Learning physics in the age of Generative AI

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Disclaimer

- This talk does not represent any official position of the University of Edinburgh
- It is my personal take on the issue
- I am not an expert in GenAI
- I am an expert in physics education

Outline

- Context
- (Current) capabilities of GenAI in physics education
- Some real examples
- Implications for learning
- Conclusions?

Important topics I’m not going to address

- Ethics
  - Harvesting of training data
  - Bias in the training data
- Environmental concerns
  - Electricity
  - Water
- Use of GenAI for coding/programming

Context

Use of ChatGPT over time

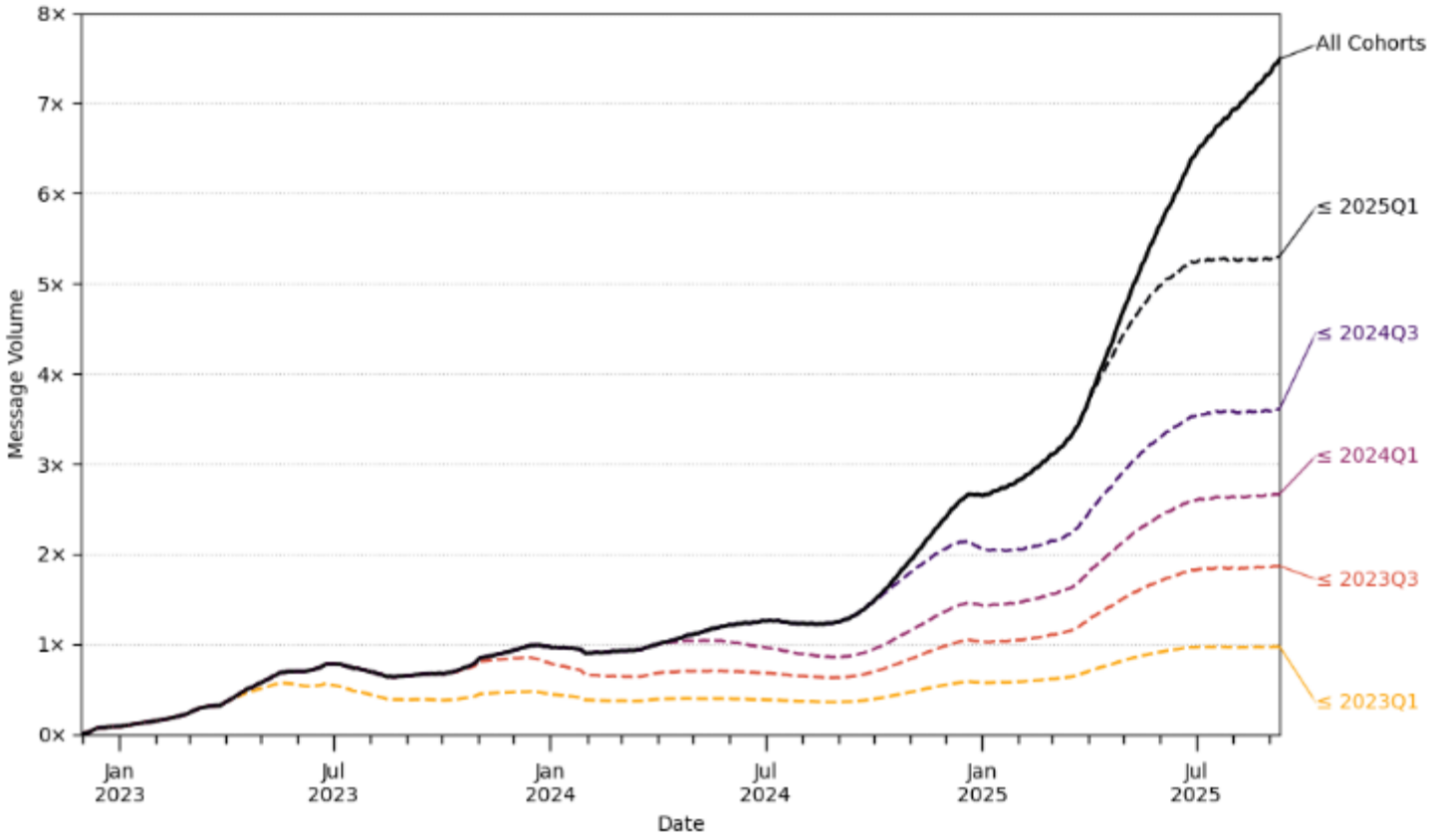


Figure 4: Daily message volumes from ChatGPT consumer plans (Free, Plus, Pro), split by sign-up date of the requesting user. Reported values are moving averages of the past 90 days. Y-axis is an index normalized to the reported value for "All Cohorts" at the end of Q1 2024 (April 1, 2024).

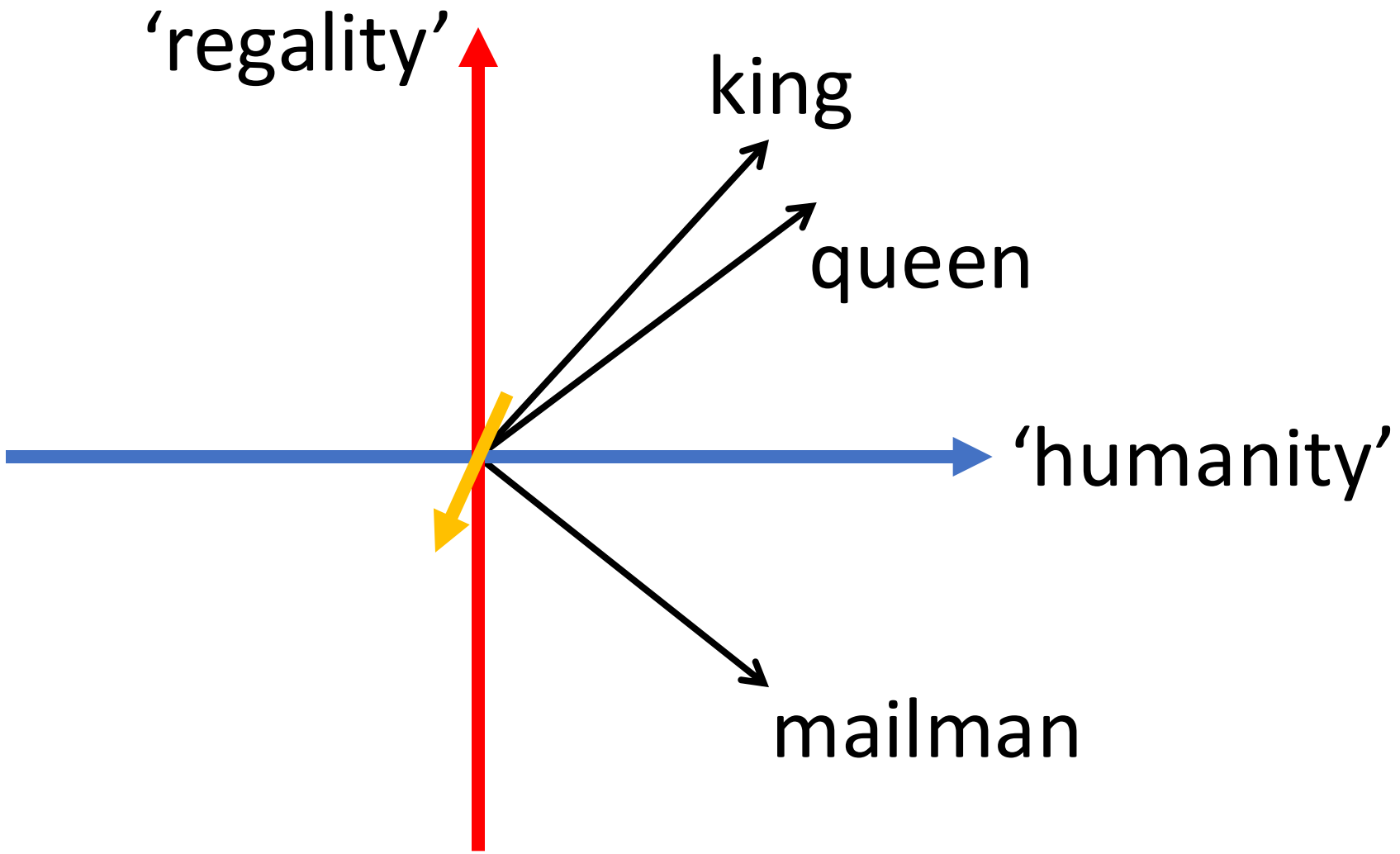
"How People Use ChatGPT", Chatterji et al. (2025)

How does GenAI work

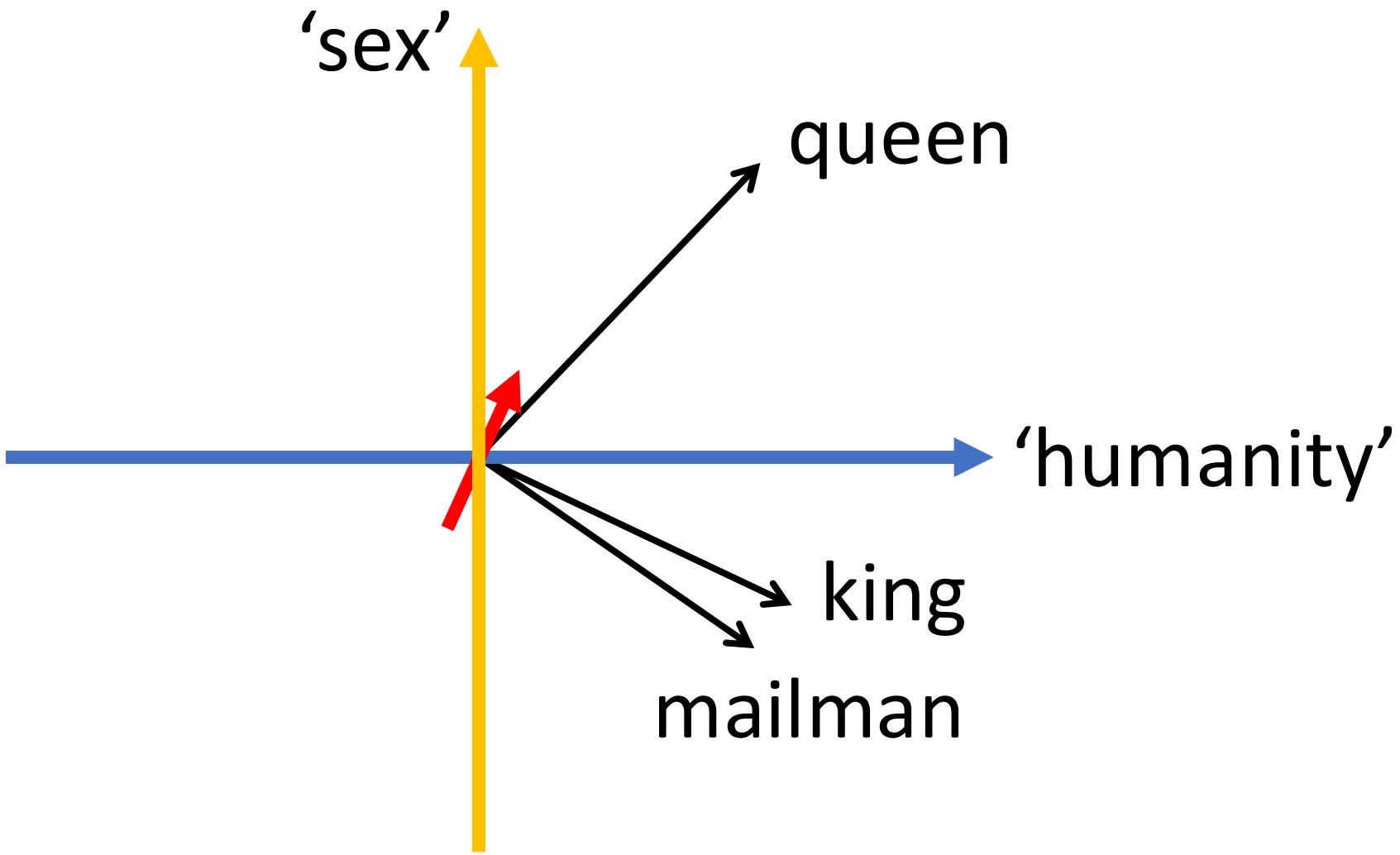
In a short paragraph, describe how generative AI works. Your target audience is first year physics students.

Generative AI operates by learning patterns and structures from large volumes of data and then uses this acquired knowledge to produce new content that mimics the original data. For first-year physics students, you can think of it similar to the way physical systems are analyzed and predictions are made. Just as you might use equations to describe the trajectory of a particle, generative AI uses algorithms, specifically neural networks, to predict the next piece of data based on the rules and patterns it learned during its training phase. The AI is trained by inputting vast amounts of text, images, or other data until it builds a complex statistical model that encapsulates the properties of that data. When you ask the AI to generate something, it effectively consults this model, inferring what likely comes next or what fits within a given context, much like solving for variables in a physics equation.

Vectors as an analogy

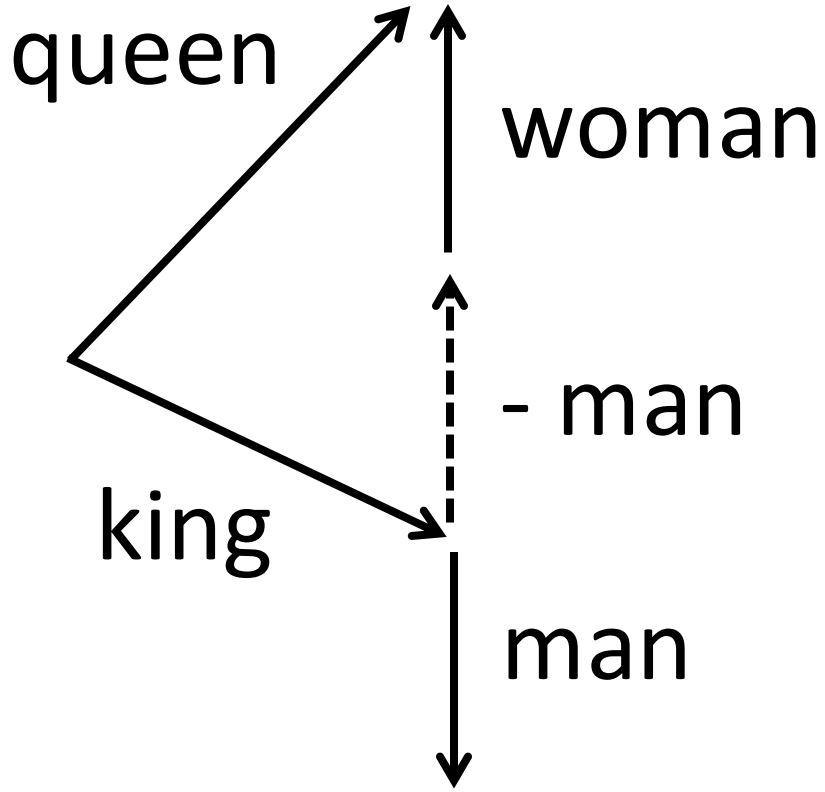


Vectors as an analogy



Vectors as an analogy

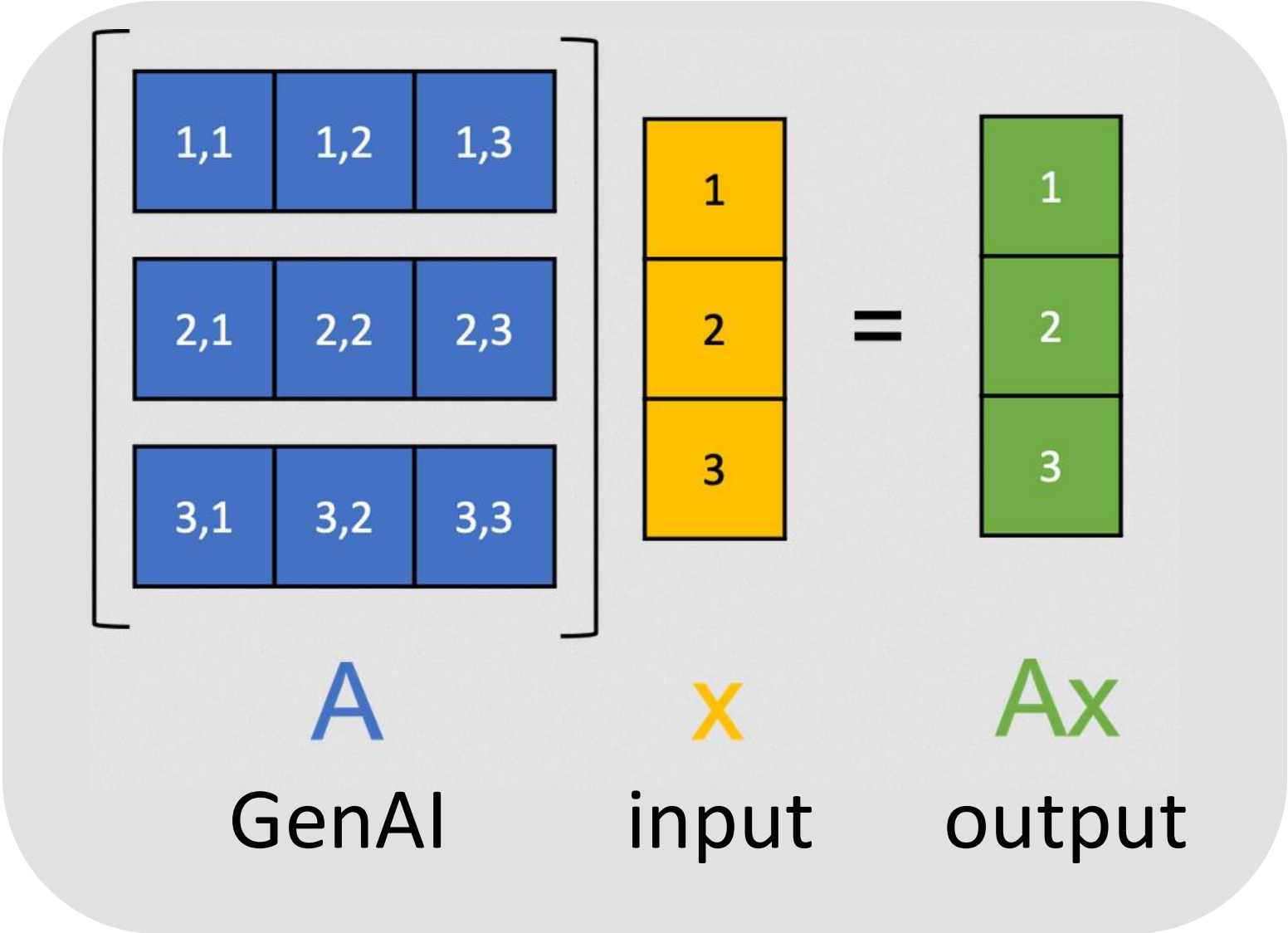
$$\vec{\text{king}} - \vec{\text{man}} + \vec{\text{woman}} = \vec{\text{queen}}$$



Adapted from Odden & Hansen, *Phys. Teach.* 63 (2025)

Adapted from https://mbernste.github.io/posts/matrix_vector_mult/

Vectors as an analogy



Current capabilities of GenAI in physics education

Current capabilities of GenAI in physics education

PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH **21,** 020101 (2025)

Multilingual performance of a multimodal artificial intelligence system on multisubject physics concept inventories

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Current capabilities of GenAI in physics education

Volume 61, Issue 4
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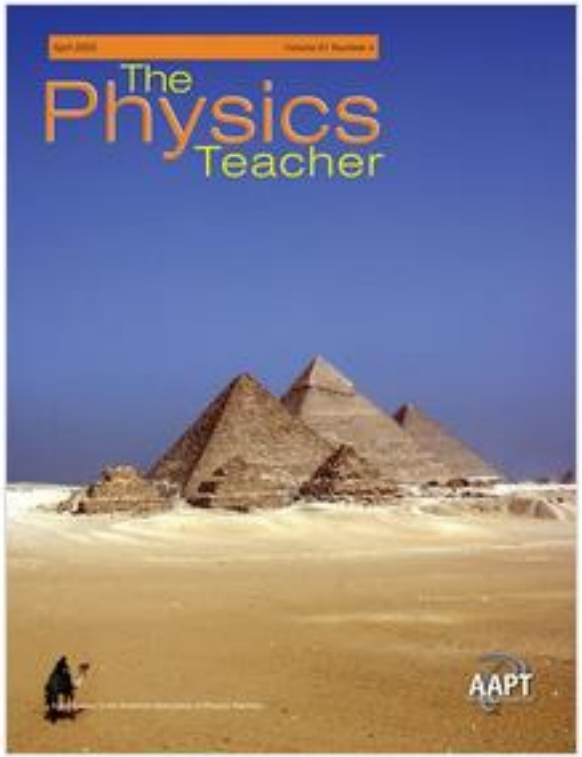

Chatbots Attempt Physics Homework—ChatGPT: Chat Generative Pre-Trained Transformer

Dan MacIsaac

“ Rest easy—we are still pretty safe from Skynet in the physics class, though you should always view your search engine responses with suspicion. ”

Current capabilities of GenAI in physics education

Home › Asia Pacific Education Review › Article

Investigating ChatGPT-4's performance in solving physics problems and its potential implications for education

Review Article | Published: 29 November 2023

Volume 25, pages 1379–1389, (2024) Cite this article

Asia Pacific Education Review

Dazhen Tong, Yang Tao, Kangkang Zhang, Xinxin Dong, Yangyang Hu, Sudong Pan & Qiaoyi Liu

" It is concluded that ChatGPT-4's performance in solving physics problems has significantly improved compared to ChatGPT-3.5, and was notably superior to the majority of middle school and high school students. This finding presents both a challenge and an opportunity for physics education and the broader educational field, "

Current capabilities of GenAI in physics education

frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 18 January 2024
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OPEN ACCESS

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Examining the potential and pitfalls of ChatGPT in science and engineering problem-solving

Karen D. Wang[1]*, Eric Burkholder[2], Carl Wieman[1,3], Shima Salehi[1] and Nick Haber[1]

“ Our findings show that ChatGPT could successfully solve 62.5% of the well-specified problems, but its accuracy drops to 8.3% for under-specified problems. ”

Current capabilities of GenAI in physics education

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Incorporating student perspectives towards Generative AI

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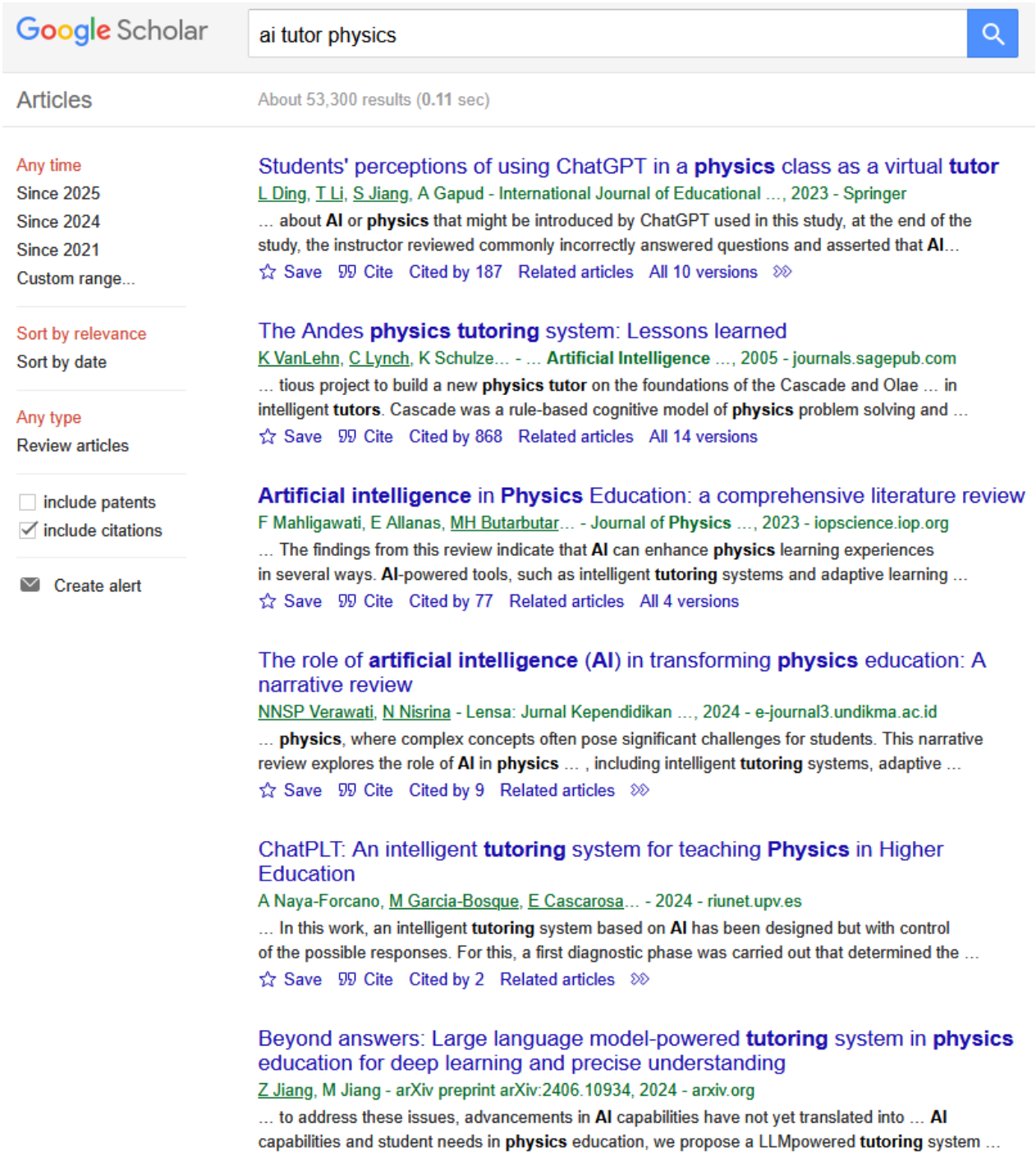
Current capabilities of GenAI in physics education



A real example

Step 3: Calculate the Cosine of the Angle

$$\cos(\theta) = \frac{7}{\sqrt{41} \cdot \sqrt{29}}$$

Step 4: Determine the Angle

Calculate θ using the inverse cosine function:

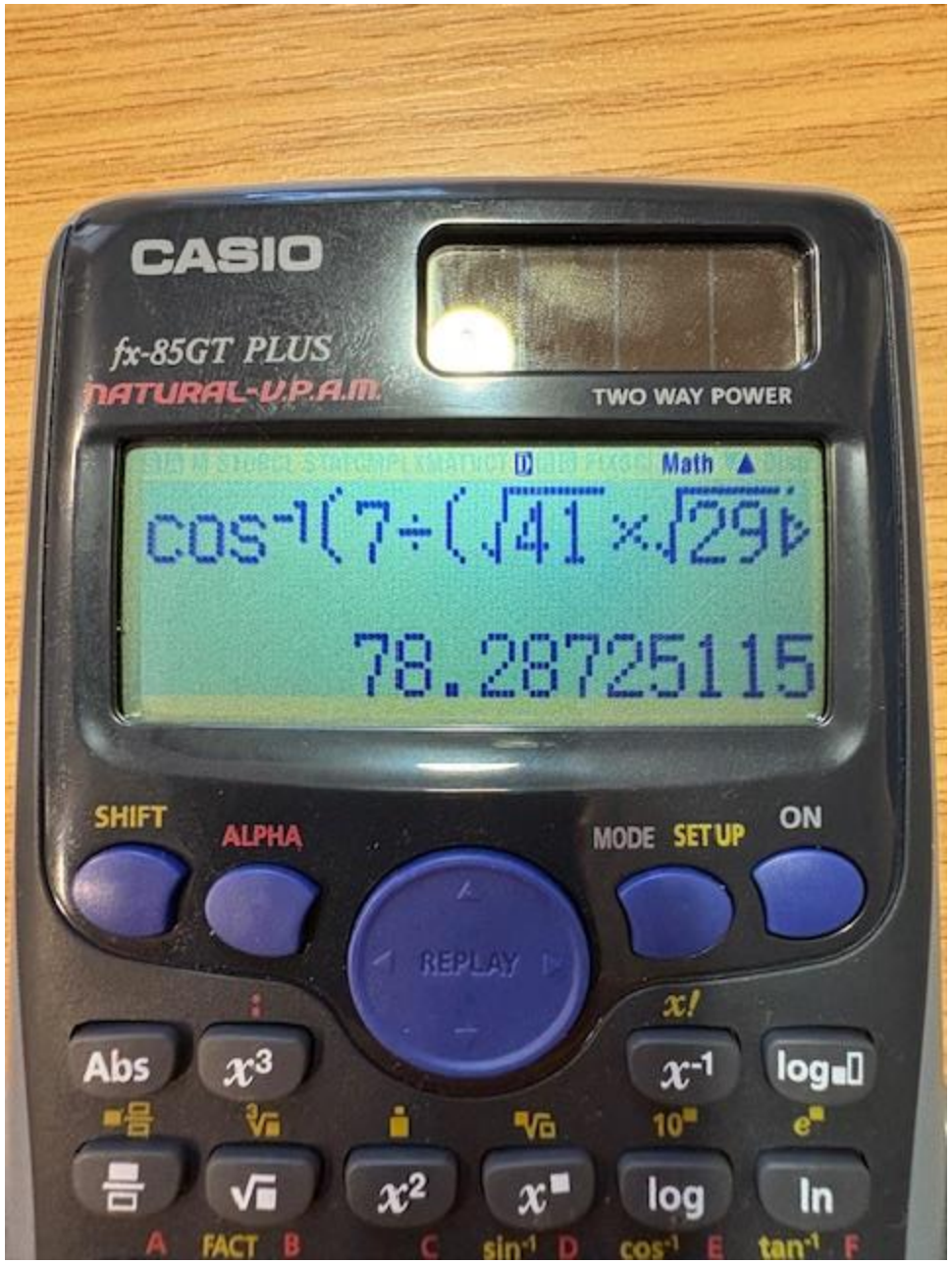
$$\theta = \cos^{-1}\left(\frac{7}{\sqrt{41} \cdot \sqrt{29}}\right)$$

Now apply a scientific calculator or similar tool to compute:

$$\theta = \cos^{-1}(0.255396) \approx 75.03^\circ$$

Conclusion

Hence, the angle θ between vectors $\vec{A}$ and $\vec{B}$ is approximately 75°.



https://research.google/blog/learn-your-way-reimagining-textbooks-with-generative-ai/

Another

Google Research Who we are

Home > B

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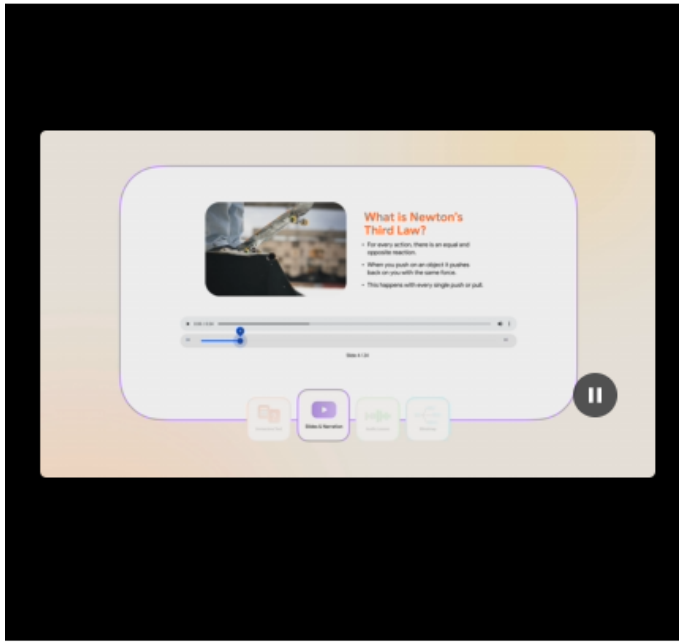


QUICK LINKS

Learn Your Way

Tech report

Share

Implications for learning

Gerace's model of knowledge structure

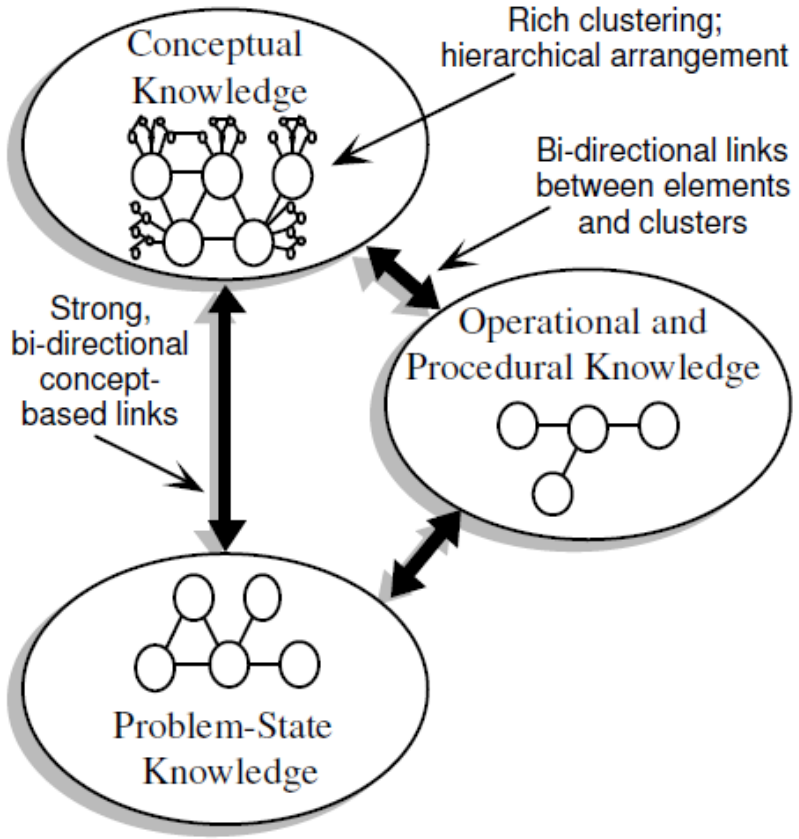


Fig. 1: *Expert's knowledge store.*

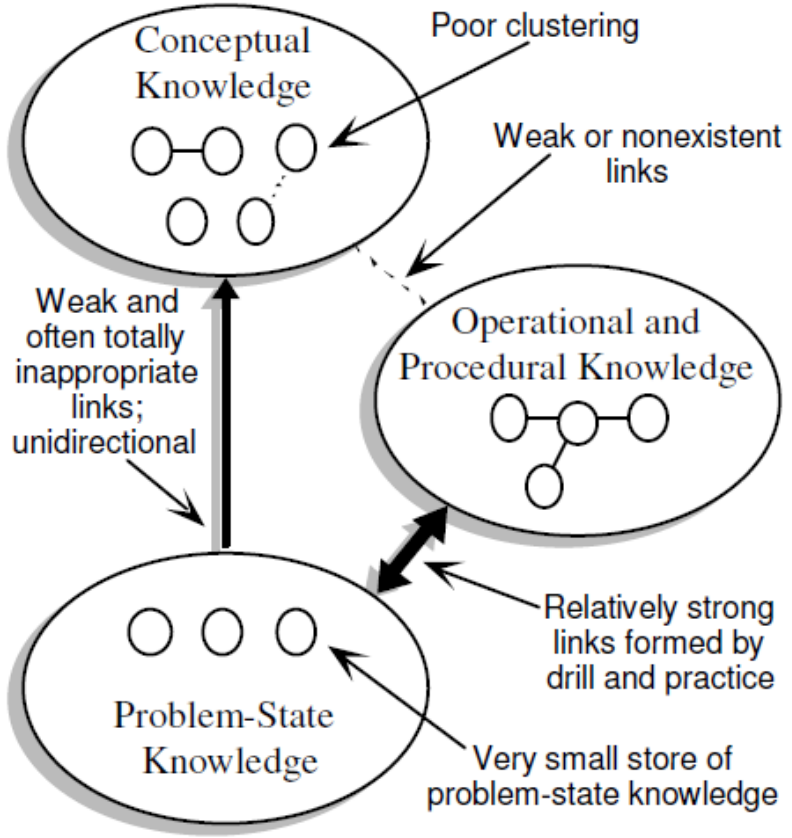
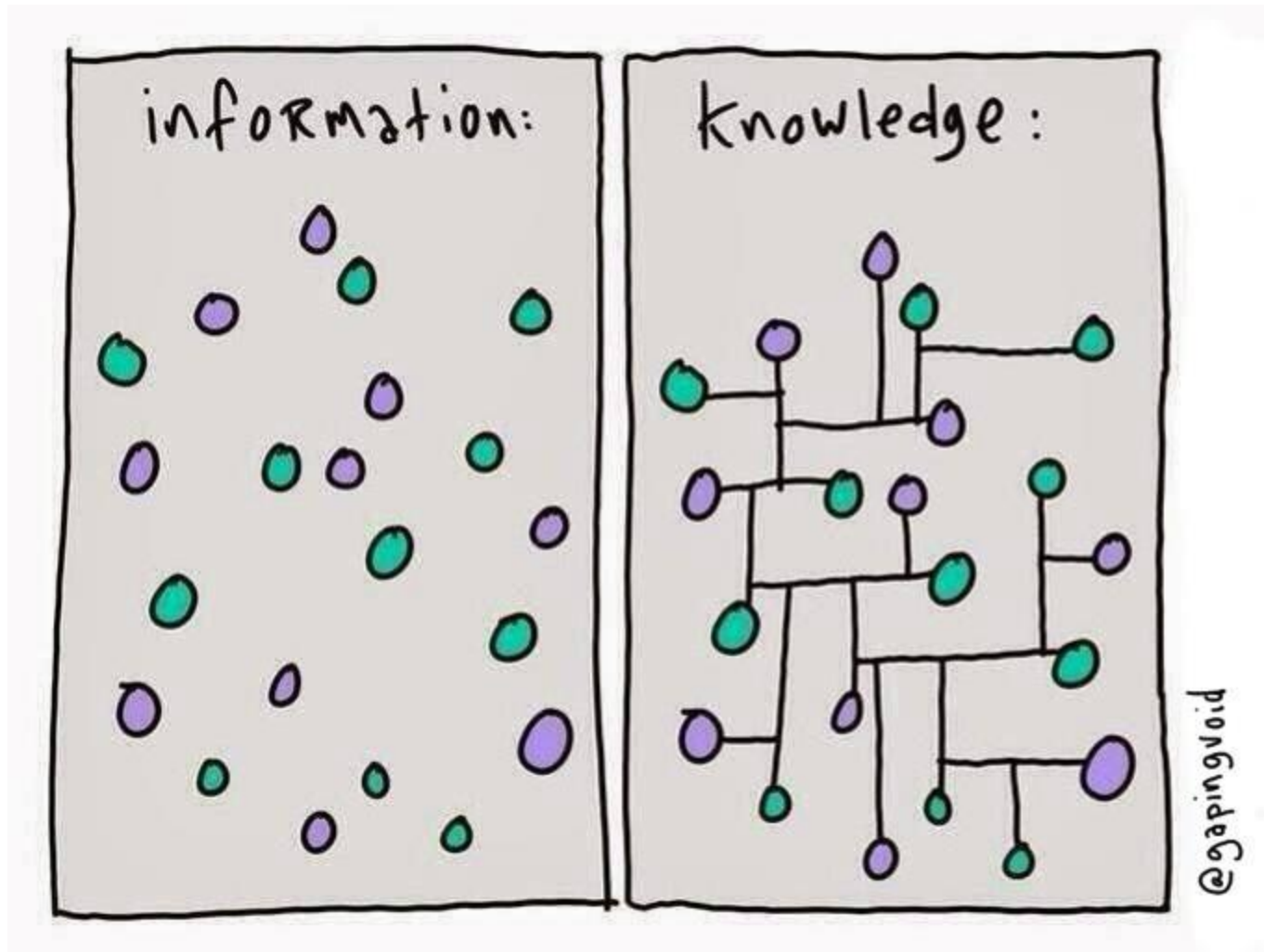


Fig. 2: *Novice's knowledge store.*

W. Gerace. "Problem solving and conceptual understanding." In *Physics Education Research Conference 2001*, PER Conference Invited Paper, Rochester, New York, July 25-26 2001.


information:
knowledge:
@gapingvoid

Cognitive offloading

Nataliya Kosmyna, Eugene Hauptmann, Ye Tong Yuan, Jessica Situ, Xian-Hao Liao, Ashly Vivian Beresnitzky, Iris Braunstein, and Pattie Maes. "Your brain on chatgpt: Accumulation of cognitive debt when using an ai assistant for essay writing task." arXiv preprint arXiv:2506.08872 (2025).

> “ Self-reported ownership of essays was the lowest in the LLM group and the highest in the Brain-only group. LLM users also struggled to accurately quote their own work. While LLMs offer immediate convenience, our findings highlight potential cognitive costs. Over four months, LLM users consistently underperformed at neural, linguistic, and behavioral levels. These results raise concerns about the long-term educational implications of LLM reliance and underscore the need for deeper inquiry into AI's role in learning. ”

Cognitive offloading

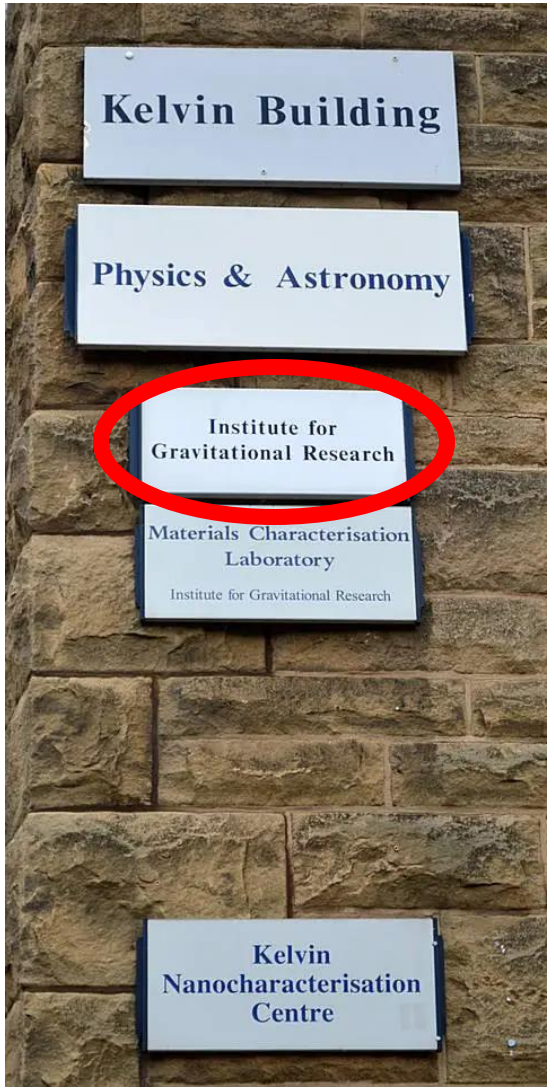
Create an image of a person driving a car that is itself on a treadmill.

Please make the same image but with the man in sports clothes.

Harry Collins (sociologist): interactional expertise

By Alexei Kouprianov - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=12101826

University of Glasgow



Harry Collins (sociologist): interactional expertise

By Alexei Kouprianov - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=12101826

No expertise

↓

Interactional expertise

↓

Contributory expertise

Some concluding thoughts

- Generative AI (at the moment) possesses (at best) interactional expertise
- Human students need to possess contributory expertise
- That is, they need a *coherent, structured* body of knowledge
- Can that be acquired while (extensively) using Generative AI?
  - (I don’t know)

Alternative title

Old Man Yells At (The) Cloud