

Who Answers Complex Multiple-choice Questions in Physics Correctly?

Nicholas T. Young¹

Mark Mills¹, Rebecca L. Matz¹, Eric Bell², Caitlin Hayward¹

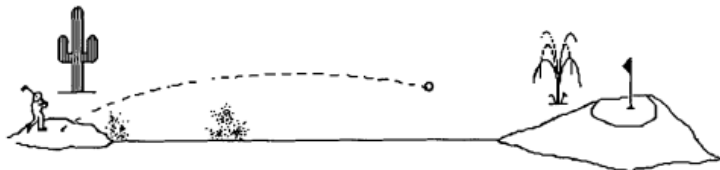
¹Center for Academic Innovation, University of Michigan

²Department of Astronomy, University of Michigan



A sample complex multiple-choice question

22. A golf ball driven down a fairway is observed to travel through the air with a trajectory (flight path) similar to that in the depiction below.



Which following force(s) is(are) acting on the golf ball during its entire flight?

1. the force of gravity
2. the force of the "hit"
3. the force of air resistance

Primary responses

- (A) 1 only
(B) 1 and 2
(C) 1, 2, and 3

- (D) 1 and 3
(E) 2 and 3

Secondary choices

*Sample complex multiple-choice question from the
Force Concept Inventory*



Why care about complex multiple-choice questions?

Grade Inequities in Physics & STEM

[Whitcomb, Cwik, Singh \(2021\)](#)



@NickYoungPER



ACADEMIC INNOVATION
UNIVERSITY OF MICHIGAN

Why care about complex multiple-choice questions?

Grade Inequities in Physics & STEM

Inequities on high stakes exams

[Whitcomb, Cwik, Singh \(2021\)](#); [Simmons & Heckler \(2020\)](#); [Salehi et al \(2019\)](#)



@NickYoungPER



ACADEMIC INNOVATION
UNIVERSITY OF MICHIGAN

Why care about complex multiple-choice questions?

Grade Inequities in Physics & STEM

Inequities on high stakes exams

Inequities on certain types of questions?

[Whitcomb, Cwik, Singh \(2021\)](#); [Simmons & Heckler \(2020\)](#); [Salehi et al \(2019\)](#)



@NickYoungPER



ACADEMIC INNOVATION
UNIVERSITY OF MICHIGAN

Research question

Which of the following are true (in physics)?

1. Complex multiple-choice questions are harder than typical multiple-choice questions
2. Complex multiple-choice questions disproportionately harm students from minoritized backgrounds in physics (e.g., women, Black/Latinx/Multiracial/Native American students)
3. Complex multiple-choice questions disproportionately benefit students who go on to earn “A”s in the course

A) 1 only

B) 1 & 2

C) 2 & 3

D) 1 & 3

E) 1, 2, & 3





Data: Problem Roulette

Problem #10444

Midterm 1 2D/3D kinematics Projectile motion

1st Finish Session

Question 1 of 10

Question:

A cannon fires two shells in succession, both at an initial speed of v_0 from ground-level. The first shell is launched at an angle 30° above the horizontal, and the second shell is launched 60° above the horizontal. Both land at ground level. If air resistance can be neglected, which of the following statements is **false**?

- A The 2nd shell travels a greater distance through the air.
- B The two shells land at the same horizontal distance away from the launch point.
- C The 2nd shell spends a longer time in the air than the 1st shell spends.
- D The 2nd shell has a greater average horizontal velocity than the 1st shell has.
- E The 2nd shell reaches a greater maximum height than the 1st shell.

Submit

☆ Save Problem to My Dashboard

» Skip Question

Submit feedback on question

Ask classmate for help

Review My Dashboard



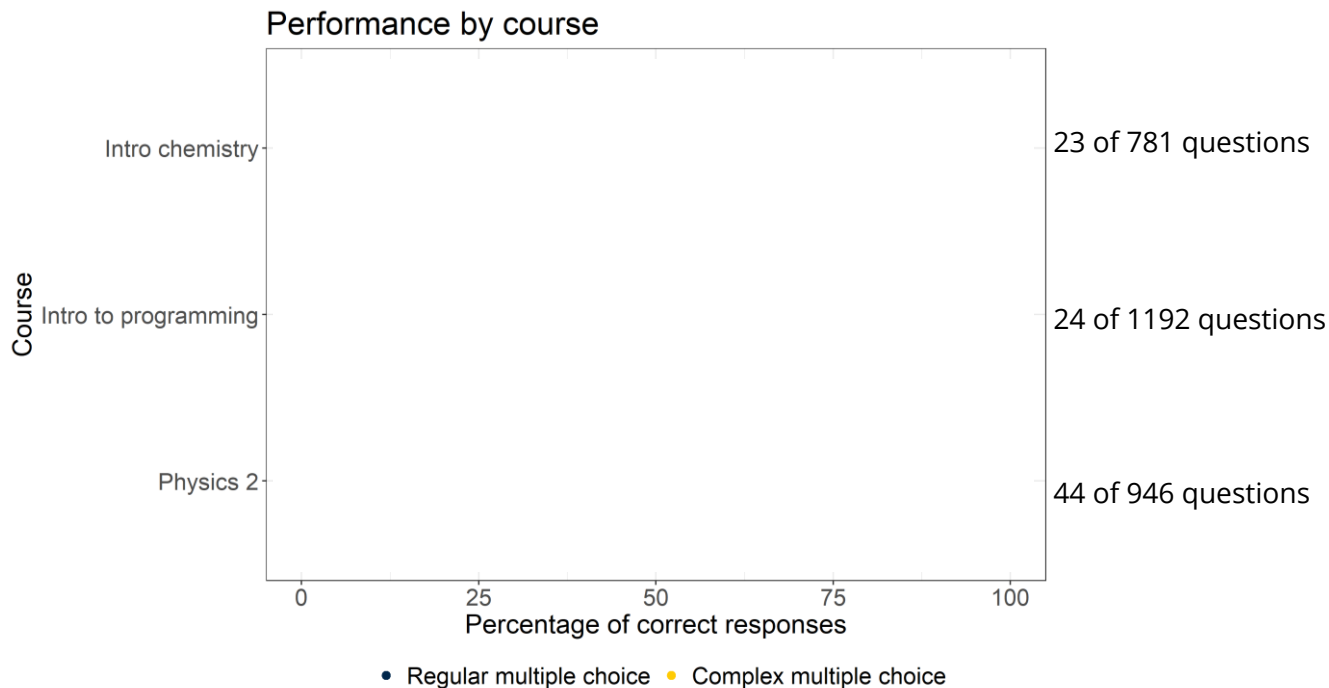
68%

57%

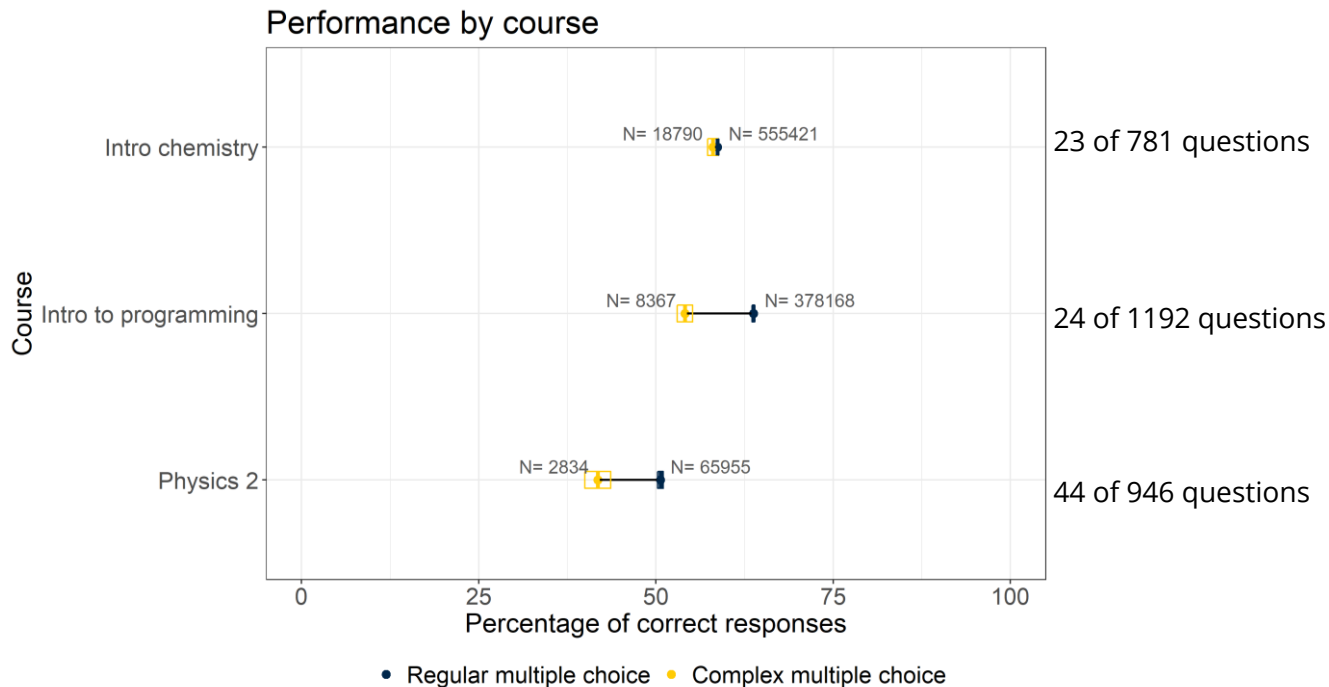
Accuracy on standard multiple choice format
vs complex multiple-choice format



Results by course



Mixed results on whether complex multiple-choice questions are harder



Research question

Which of the following are true (in physics)?



1. Complex multiple-choice questions are harder than typical multiple-choice questions
2. Complex multiple-choice questions disproportionately harm students from minoritized backgrounds in physics (e.g., women, Black/Latinx/Multiracial/Native American students)
3. Complex multiple-choice questions disproportionately benefit students who go on to earn “A”s in the course

A) 1 only

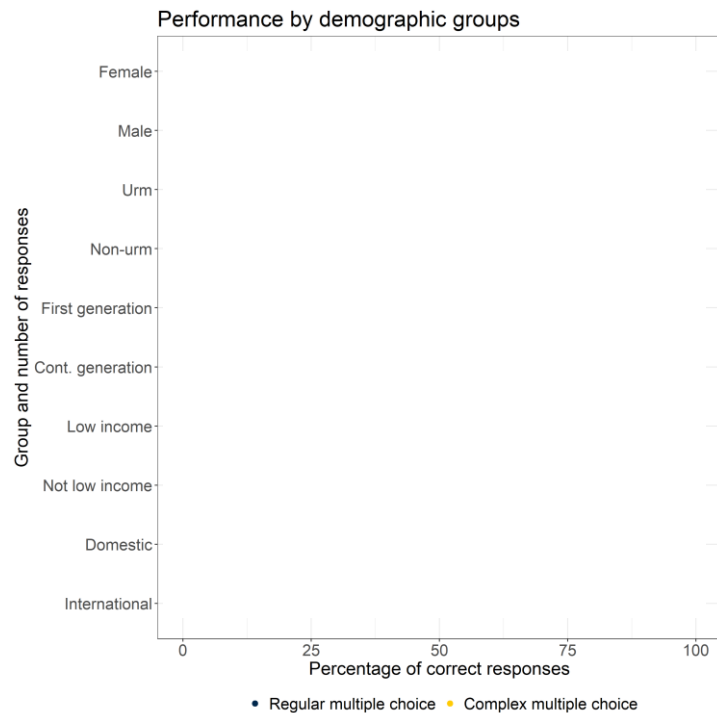
B) 1 & 2

~~C) 2 & 3~~

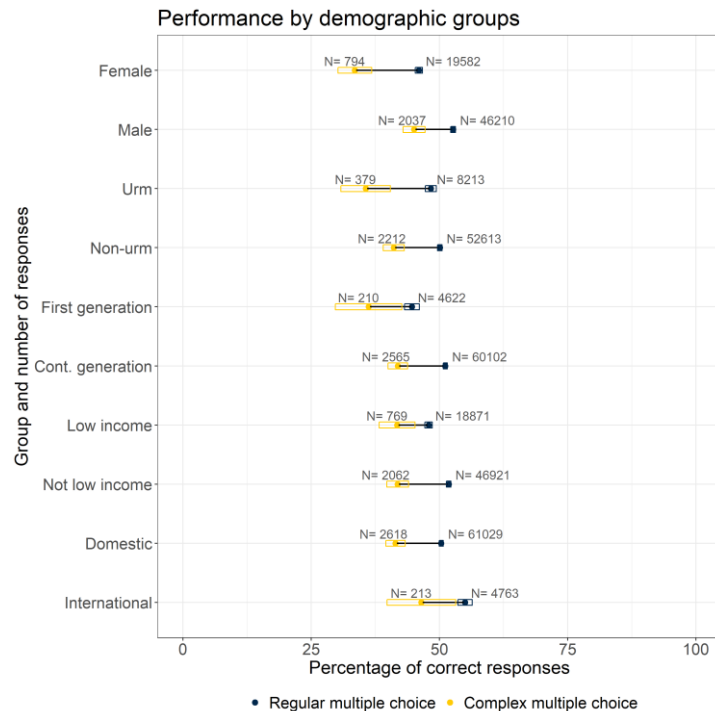
D) 1 & 3

E) 1, 2, & 3

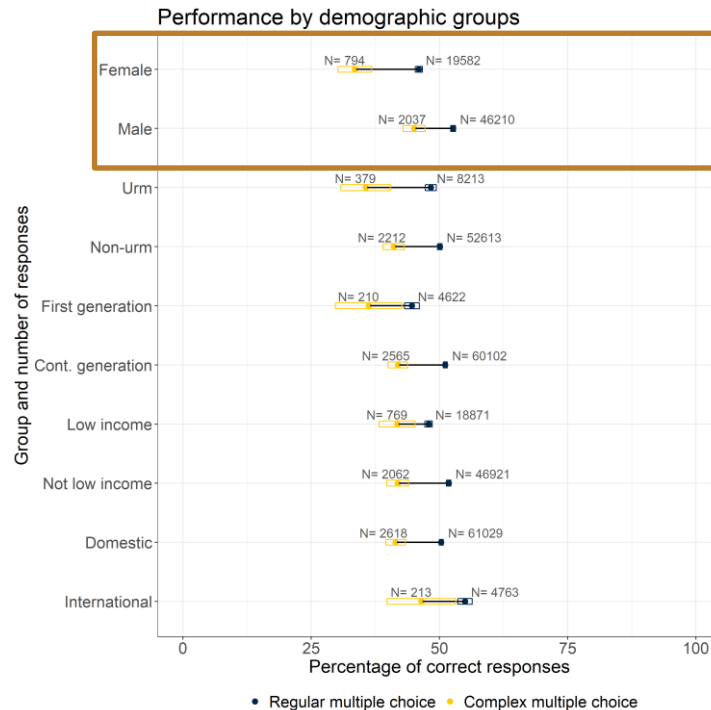




Limited evidence of disproportionate impact; all students suffer penalty



Maybe a gender effect?



Research question

Which of the following are true (in physics)?



1. Complex multiple-choice questions are harder than typical multiple-choice questions



2. Complex multiple-choice questions disproportionately harm students from minoritized backgrounds in physics (e.g., women, Black/Latinx/Multiracial/Native American students)

3. Complex multiple-choice questions disproportionately benefit students who go on to earn “A”s in the course

A) 1 only

~~B) 1 & 2~~

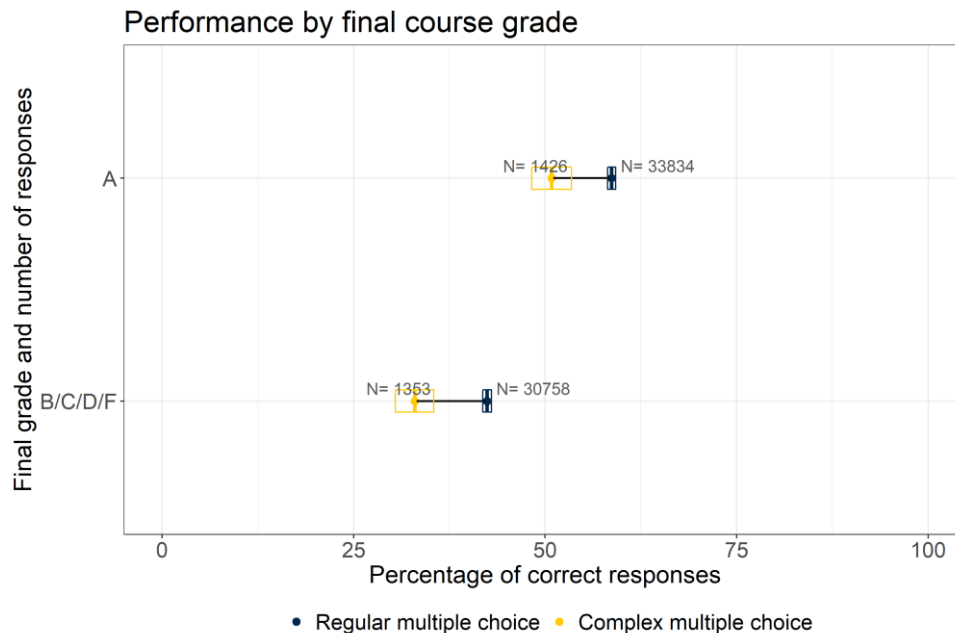
~~C) 2 & 3~~

D) 1 & 3

~~E) 1, 2, & 3~~






We don't find evidence of a disproportionate effect by final grade earned



Research question

Which of the following are true (in physics)?

-  1. Complex multiple-choice questions are harder than typical multiple-choice questions
-  2. Complex multiple-choice questions disproportionately harm students from minoritized backgrounds in physics (e.g., women, Black/Latinx/Multiracial/Native American students)
-  3. Complex multiple-choice questions disproportionately benefit students who go on to earn “A”s in the course

(A) 1 only

~~B) 1 & 2~~

~~C) 2 & 3~~

~~D) 1 & 3~~

~~E) 1, 2, & 3~~





Summary

- Complex multiple-choice questions are harder than typical multiple-choice questions



Summary

- Complex multiple-choice questions are harder than typical multiple-choice questions
- There does not appear to be a disproportionate penalty for students from minoritized backgrounds or identities



Summary

- Complex multiple-choice questions are harder than typical multiple-choice questions
- There does not appear to be a disproportionate penalty for students from minoritized backgrounds or identities
- Also do not find evidence that complex multiple-choice questions benefit “A” students as we would expect if they measured higher-order thinking



Takeaways

Complex multiple-choice questions probably aren't contributing to grading inequity in physics

But they aren't doing your students any grading favors either.



Takeaways

Complex multiple-choice questions probably aren't contributing to grading inequity in physics

But they aren't doing your students any grading favors either.

POS1E05 7:00-7:45pm tonight (July 11th)

ntyoung@umich.edu

