informed consent” to participate in, or receive, treatments and services. Are skill testing questions sufficient to determine a participant’s ability to provide informed consent? (e.g. $2 \times 5 - 10 + 7 = ?$)

- a. Yes
- b. No

Explain your response: _____

GROUP A

Earlier in this presentation, you initiated a chemical reaction!

The following questions relate to that reaction.

Select the most appropriate response for each of the following questions.

- The reaction that you observed can be described by the chemical formula:
 - $\text{Mg}^{2+} + 2\text{CH}_3\text{COOH} \Rightarrow \text{Mg}(\text{CH}_3\text{COO})_2 + \text{H}_{2(g)}$
 - $\text{Mg}^{2+} + 2\text{CH}_3\text{COOH} + 2\text{O}_2 \Rightarrow \text{Mg}(\text{CH}_3\text{COO})_2 + 2\text{H}_2\text{O}$
 - $\text{Mg}^{2+} + 2\text{CH}_3\text{COH} + \text{HCl} \Rightarrow \text{Mg}(\text{CH}_3\text{COO})_2 + \text{H}_2\text{O} + \text{MgCl}_{(s)} + \text{CO}_{2(g)}$
- The chemical reaction completed when:
 - a limiting reagent was consumed
 - gas pressure in the solution equilibrated with the atmosphere
 - the temperature of the reaction cup equilibrated to room temperature
 - all of the above
- Which of the following would have increased the rate of the reaction you observed?
 - stirring the solution as it reacted
 - cutting the magnesium ribbon into smaller pieces
 - increasing the temperature of the acetic acid added to the cup
 - all of the above

A vs. B

Priming
Students
To draw
On Experiential
Understanding

GROUP B

Earlier in this presentation, you initiated a chemical reaction!

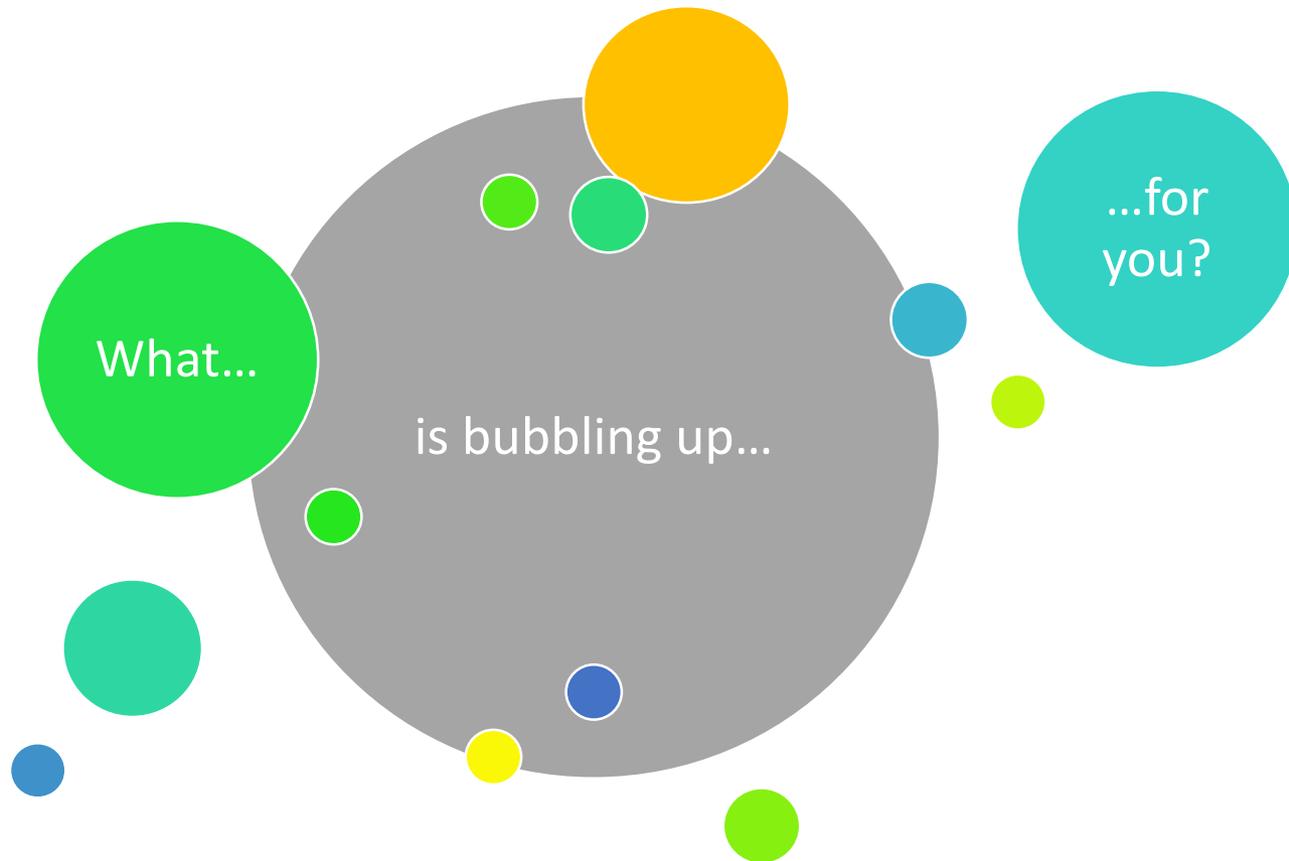
The following questions **relate to the reaction you observed**.

Select the most appropriate response for each of the following questions **based on what you observed and your prior experiences with bubbly solutions**.

- The reaction that you observed can be described by the chemical formula:
 - $\text{Mg}^{2+} + 2\text{CH}_3\text{COOH} \Rightarrow \text{Mg}(\text{CH}_3\text{COO})_2 + \text{H}_{2(g)}$
 - $\text{Mg}^{2+} + 2\text{CH}_3\text{COOH} + 2\text{O}_2 \Rightarrow \text{Mg}(\text{CH}_3\text{COO})_2 + 2\text{H}_2\text{O}$
 - $\text{Mg}^{2+} + 2\text{CH}_3\text{COH} + \text{HCl} \Rightarrow \text{Mg}(\text{CH}_3\text{COO})_2 + \text{H}_2\text{O} + \text{MgCl}_{(s)} + \text{CO}_{2(g)}$
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- Which of the following would have increased the rate of the reaction you observed?
 - stirring the solution as it reacted
 - cutting the magnesium ribbon into smaller pieces
 - increasing the temperature of the acetic acid added to the cup
 - all of the above

For 1 bonus mark, explain how you selected your answer for question 1.

You may use an illustration if it is helpful to your explanation:



Good Reading...

- Arora, A. 2018. First Nations, Métis and Inuit Statistics: The way forward. Presentation in Saskatoon, Saskatchewan, June 13, 2018. Retrieved from: <https://www150.statcan.gc.ca/n1/en/pub/11-631-x/11-631-x2018005-eng.pdf?st=N1Vc-b3g>
- Bassett, M.H., 2016. Teaching Critical Thinking without (Much) Writing: Multiple-Choice and Metacognition. *Teaching Theology & Religion*, 19(1), pp.20-40.
- Bidwell, K. & Bonny, S. 2017. Indigenous Success in the STEM Disciplines; Exploring Assets and Barriers to STEM Engagement for Indigenous Students. Presented at the University of Saskatchewan Building Reconciliation Forum, February 2017. Retrieved from: <https://aboriginal.usask.ca/documents/research/Indigenous%20Success%20in%20the%20STEM%20Disciplines.pdf>
- Deer, F., De Jaeger, A., & Wilkinson, L. 2015. *Canadian Post-Secondary Education and Aboriginal Peoples of Canada: Preparation, Access, and Relevance of Post-Secondary Experiences*. Retrieved from: <http://umanitoba.ca/catl/indigenous/report.html>
- Ernst, B. & Steinhauser, M. 2012. Feedback-related brain activity predicts learning from feedback in multiple-choice testing. *Cognitive, Affective, & Behavioral Neuroscience*, 12(2), pp.323-336.
- Indspire, 2018. Post-Secondary Experience of Indigenous Students Following the Truth and Reconciliation Commission; Summary of Survey Findings, 10 pp. Retrieved from: <https://indspire.ca/wp-content/uploads/2018/09/PSE-Experience-Indigenous-Students-Survey-Summary-Sept2018.pdf>
- Koretsky, M.D., Brooks, B.J. & Higgins, A.Z., 2016. Written justifications to multiple-choice concept questions during active learning in class. *International Journal of Science Education*, 38(11), pp.1747-1765.
- Levant, B., Zückert, W. & Paolo, A. 2018. Post-exam feedback with question rationales improves re-test performance of medical students on a multiple-choice exam. *Advances in Health Sciences Education*, 23(5), pp.995-1003.
- Little, J.L., Bjork, E.L., Bjork, R.A. & Angello, G. 2012. Multiple-choice tests exonerated, at least of some charges: Fostering test-induced learning and avoiding test-induced forgetting. *Psychological science*, 23(11), pp.1337-1344.
- Sadowski, C.J. & Gülgös, S. 1996. Elaborative processing mediates the relationship between need for cognition and academic performance. *The Journal of Psychology*, 130(3), pp.303-307.
- Truth and Reconciliation Commission of Canada. 2015. *Canada's Residential Schools: Reconciliation: The Final Report of the Truth and Reconciliation Commission of Canada, Volume 6*. McGill-Queen's University Press. Retrieved from <http://www.jstor.org/stable/j.ctt19qghck>
- Thompson, J.J., Conaway, E. & Dolan, E.L. 2015. Undergraduate student's development of social, cultural and human capital in a networked research experience. *Cultural Studies of Science Education*; DOI 10.1007/s11422-014-9628-6
- VanSchenkhoef, M., Houseworth, M., McCord, M. & Lannin, J. 2018. Peer evaluations within experiential pedagogy: Fairness, objectivity, retaliation safeguarding, constructive feedback, and experiential learning as part of peer assessment. *The International Journal of Management Education*, 16(1), pp.92-104
- Voice, Vision and Leadership: A Place for All. 2013. *Final report of: the joint task force on improving education and employment outcomes for First Nations and Métis People*, 80 pp. Retrieved from www.jointtaskforce.ca
- Wilson, J.R., Yates, T.T. & Purton, K. 2018. Performance, Preference, and Perception in Experiential Learning Assessment. *Canadian Journal for the Scholarship of Teaching and Learning*, 9(2), p.n2

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