Comparing Student Perspectives of Intermediate Classical Mechanics and Quantum Mechanics

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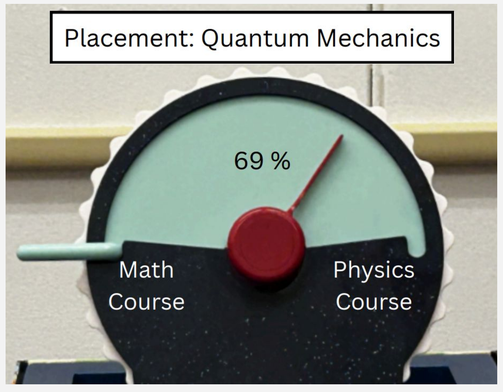
Abstract

- This study examines how students compare quantum mechanics (QM) and intermediate classical mechanics (CM) through disciplinary identity (math vs. physics) and epistemic focus (mathematical vs. conceptual).
- Student perspectives were obtained through interviews that involved a manipulative, continuous dial followed by placement justification
- In our study:
  - students thought that CM was more of a "physics course" than a "math course" while their thoughts on QM were more varied on this scale
  - students' perspectives on the "mathematical" to "conceptual" scale were more varied for both courses

Methodology

- Interviewed 6 students who had completed both quantum mechanics (QM) and intermediate classical mechanics (CM)
- Made use of a continuous, manipulative dial inspired by semantic differential with antonymic adjective pairs at either ends of the scale



- Students placed a concept based on the given extremes and gave justifications for their placement
- Image processing with a digital protractor was used to determine the angle

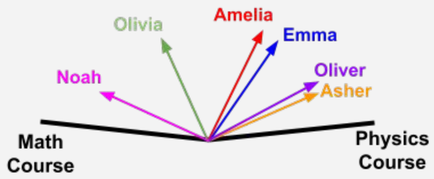
Objects Placed	Left End	Right End
QM	Math Course	Physics Course
CM	Math Course	Physics Course
QM	Mathematical Course	Conceptual Course
CM	Mathematical Course	Conceptual Course

- Audio was transcribed and themes in student justification of their placements were identified

Math vs Physics

If the left side is "Math Course" and the right side is "Physics Course", place "QM"/"CM".

Quantum Mechanics



4 students placed QM on the physics side contrasting it with their math classes and stating that in QM the math is connected to a physics concept and real life:

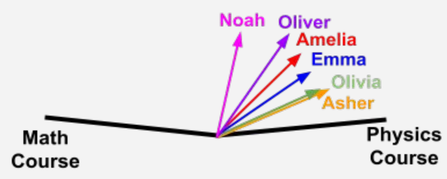
Emma: I'm also taking math classes and how the math classes are…constructed, like they are *so different from the physics ones* and also different from quantum more specifically because like we are doing proofs in them… But like in physics we were connecting it to *real life examples.*

Asher: Because we barely talked anything about linear operators, in terms of its mathematical properties…. We gloss those things over, so there are many important relations, like in the mathematical sense, that we didn't really cover. *We're more often just given the relations and apply that relation.*

2 students place QM on the math side stating that they have to frequently learn new math in the course:

Noah: *Every chapter is some new math theorem* that is supposed to be applied in some sort of way… the *physical connections are not readily seen* unless they've already been observed.

Intermediate Classical Mechanics



All of the students placed CM on the physics side because of the 'tangible' material covered as well as their familiarity with the topics:

Noah: the math involves a lot of…physical processes that you see before in class when we do some *demos*… we have to think about *why something is behaving the way it is. They're not theoretical things.*

Emma: We even watched videos to look at like people doing experiments like *tangible or concrete stuff with real life like materials*… it felt like it was more physics than quantum in that sense. And *we deal with macroscopic stuff too.*

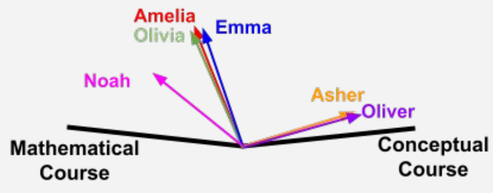
Oliver: When I think of intermediate mechanics, it's doing a lot of math… But… I understand the underlying principles behind the physical concepts that I'm expressing through mathematical equations.

Olivia: I've taken mechanics like five times now, but I guess… That's like kind of the *epitome of physics* is mechanics

Mathematical vs Conceptual

If the left side is "Mathematical Course" and the right side is "Conceptual Course", place "QM"/"CM".

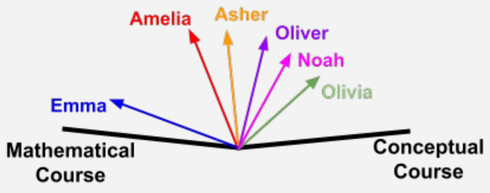
Quantum Mechanics



4 students placed QM on the mathematical side:

Amelia: I'm given like some equation and I'm going to go manipulate it to like get a different one that I know is like a better form, but I'm *not like connecting it to the like why and how* and like all that sort of stuff.

Intermediate Classical Mechanics



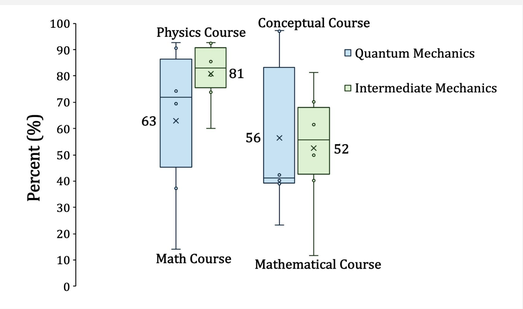
3 students placed CM on the mathematical side:

Emma: Most of the results we reached, we had to carry out some calculations beforehand. There was rarely something which we looked at only as a concept. But in quantum, I can remember things [where] we were only approaching it conceptually. There wasn't any rigorous calculations. But in intermediate mechanics, I feel like we always did a bunch of calculations.

Comparisons

Box and Whisker Plot of Student Dial Placements:

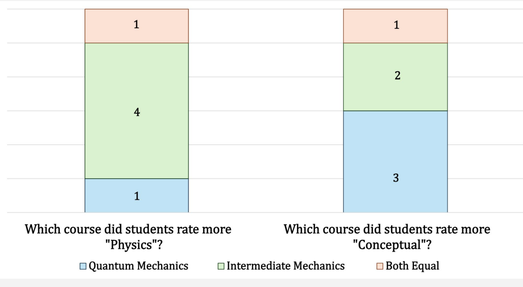
- "0%" represents left of dial while "100%" represents right side
- Mean is displayed while median given as vertical line in box



- This plot suggests that overall students' perspectives on CM are more closely aligned than their perspectives on QM

Stacked Bar Chart of Student Dial Placements:

- The left bar shows the number of students who placed the dial on the physics side of the scale for QM, CM, or both
- The right bar shows the number of students who placed the dial on the conceptual side of the scale QM, CM, or both



Funding and References

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References:

1. G. Kalkanis, P. Hadzidaki, and D. Stavrou, An instructional model for a radical conceptual change towards quantum mechanics concepts, Science education, 87, 2 (2003)