

Case study of ChatGPT in a quantum physics class

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1. Background

- Class: Junior/senior intro quantum mechanics (~8-12 enrollment, over F23 and S24 semesters)
- Use: ChatGPT with conceptual & computational questions
- Facilitated discussion: Think-Pair-Share (TPS) activities

1. Motivation

- Given that students are & will be using AI tools like ChatGPT:
 - Help students become critical users of such tools via TPS activities
 - Track their belief/attitude change with pre- and post-test surveys
- Can ChatGPT help with learning of QM?
 - What does it do well or poorly on the subject?
 - Does it *know*, or have contextual *understanding* of, QM?

First impression (Jan 2023, v3?, outside class)

- Question: An electron is prepared with its spin in the positive z direction. After passing through a Stern-Gerlach selector in the x direction, what is the probability of finding the electron with its spin in the positive x direction?
- Response: The Stern-Gerlach selector separates electrons with different spins in different directions. (... fluid reasoning) The electron's spin in the x direction will be **zero** after the measurement.

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Recent iteration (May 2024, v3.5)

- Question: If an electron spin is prepared in the +z direction, what will one obtain if one tries to measure the +x component?
- Response: If an electron spin is prepared in the +z direction, and you measure the +x component, you will obtain either $+\hbar/2$ or $-\hbar/2$ with **equal probability**. Here's why: (... fluid reasoning) **In summary:**
 - You cannot know both the +z and +x spin components with certainty simultaneously.
 - Measuring the +x component after preparing the spin in +z will give you either $+\hbar/2$ or $-\hbar/2$, each with a 50% probability.

Think-Pair-Share activities

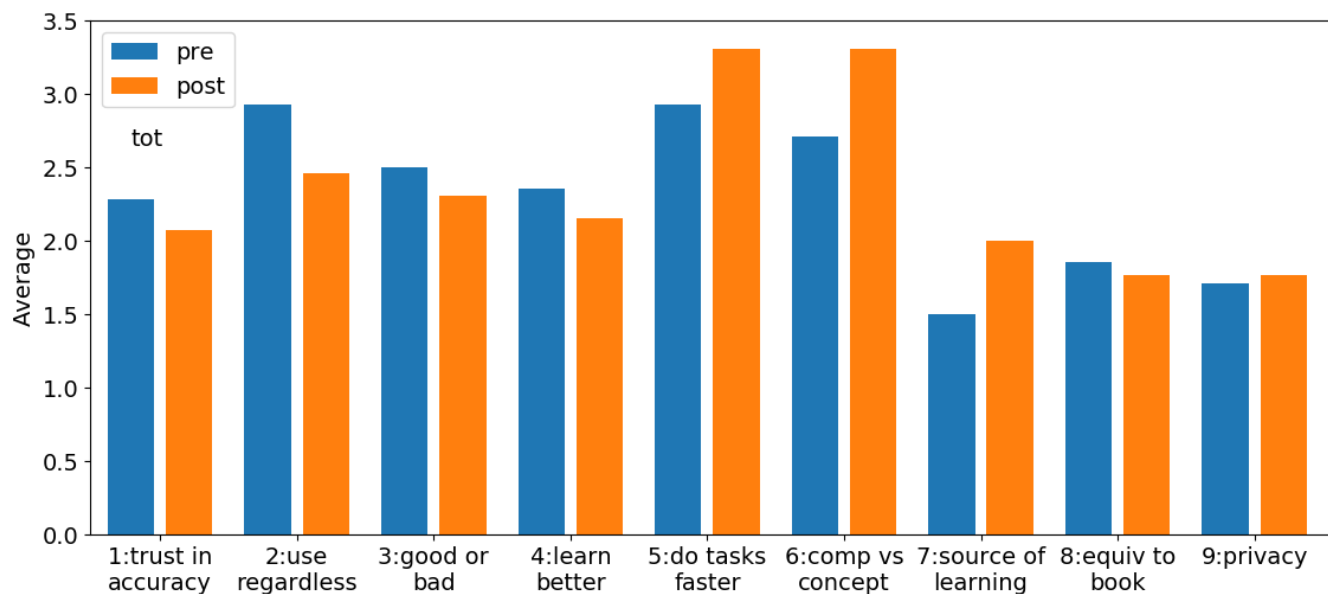
1. Questions and ChatGPT output are generated and shown to the class; class has a few minutes to think and analyze the question/response individually
2. Students are asked to turn to their neighbor to exchange their thoughts and reasoning. Whether they agree or not is unimportant, but they should explain their answer or reasoning.
3. After a few minutes, the class discusses the question together, and students explain or justify their thinking. The instructor plays the role of a facilitator, guiding the discussion but not judging.

The survey questions

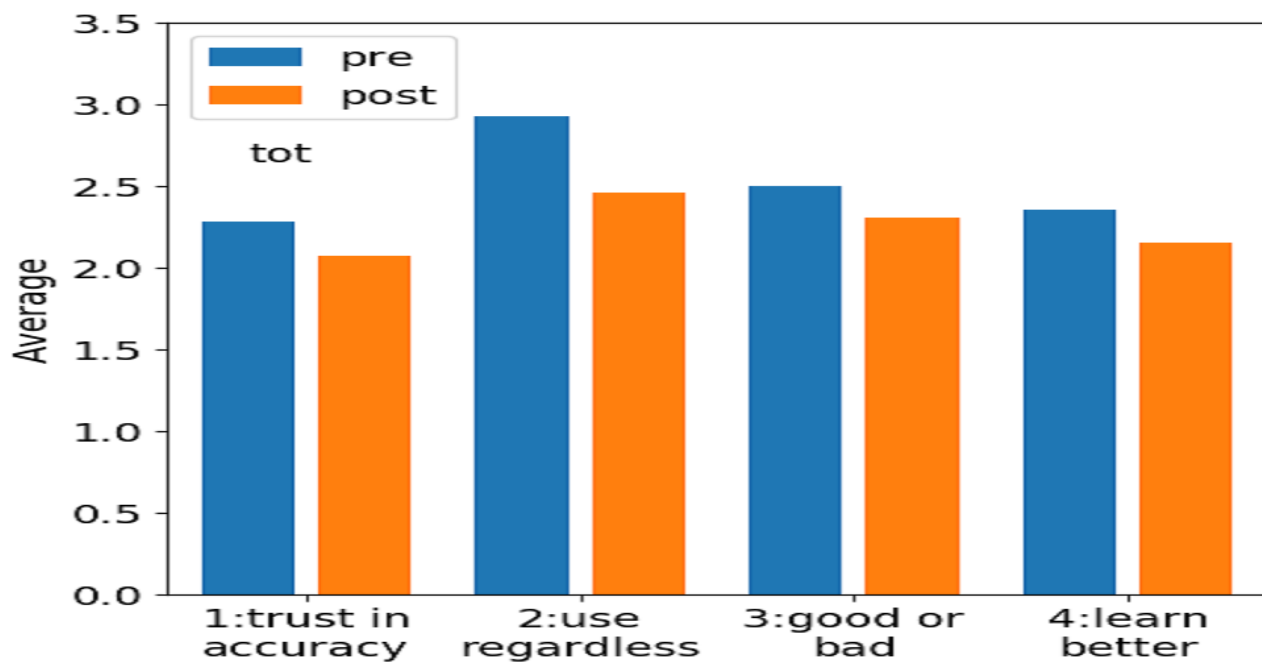
- Ten questions asking students' beliefs and attitude on ChatGPT, e.g.,
 - Rate your trust in ChatGPT to give answers accurately on a scale 1 to 5, 1 being least accurate and 5 most accurate.
 - How hopeful are you that ChatGPT can help you learn quantum mechanics better? Rate your belief on a scale 1 to 5, 1 being least hopeful and 5 most hopeful.
- Survey given as pre- and post-tests, respectively, before and after the semester. Responses collected anonymously.



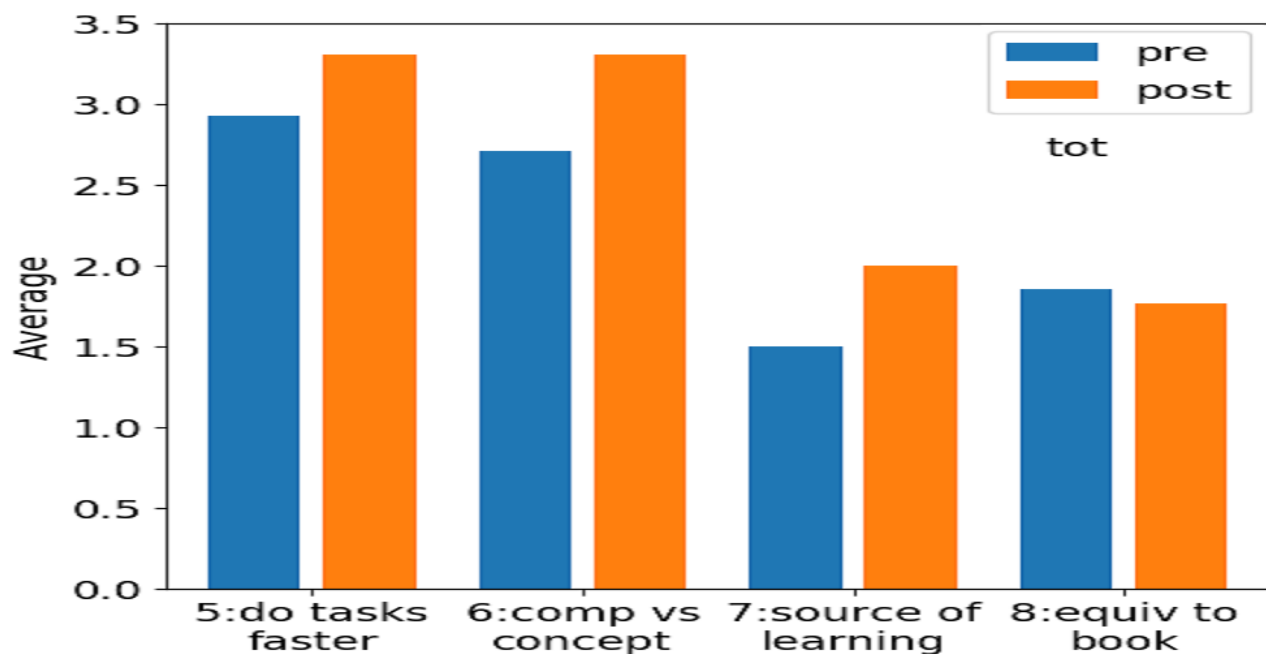
The survey results (low sample N=15)



The survey results (part 1) (low sample, N=15)



The survey results (part 2)



What students say

- "it becomes really apparent that it is not natural for the AI to think in terms of quantum mechanics."
- "It seems that the AI will **not argue** for its answer and will simply **confirm** the user's assertion... even though the answer is outlandish."
- "chatgpt can be helpful but **cannot be used as a learning source.**"
- "It is basically **impossible to know** when ChatGPT is wrong or right **without already knowing** the answer, or the process to obtain it."
- "I've had the most luck using ChatGPT for any **coding problems** I run into... it is able to get the bulk the tedious work out of the way so I can work on the **real problem.**"

Conclusion and further work

- Students develop healthy, critical views toward ChatGPT
- ChatGPT does better with conceptual than computational problems; lacking contextual 'understanding'
- Integrate computation and AI
 - Use API of Gemini or OpenAI to generate and analyze output computationally
- Expand scope to other subjects, refine questions, collaborate with interested parties

In []: