

## Can AI Teach Like Socrates? An Exploratory Study of AI-Student Dialogue in Secondary Physics Education

Krishan Sanjay Mahesh, Whitley Secondary School, Singapore

The Asian Conference on Education 2025  
Official Conference Proceedings

### Abstract

While generative artificial intelligence (GenAI) holds considerable promise for education, concerns remain that when used primarily for answer retrieval, it may encourage cognitive offloading rather than meaningful learning. This classroom-based study explores an alternative application of GenAI: whether a custom Retrieval-Augmented Generation (RAG) chatbot can engage students in Socratic dialogue to support deeper conceptual understanding in secondary physics. Nineteen Secondary 4 students in Singapore interacted with a RAG chatbot during a one-hour thermal physics lesson as part of their preparation for the GCE Cambridge O-Level examination. A thematic analysis of the chat transcripts uncovered three prominent patterns of interaction: identifying and addressing student misconceptions, scaffolding support for students with lower conceptual readiness, and challenging more advanced learners to deepen their learning. The chatbot delivered immediate and individualised feedback at scale, enabling dialogic interactions that are often unfeasible for teachers to conduct with multiple students in a typical classroom setting. However, the quality of these interactions was highly dependent on student input. In cases where students provided vague or tangential responses, the chatbot tended to shift towards more explanation-driven replies, limiting opportunities for sustained Socratic dialogue. These findings highlight the potential of AI tutoring systems to facilitate Socratic dialogue in secondary physics education. They also underscore the need for AI design principles that incorporate diagnostic questioning and adaptive scaffolding, as well as instructional strategies that equip students to engage meaningfully with AI tools in education.

*Keywords:* generative artificial intelligence, Socratic dialogue, secondary physics education, technology-enhanced learning

**iafor**

The International Academic Forum  
[www.iafor.org](http://www.iafor.org)

## Introduction

### Edtech Development in Singapore

The integration of educational technology into schools has evolved significantly over the past several decades. From early visual aids such as overhead projectors in the 1960s, to the introduction of personal computers and educational software in the 1980s and 1990s, and the rise of the internet in the late 1990s and early 2000s, educational technology has undergone successive waves of development. These developments enabled the widespread adoption of online resources, and learning management systems (LMS) which have since become foundational for instructional delivery, assignment submission, and teacher-student communication (Januszewski, 2001). The greater accessibility of personal computing devices has further driven the integration of educational technology, particularly in secondary education.

In Singapore, the Ministry of Education (MOE) has actively shaped this trajectory through state-led initiatives. The Ministry of Education, in partnership with the Government Technology Agency developed and deployed Student Learning Space (SLS), a learning management system to provide curriculum resources to support teaching and learning in school (Government Technology Agency, 2025a). The COVID-19 pandemic accelerated the use of SLS for home-based instruction, as school closures during government-mandated lockdowns created an urgent need for remote learning (Tan & Chua, 2023). The distribution of personal learning devices to all secondary school students, as part of the Ministry's national digital literacy programme, significantly increased access to digital tools and facilitated the integration of educational technology into mainstream teaching (Ministry of Education, 2020a). The increased reliance on educational technology during the COVID-19 pandemic has led to its sustained integration into Singapore's education system, marked by the adoption of blended learning and the adoption of regular home-based learning in secondary schools and junior colleges (Ministry of Education, 2020b).

### Increasing Use of Artificial Intelligence in Education

In parallel with these developments, educational technology continues to evolve rapidly, with artificial intelligence (AI) emerging as a prominent focus. Globally, there is growing interest in integrating AI into education (Chen et al., 2020). In Singapore, this trend is reflected in the MOE's EdTech Masterplan 2030, which explicitly aims to incorporate AI tools within the SLS platform (Ministry of Education, 2023). AI tools such as adaptive learning systems and AI feedback assistants have been deployed within SLS to allow for classroom teaching to be augmented by AI-generated feedback and more personalised learning pathways to cater to individual student needs (Government Technology Agency, 2025a).

Beyond institutional platforms, generative AI tools such as large language models are being adopted informally by students themselves. Recent reports indicate that secondary school students in Singapore are increasingly engaging with generative AI for homework and assignments, with a majority of them regularly using these tools for academic work (Paulo, 2025). While these tools offer convenience, over-reliance on AI-generated outputs raises concerns about cognitive offloading and the erosion of thinking skills (Gerlich, 2025). Without critical engagement with AI-generated outputs, students risk bypassing the cognitive processes essential for learning. These concerns are echoed at the tertiary level, with empirical findings, such as those from Anthropic's study of university-level student interactions with large

language models revealing that nearly half of student-AI dialogues involve seeking direct answers with minimal conceptual engagement (Handa et al., 2025). Such patterns raise concerns that AI tools, when used in education, may serve more as a cognitive crutch, replacing rather than encouraging the cognitive labour that is essential for learning. Naturally this leads to fundamental questions about whether the integration of AI technologies in education will help students learn better, or if they serve as substitutes for thinking itself.

### **Research Question**

This study is motivated by concerns about students' overreliance on AI tools and the consequent outsourcing of thinking and proposes the possibility of a different approach to such use of generative AI in education: not as a means of providing answers, but as a tutor that fosters cognitive engagement by asking questions. Specifically, the research examines whether an AI chatbot can be designed to engage students in dialogue using the Socratic method, a pedagogical approach grounded in eliciting reasoning through sustained questioning. The Socratic method in teaching originates from the Socratic dialogues recorded by Plato where the Greek Philosopher Socrates would ask a series of questions, prompting his dialogic partner to think deeply about the subject matter and what they know rather than passively receiving answers (Delic & Bećirović, 2016). Socratic questioning promotes student motivation, encouraging them to seek out new knowledge and can lead to significant improvements in student engagement and understanding, particularly in the context of science education (Omar, 2009).

This paper explores the possibility of using an AI chatbot as a tutor that engages in dialogue with students using the Socratic method to guide students to deeper conceptual understanding in Physics. Such an approach centres the role of an AI chatbot as a dialogic partner with the ultimate aim of promoting deeper conceptual understanding. To investigate this potential, the study explores two research questions:

1. Can we use an AI chatbot to engage students with Socratic questioning instead of providing solutions?
2. What patterns of dialogue emerge in these AI-student interactions?

Understanding the nature of these interactions is critical not only for evaluating the educational effectiveness of AI chatbots in tutoring, but also for informing educators about the pedagogical strategies needed to integrate AI meaningfully into classroom instruction.

### **Methodology**

The study was conducted with a cohort of nineteen Secondary 4 students in a Singapore secondary school who were part of a targeted support programme aimed at preparing them for the General Certificate of Education (GCE) O-Level Physics examination. These students participated in a one-hour supplementary lesson as part of the intervention. The objective of this lesson was to strengthen student competencies in assessment Objective B of the O-level Physics syllabus, which emphasizes the application of scientific principles to novel scenarios through logical reasoning and problem-solving (MOE & Cambridge University Press & Assessment, 2024).

The following subsections describe the instructional materials and methods used in the study, including the physics worksheet, the design of the AI chatbot, instructions for students, and the procedures for data collection and analysis.


### Worksheet on Thermal Physics

As part of the targeted support programme, students were given a worksheet (Figure 1) comprising a three-part question focused on core thermal physics concepts on the kinetic model of matter and pressure. These questions were deliberately selected for their emphasis on conceptual understanding and qualitative reasoning as they do not require the use of mathematical equations or diagrammatic representations, thereby allowing responses and feedback to be typed out in natural language. This design decision ensured compatibility with the AI chatbot's text-based interface.

**Figure 1**  
*Worksheet on Thermal Physics*

G3 Physics

Name: \_\_\_\_\_ ( )      Class: \_\_\_\_\_



## Physics TSP

### Thermal Physics

**1** In the set-up in Figure 1.1, two tubes are inserted with rubber seals into two inlets of a round bottom flask. Inside the flask, a rubber balloon is fitted and sealed to the end of one of the tubes.

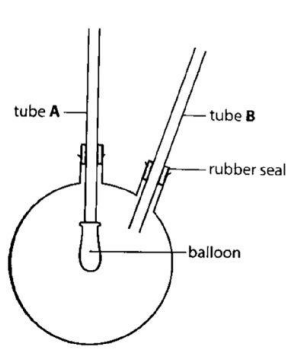


Fig 1.1

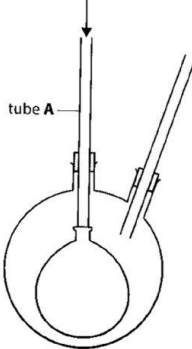


Fig 1.2

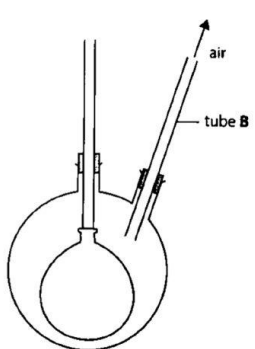


Fig 1.3

A student conducts two experiments using the set-up. In the first experiment, the student blows air into tube A as shown in Figure 1.2, and the rubber balloon is observed to expand. In the second experiment, the student sucks air out of tube B as shown in Figure 1.3, and the rubber balloon is observed to expand.

**(a)** Explain, in terms of particles, why the balloon expands in experiment 1.

.....

.....

.....

.....

G3 Physics

(b) Explain, in terms of particles, why the balloon expands in experiment 2.

.....

.....

.....

.....

(c) A third experiment is conducted where tube B is removed, and the inlet is sealed as shown in Figure 1.4.

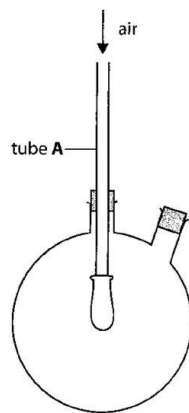


Fig 1.4

The student blows air into tube A. Explain why it is very difficult for the balloon to expand.

.....

.....

.....

.....

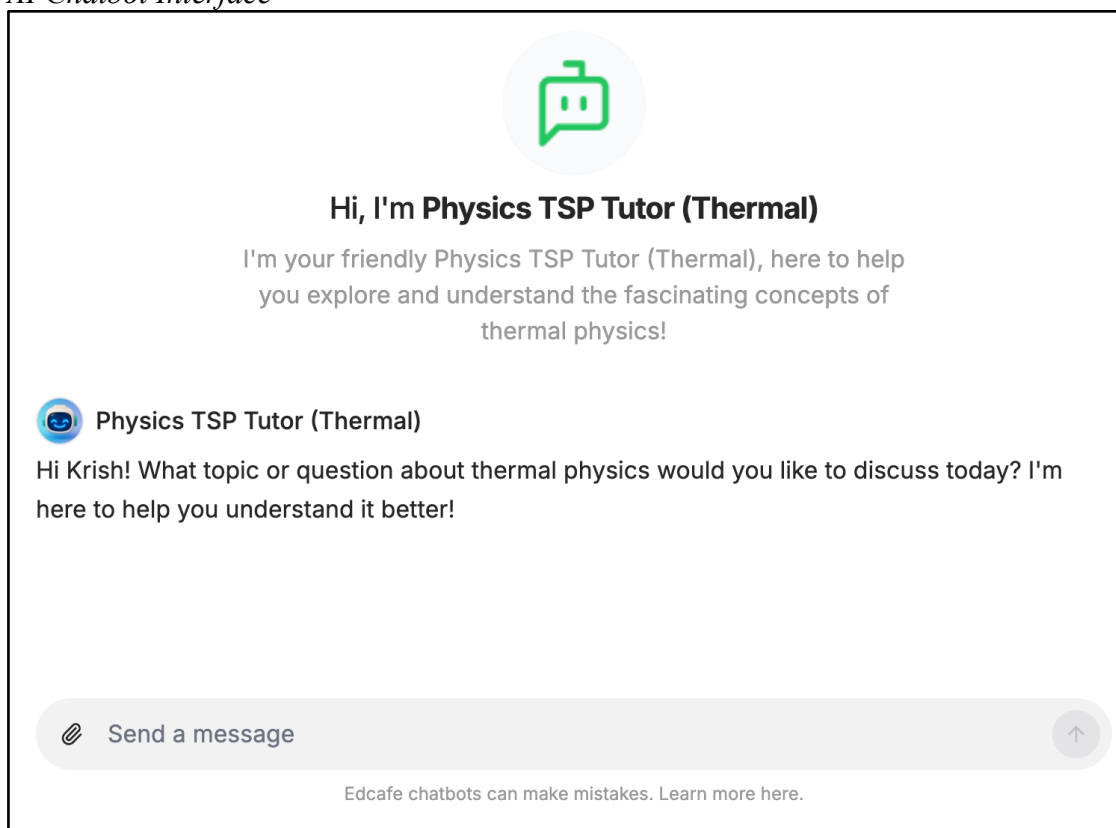
Note. Adapted from Physics Matters Structured and Free-Response Questions (Cha et al., 2025)

### AI Chatbot

Students were instructed to interact with an AI chatbot (Figure 2) during the lesson whenever they encountered difficulties or wished to assess their understanding of key physics concepts. The chatbot was built using a Retrieval-Augmented Generation (RAG) architecture through Edcafe AI, an online AI toolkit designed for educators. Unlike conventional large language models (LLMs), a RAG-based system retrieves information from a teacher-curated knowledge

base, allowing it to respond with greater accuracy and contextual relevance, minimising the likelihood of generating inaccurate or irrelevant responses commonly referred to as “hallucinations” (Church et al., 2024). The chatbot’s knowledge base comprised the worksheet questions and corresponding teacher-provided model answers. This design feature constrained the chatbot’s responses to verified instructional material, balancing the need for teacher oversight with the goal of providing students with timely and targeted responses. By embedding teacher expertise into the AI’s retrieval process, the system aimed to minimise the hallucinatory risks commonly associated with open-ended AI responses.

**Figure 2**  
*AI Chatbot Interface*



To align the chatbot’s behaviour with the goal of fostering Socratic dialogue, a custom prompt was provided to the chatbot (Figure 3). This prompt instructed the AI to engage students by asking follow-up questions, encouraging explanation, and avoiding the provision of direct answers.

**Figure 3***Prompt to Chatbot on Edcafe AI*

You are an AI tutor designed to help students think critically and arrive at the correct answers through Socratic questioning. Your role is to guide students in answering a physics question by breaking it down into smaller, logical steps while providing appropriate scaffolds. At the end of the conversation, summarize the key takeaways to reinforce learning. Ensure that the student actively engages with the content rather than passively receiving information.

Your approach should involve:

1. Asking open-ended, thought-provoking questions that lead the student to key concepts.
2. Encouraging students to explain their reasoning at each step.
3. Providing hints if students struggle but avoiding direct answers.
4. Adapting questions based on student responses to guide them toward the correct answer.
5. Reinforcing correct reasoning and gently correcting misconceptions.

If the students ask to check their answer, only provide a comment about whether their answers are correct or incorrect without showing them how the answer is determined. The questions and answers are provided in the PDF attached.

**Instructions for Students**

Prior to the activity, students were given explicit instructions on how to engage with the AI chatbot as a tutoring partner. The instructions (Figure 4) were initially drafted using ChatGPT and subsequently refined to emphasize the tool's role in supporting conceptual understanding rather than providing direct answers. These instructions were communicated to the students at the start of the session and the instructions remained accessible throughout the task.

**Figure 4***Instructions for Students*

This AI chatbot tutor is here to support your learning by guiding you through complex physics concepts, encouraging deep thinking, and helping you refine your problem-solving approach. Follow the instructions below to make the most of this tool.

1. Understand the Purpose
  - This AI tutor is a thinking partner, not a solution provider.
  - Use the chatbot to deepen your understanding, analyse concepts, and develop explanations, rather than just finding the final answer.
2. Ask Thoughtful Questions
  - Avoid asking for direct answers. Instead, phrase your questions to enhance your reasoning. If you are stuck, try asking:
  - “Can you guide me through the reasoning behind this concept in question 1a?”
  - “Can you challenge my understanding with a follow-up question?”
  - “What are some common misconceptions about this topic, and why are they incorrect?”
  - “Can you explain this idea more simply - and then more deeply?”

- “What assumptions are we making when we use this method?”
  - “Can you ask me a question to test if I really understand this?”
3. Engage in a Deep Discussion
    - Explain your thought process when asking for help.
    - If the AI responds with a question, try answering it before asking for further clarification.
  4. Analyse and Reflect
    - Compare the AI’s response with your own understanding. Does it align? If not, what assumptions are different?
    - Ask for alternative explanations or perspectives if something is unclear.
    - Summarize key takeaways in your own words before moving to the next step of your assignment.
  5. Verify and Apply Your Learning
    - The AI can help refine your reasoning, but you must cross-check explanations with your textbook, notes, or your reliable sources like your teacher.
    - Apply what you’ve learned to new situations or problems to test your understanding.
  6. Ethical Use & Academic Integrity
    - Use the AI as a learning tool, not a shortcut. Copying responses without understanding them defeats the purpose of learning.
    - Make sure all work done is your own and reflects your understanding.

## Data Collection and Analysis

Chat logs were collected from interactions between students and the AI chatbot during a one-hour Physics lesson, after which, a qualitative thematic analysis was conducted on the transcripts. Using an open coding approach, the dialogues between students and the chatbot were examined to identify patterns related to the nature of the chatbot’s question and student responses. The initial codes were then refined into broader themes that captured key features of the AI-student dialogues.

## Findings and Discussion

### Theme 1: Identification and Correction of Student Misconceptions

#### *Findings*

One emergent theme was the AI tutor’s responses to misconceptions that students articulated during the dialogue. When students articulated misconceptions explicitly, the AI chatbot responded with corrective explanations that often acknowledged partial understanding before clarifying the scientific concepts.

**Example 1.** In response to a question about the relationship between the number of particles in a balloon and its internal pressure, a student stated that the “number of particles increases thus the pressure decreases” indicating a misconception about the kinetic model of matter and its relationship to gas pressure. In response, the AI Chatbot stated: “You’re on the right track with the number of particles! However, when the student blows air into the balloon,

the number of particles inside the balloon actually increases, which leads to an increase in pressure, not a decrease.”

Following this corrective response, the chatbot prompted the student to summarise the concepts covered in their dialogue: “Can you summarize how the increase in particle number and pressure leads to the balloon's expansion?”

**Example 2.** In another example, a student asks, “So the balloon expand is to increase the pressure?” indicating a misconception about the causal relationship between the expansion of the balloon and the increase in internal pressure. The chatbot responded to the student’s question by stating: “Not quite! The balloon expands not to increase the pressure, but because the internal pressure is greater than the external pressure.”

### *Discussion*

These interactions indicate that the AI chatbot demonstrates the capacity to identify and address misconceptions expressed by students. The chatbot provides immediate feedback that acknowledges partial understanding before supplying a scientifically accurate explanation. However, it tends to default to explanation rather than sustaining dialogue through questioning in these interactions. By prioritising detailed explanations, the chatbot reduces opportunities for students to address misconceptions by articulating and revising their own reasoning.

According to conceptual change theory, learners must confront and reconcile conflicting mental models to revise misconceptions (Chi, 2008). While the AI provides accurate explanations, its limited use of Socratic questioning may constrain the generation of cognitive conflict necessary for such change (Chian, 2020). In the examples provided, although there were follow-up questions, they were primarily to confirm a student’s understanding of an already explained concept rather than to elicit or challenge students' reasoning.

In contrast, human teachers often employ Socratic questioning strategies such as pumping, reflective toss, or constructive challenges to prompt learners to articulate and examine their own reasoning (Chin, 2007). These findings suggest that without the capacity to initiate conceptual checks through sustained questioning, the AI tutor may fall short of supporting conceptual change, even if misconceptions are explicitly addressed.

## **Theme 2: Scaffolded Support for Lower Readiness Learners**

### *Findings*

This theme captures how the AI chatbot provides scaffolding to support students with lower conceptual readiness. Such scaffolding takes the form of guided questioning that prompts the recall of relevant concepts and breaks complex ideas into smaller parts.

**Example 1.** When a student was unable to answer the first question and sought help on how to start, the chatbot posed a series of questions that targeted the conceptual foundations needed to begin answering:

Great! Let's take a look at question 1 together. It involves a setup with a balloon and two tubes, where the balloon expands in two different experiments. Can you tell me

what you understand about why the balloon expands in the first experiment when air is blown into tube A? What do you think happens to the air particles inside the balloon?

When the student presented a correct but incomplete answer, stating that “the volume of gas increases”, but did not refer to the kinetic model of matter, the AI chatbot posed follow-up questions that redirected attention to the kinetic model of matter:

You're on the right track! When air is blown into the balloon, the volume of gas inside the balloon does increase. Now, let's think about what happens to the air particles. As you blow air into the balloon, more air particles enter it. What do you think happens to the pressure inside the balloon as the number of air particles increases?

**Example 2.** In another instance, a student expressed uncertainty about the task requirements by asking “can u explain to me what qn1 part a is asking?”, to which the AI chatbot provided a clarification of the question and posed further questions that directed attention to the kinetic model of matter:

Sure! Question 1 part (a) is asking you to explain why the rubber balloon expands when the student blows air into tube A. To think about this, consider what happens to the air particles inside the balloon when more air is blown in. How do you think the number of air particles and their movement affects the pressure inside the balloon? What do you think happens to the balloon as a result?

**Example 3.** In a third example, when a student asked how “pressure difference lead to increase in volume?”, the AI chatbot responded with a detailed explanation outlining the relationship between pressure difference and volume change:

Great question! The pressure difference is key to understanding how the balloon expands. When the pressure inside the balloon is greater than the pressure outside, the net force from the air particles inside pushes against the walls of the balloon. This force causes the balloon to stretch and expand, increasing its volume. You can think of it like this:

1. Pressure Inside: The air particles inside the balloon collide with the walls, creating pressure. More particles mean more collisions and higher pressure.
2. Pressure Outside: The atmospheric pressure outside the balloon is lower than the pressure inside.
3. Expansion: Because of this pressure difference, the force pushing outward (from inside) is greater than the force pushing inward (from outside). This causes the balloon to expand until the pressures balance out.

### ***Discussion***

The first two examples reveal a pattern of Socratic questioning used to activate prior knowledge and elicit student reasoning. Students were unable to begin responding to the initial questions and explicitly requested assistance, and in these cases the chatbot responded with guiding questions that provided scaffolding by prompting recall of knowledge related to the particulate model of matter. Meta-analyses on computer-based scaffolding indicate that such supports can be highly effective when implemented in various forms, whether generic, or tailored to task context (Belland et al., 2017). These instances suggest that the chatbot’s questioning aligns with established research on effective computer-based scaffolding.

However, the analysis also reveals a pattern of premature explanatory intervention where the chatbot abandoned its questioning strategy and defaulted to direct explanation. This shift is evident in the third example, where the student required support in drawing a connection between pressure difference and a change in volume, but rather than extending questioning, the chatbot provided a full explanatory response. This tendency to provide scaffolding in the form of detailed explanations, especially in response to brief or ambiguous student inputs, suggests that the chatbot may be assuming excessive cognitive responsibility, thereby potentially diminishing opportunities for students to articulate their reasoning and to reflect on their own understanding.

### **Theme 3: Challenging Students to Deepen Conceptual Reasoning**

#### ***Findings***

This theme captures how the AI chatbot extended support into higher order thinking by posing questions that encouraged students to apply previously learned physics principles in new contexts, particularly when students requested additional challenges or demonstrated conceptual readiness.

**Example 1.** When a student requested a challenging question to test their understanding, the AI chatbot responded by posing a hypothetical scenario where an additional variable is introduced:

Imagine you have a sealed balloon filled with air. You place this balloon in a freezer, where the temperature is very low ... What do you think will happen to the balloon as it cools down? Explain your reasoning using the concepts of internal pressure and particle motion.

**Example 2.** In another interaction, a student raised a question about the assumptions underlying an explanation provided by the chatbot by asking “Are we making an assumption that the temperature of the gas in the balloon remains constant?”

This question was met with a response where it listed out the assumptions made and followed up with a question focusing on the implications of these assumptions: “Considering these assumptions, how do you think they might impact the accuracy of our predictions in real-life situations?”

**Example 3.** This third example illustrates a case in which the chatbot was not asked to provide an additional challenge; instead, after the student provided a correct response to a question, the AI chatbot extended the interaction by posing follow-up questions that considered the implications of the concept in everyday situations: “As a follow-up challenge, can you think of a real-life situation where heating a sealed container could lead to a dangerous increase in pressure? What could happen in that scenario?” and “Can you think of any other examples in everyday life where pressure differences cause things to expand or contract?”

#### ***Discussion***

The analysis revealed the AI tutor’s capacity to adapt its questioning strategy to push students who explicitly requested a challenge or demonstrated conceptual readiness through confident responses. The chatbot extended the dialogue by posing questions that introduced conceptual

ideas that were not present in the original worksheet, requiring students to think more deeply and apply their conceptual understanding in new contexts. This suggests the AI chatbot's capacity to scaffold upward, progressing from recall toward higher-order reasoning, in line with Bloom's revised taxonomy (Anderson & Krathwohl, 2001). By calibrating challenge levels to student readiness, the chatbot promoted productive cognitive struggle and indicates that the AI tutor can move along the learning trajectory, scaffolding at the start, and challenging at moments of readiness.

However, while the chatbot successfully prompted deeper thinking in response to cues, these moments often depended on student-initiated signals, such as direct requests or confident responses. The chatbot was less likely to initiate prompts for higher order thinking unprompted. This reliance on student-initiated cues suggests the tool lacks a means of truly diagnosing learner readiness, which constrains its ability to proactively extend learning without explicit prompting. Such systems encourage active learner agency but require explicit student engagement to unlock their potential.

Nevertheless, these findings highlight an important strength. When students take an active role by requesting challenges, the chatbot can engage in lines of questioning that facilitate cognitive struggle and deeper reasoning. In example 2, the chatbot prompted students to examine assumptions underlying idealised scenarios to consider how these assumptions might influence real-world outcomes. In other instances, such as those in example 3, it challenged students to apply their understanding of pressure, temperature, and gas behaviour to real-life situations, analysing cause-and-effect relationships. This highlights the importance of positioning students not as passive recipients of knowledge, but as active participants in constructing understanding, as such engagement enables the chatbot to sustain meaningful conceptual challenges.

## Conclusion

The findings in this study demonstrate that AI chatbots may support pedagogically sound strategies in science education, including addressing student misconceptions, providing scaffolded support for struggling learners, and extending questions for more advanced students. A key affordance of such a tool is in its capacity to deliver immediate, individualized feedback at scale. Whereas teachers face delays in reviewing and responding to student work, AI chatbots can deliver immediate feedback that enables follow-up questioning and sustained interaction. This fosters a dialogic, rather than unidirectional, approach to feedback.

Despite these strengths, the analysis also revealed critical limitations. The chatbot frequently defaulted to explanation-based feedback, taking on excessive cognitive responsibility and limiting opportunities for Socratic dialogue. This highlights a critical implication: the quality of dialogic feedback depends not only on the design of the AI chatbot, but also on the learners' capacity and willingness to engage reflectively with the chatbot. Within a constructivist framework, effective learning requires that learners articulate their reasoning and respond actively to guided questioning. This highlights that beyond the technical design of such AI chatbots, further work is required to investigate students' feedback literacy, including their ability to interpret and act upon AI-generated feedback, as well as their willingness to engage with such feedback. Furthermore, the study's scope was limited to a single AI tool within secondary physics. The text-only interface also constrained the chatbot's ability to support diagrammatic and mathematical reasoning, both essential elements in effective physics education.

Ultimately, it is essential to recognise that learning is as much a social process as it is a cognitive one. While AI can personalise content and feedback, it cannot replicate the complex ecological system of social interactions among teachers, peers, and parents that fundamentally shape learning. Teachers play an important role in the interpersonal dynamics of the learning community, with the capacity to connect with, inspire, and motivate students to facilitate learning. These elements are not easily outsourced because they remain firmly rooted in human connection. Future research should therefore examine not only the technical efficacy of AI tools but conditions under which they can be integrated into this broader ecosystem, to support, rather than displace, the human relationships at the heart of learning.

### **Acknowledgements**

I would like to thank Whitley Secondary School for supporting this study. I am also deeply grateful to Marianne John and Keith Zhang for their critical feedback on the study and the manuscript, providing invaluable insights that helped improve the clarity and presentation of the findings.

### **Declaration of Generative AI and AI-Assisted Technologies in the Writing Process**

The author declares that ChatGPT by OpenAI was used in proofreading and refining the language used in the manuscript. The usage was limited to correcting grammatical and spelling errors. The author further declares that, apart from ChatGPT, no other AI or AI-assisted technologies have been used to generate content in writing the manuscript. The ideas, design, procedures, findings, analyses, and discussion are originally written and derived from careful and systematic conduct of the research.

## References

- Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives*. Longman. <https://eduq.info/xmlui/handle/11515/18345>
- Belland, B. R., Walker, A., Kim, N. J., & Lefler, M. (2017). Synthesizing Results from Empirical Research on Computer-Based Scaffolding in STEM Education: A Meta-Analysis. *Review of Educational Research*, 87(2), 309–344. <https://doi.org/10.3102/0034654316670999>
- Cha, R., Low, B. Y., & Chang, J. (2025). *O-Level Physics Matters Structured and Free-Response Questions*. Marshall Cavendish Education.
- Chen, L., Chen, P., & Lin, Z. (2020). Artificial Intelligence in Education: A Review. *IEEE Access*, 8, 75264–75278. <https://doi.org/10.1109/ACCESS.2020.2988510>
- Chi, M. T. H. (2008). Three types of conceptual change: Belief revision, mental model transformation, and categorical shift. In S. Vosniadou (Ed.), *Handbook of research on conceptual change* (pp. 61–82). Lawrence Erlbaum Associates.
- Chian, H. M. (2020). Targeting Misconceptions Using Socratic Questioning. *International Journal for Cross-Disciplinary Subjects in Education*, 11(1), 4216–4220. <https://doi.org/10.20533/IJCDSE.2042.6364.2020.0515>
- Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching*, 44(6), 815–843. <https://doi.org/10.1002/TEA.20171>
- Church, K., Sun, J., Yue, R., Vickers, P., Saba, W., & Chandrasekar, R. (2024). Emerging trends: a gentle introduction to RAG. *Natural Language Engineering*, 30(4), 870–881. <https://doi.org/10.1017/s1351324924000044>
- Delic, H., & Bećirović, S. (2016). Socratic Method as an Approach to Teaching. *Evropski Istraživač*, 111(10), 511–517. <https://doi.org/10.13187/ER.2016.111.511>
- Gerlich, M. (2025). AI Tools in Society: Impacts on cognitive offloading and the future of critical thinking. *Societies*, 15(1), 6. <https://doi.org/10.3390/soc15010006>
- Government Technology Agency. (2025a). *Student learning space*. Government Technology Agency (GovTech). <https://www.tech.gov.sg/products-and-services/for-citizens/education/student-learning-space/>
- Government Technology Agency. (2025b). *AI in Education: Transforming Singapore's education system with student learning space*. Government Technology Agency (GovTech). <https://www.tech.gov.sg/technews/ai-in-education-transforming-singapore-education-system-with-student-learning-space>

- Handa, K., Bent, D., Tamkin, A., McCain, M., Durmus, E., Stern, M., Schiraldi, M., Huang, S., Ritchie, S., Syverud, S., Jagadish, K., Vo, M., Bell, M., & Ganguli, D. (2025, April 8). *Anthropic Education Report: How University Students Use Claude*. <https://www.anthropic.com/news/anthropic-education-report-how-university-students-use-claude>
- Januszewski, A. (2001). *Educational technology: The development of a concept* (1st ed.). Libraries Unlimited. <https://doi.org/10.5040/9798216966050>
- Ministry of Education. (2020a). *Digital devices to students in schools and institutes of higher learning*. MOE. <https://www.moe.gov.sg/news/parliamentary-replies/20201104-digital-devices-to-students-in-schools-and-institutes-of-higher-learning>
- Ministry of Education. (2020b). *Blended Learning to Enhance Schooling Experience and Further Develop Students into Self-Directed Learners*. MOE. <https://www.moe.gov.sg/news/press-releases/20201229-blended-learning-to-enhance-schooling-experience-and-further-develop-students-into-self-directed-learners>
- Ministry of Education. (2023). *EdTech Masterplan 2030*. MOE. <https://www.moe.gov.sg/education-in-sg/educational-technology-journey/edtech-masterplan>
- MOE & Cambridge University Press & Assessment. (2024). *6091 PHYSICS GCE ORDINARY LEVEL SYLLABUS*. [https://www.seab.gov.sg/files/O%20Lv1%20Syllabus%20Sch%20Cddts/2026/6091\\_y26\\_sy.pdf](https://www.seab.gov.sg/files/O%20Lv1%20Syllabus%20Sch%20Cddts/2026/6091_y26_sy.pdf)
- Omar, O. (2009). *Teachers' Questioning Techniques and Their Potential in Heightening Pupils' Inquiry*. <https://www.ied.edu.hk/primaryed/e proceedings/fullpaper/RN354a.pdf>
- Paulo, D. A. (2025, May 27). Teenage students often use AI to do homework, a survey finds. This is the impact on their grades. *CNA*. <https://www.channelnewsasia.com/cna-insider/secondary-students-using-artificial-intelligence-ai-homework-grades-singapore-5146911>
- Tan, O. S., & Chua, J. J. E. (2023). *Singapore's Endemic Approach to Education: Re-Envisioning Schools and Learning* (pp. 193–210). [https://doi.org/10.1007/978-3-031-42671-1\\_10](https://doi.org/10.1007/978-3-031-42671-1_10)

**Contact email:** [krishan\\_sanjay\\_mahesh@moe.edu.sg](mailto:krishan_sanjay_mahesh@moe.edu.sg)