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May Different AI Tools Address Misconceptions in Physics?

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Abstract

This study aims to comparatively examine the potential of four widely used free AI chatbots (ChatGPT, DeepSeek, Gemini, Grok) to spread misconceptions about high school-level physics. Free versions of ChatGPT, DeepSeek, Gemini, and Grok's chatbots were selected as AI tools. As fundamental physics concepts, the concepts of mass, weight, heat, temperature, and capacitors, which are the most common misconceptions among students, were selected. For this purpose, the responses of the AI tools to the questions posed to them were compared in terms of scientific accuracy. The responses of various AI tools are presented, along with links and screenshots. The responses were analyzed by three researchers who are experts in physics education. The results show that although AIs provide scientifically accurate answers to some questions, all AI systems contain statements consistent with the known misconceptions held by students. Particularly on topics with differing scientific interpretations, such as mass and weight, chatbots have been observed to generally provide definitive answers from a single perspective, disregarding different scientific viewpoints.

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Introduction

Access to information is becoming easier every day. We are facing a generation that can easily access information from their computers or mobile phones, leaving behind a generation that must travel from library to library to access information. Technological tools, especially those based on artificial intelligence (AI), have made a significant advance in knowledge production. Users can access information without any time limit and usually without charge. Therefore, AI apps are now one of the first choices for students of all levels to access information. But how accurate is this information? Due to their reliance on databases, chatbots often exhibit bias in their responses, which can be influenced by public data from biased media sources or misinformation.

The development of AI tools includes milestones such as the creation of ELIZA in the 1960s (Weizenbaum, 1966). While in the 1980s, machines were allowed to process stored information with a new experience, a humanoid robot was created in 2001 (Breazeal, 2004). Then, in 2018, OpenAI introduced the Generative Pre-trained Transformer (GPT) autoregressive language model. On November 30, 2022, OpenAI released a chatbot called ChatGPT, which is based on the third version of GPT. This tool, GPT-3.5 and GPT-4, is based on the previous major language models. When you give ChatGPT a prompt, it uses the transformer architecture to respond. This deep learning technique works on terabytes of data containing billions of words to generate a response. ChatGPT, developed by OpenAI, reached 1 million users on December 4, 2022. In January 2023, ChatGPT reached one hundred million monthly prompts, making it the fastest-growing app in history.

Today, AI tools are present across various industries, including smartphones, healthcare, finance, and marketing (Veloso et al., 2021; Yang, 2022), and their influence continues to grow (Shabbir & Anwer, 2015). The growing popularity of AI tools has led to the rapid emergence of various AI-based chatbots and tools in different domains, including education. AI-based chatbots are increasingly integrated into learning environments, especially due to their 24/7 availability, instant feedback, and personalized support (Labadze et al., 2023). Due to their multifunctional properties, chatbots promote student engagement and motivation by creating interactive and dynamic educational experiences (Benotti et al., 2017; Deng & Yu, 2023; Okonkwo & Ade-Ibijola, 2021). People use AI-based chatbots for various purposes, including generating creative content, answering questions, providing explanations, making suggestions, and engaging in casual conversation (Crawford et al., 2023; Wu et al., 2023).

According to the results of bibliometric research on ChatGPT, one of the famous AI-based chatbots, most of the studies focused on topics related to non-specific learning and English language learning in ChatGPT, and topics related to STEAM courses, where most studies used ChatGPT-based assistant learning as an instructional design in the course, were the most frequently researched topics (Chang et al., 2024). A meta-analysis by Laun and Wolff (2025) found that chatbots have a positive impact on learning outcomes in educational settings. For example, Alneyadi and Wardat (2023) found that students using ChatGPT demonstrated significantly higher achievement in magnetism-related topics than those without access to the chatbot over a four-week period. The effectiveness of chatbot-assisted learning varies depending on several factors, including interaction modality, subject area, intervention duration, and educational level (Laun & Wolff, 2025).

Each AI tool has some strengths and weaknesses. For example, DeepSeek is an AI model focusing on information retrieval and organization. Unlike other models, it specializes in structured knowledge searches, using advanced indexing techniques to provide precise and verifiable responses (Souza & Weigang, 2025). DeepSeek is particularly useful in areas such as scientific research, legal consulting, and technical support, where accurate and reliable information is critical (Mercer, Spillard, & Martin, 2025).

Challenges of AI Tools, Especially in Physics Education

Despite these benefits, four thematic clusters emerged from the research on the role and challenges of ChatGPT in teaching and learning in higher education institutions: ChatGPT and academic integrity, ChatGPT and the learning environment, ChatGPT and student engagement, and ChatGPT and scholarly research (Bhullar et al., 2024). A critical concern is the potential for generating and disseminating false or biased information (Ahmad et al., 2023; Baidoo-Anu & Ansah, 2023; Gregorcic & Pendrill, 2023; Kortemeyer, 2023; Spitale et al., 2023). Worse still, students hold misconceptions about AI, such as the belief that AI is infallible and can be 100% objective (Bewersdorf et al., 2023). Despite informing students that AI can make mistakes and even providing the keys to the physics examples, almost half of the students still agree with all the responses provided by ChatGPT, regardless of whether the responses are correct or incorrect (Ding et al., 2023). Reports emerged that the New York City Department of Education had unexpectedly banned access to the tool due to concerns about academic integrity violations (Crawford et al., 2023). Also, on March 22, 2023, more than 1000 AI experts published an open letter. They said that AI systems with competitive intelligence could pose great risks to society and humanity and asked GPT-4 to pause the training of robust systems.

In addition, AI tools can respond to prompts in different languages with varying levels of accuracy. In this case study, Revalde et al. (2025) analyzed ChatGPT's ability to solve typical physics tests and problems in four languages: Kazakh, Latvian, Russian, and English, by collecting over 400 questions, including problem-solving tasks, to evaluate ChatGPT's performance. The highest accuracy was observed in English, with an 83% success rate, while Kazakh had the lowest at only 33%, highlighting the problems of using ChatGPT in non-English languages. In a study by Dahlkemper and colleagues (2023), where students were asked to evaluate ChatGPT-3.5's responses in three different areas of physics, the results suggest that over-reliance on AI tools may weaken critical thinking and problem-solving skills.

With the increasing use of AI tools in education, particularly in high school and above, students are starting to benefit from AI tools in all types of homework, including physics. In the past, students used to utilize websites such as Wikipedia when doing their homework and research for the course, even though the resources have a high potential to cause misconceptions (Damlı & Kızılcık, 2012). Students can now ask their questions directly to AI tools. Although these tools, trained with different sources, may appear reliable, this is not always the case (Camilleri, 2024). For this reason, AI tools have the potential to become a new and widespread source of misconceptions among physics students. This is because inaccurate or incomplete feedback from chatbots may reinforce the students' existing misconceptions or contribute to the formation of new misconceptions (Liang et al., 2023). Studies also support this hypothesis. For example, Wheeler & Scherr (2023) found that ChatGPT's

responses to standard physics questions were consistent with an accurate theoretical understanding but were often incorrect when applied to a given system, reflecting many of the same misconceptions as students when they prompted ChatGPT with questions based on the Force Concept Inventory (FCI). Similarly, Gregorcic and Pendrill (2023), Kortemeyer (2023), and Rane et al. (2023) claimed that ChatGPT presented potentially incorrect information as if it were a fact for the same physics questions. In addition, Ding et al. (2023) investigated students' perceptions of using ChatGPT as a virtual tutor in a physics class. Their findings support the fact that ChatGPT only provides 85% accuracy in solving physics questions, particularly for topics related to light and radioactivity. Similarly, Newton and Xiromeriti (2023) claimed that ChatGPT performed poorly on multiple-choice-based exams, especially when they included problem-solving, transfer tasks, or mathematical problems. For physics questions in particular, the studies reported that ChatGPT, especially older versions of ChatGPT, makes errors that are similar to those made by novice physics learners while not showing any signs of metacognition, i.e., ChatGPT presents potentially incorrect information as if it were a fact (Kortemeyer, 2023; West, 2023; Gregorcic & Pendrill, 2023). Therefore, to be used effectively in physics education, chatbots must provide scientifically validated content and include mechanisms to detect and correct students' misconceptions (Liang et al., 2023).

Research on artificial intelligence has primarily focused on ChatGPT. However, numerous different chatbots developed by various companies, such as DeepSeek, Gemini, and Grok, have been released to the market, which students can access for free. Gemini was developed by Google, DeepSeek was developed by DeepSeek, a Chinese company, and Grok was developed by xAI. Gemini is integrated into mobile devices based on the Android operating system, which is widely used worldwide. With China's Great Firewall, officially known as the Golden Shield Project, restricting access to the Internet, DeepSeek is a crucial alternative for millions of Chinese users. Grok is also used by users of the X platform (formerly Twitter). These free chatbots are, therefore, easily accessible.

Research on AI in education, particularly in physics, has predominantly centered on ChatGPT. However, a new wave of free and easily accessible large language model chatbots—specifically DeepSeek, Gemini, and Grok—has entered the market, yet their educational reliability remains largely uncharted territory. The existing literature primarily evaluates chatbots through formal diagnostic tests, such as the FCI, or complex open-ended problems (Polverini & Gregorcic, 2024). Unlike previous studies, this research conducts a novel comparative analysis by directly targeting conceptual questions related to the most persistent and common physics misconceptions (e.g., mass, weight, heat, capacitors) to these four leading free AI chatbots. The aim is to determine if these widely adopted tools provide a scientifically accurate foundation or, critically, serve as new vectors for misinformation for high school students.

Method

In this study, several popular artificial intelligence (AI) tools are provided with basic physics prompts that a high school student could use. In March 2025, the prompts were given by logging into some popular AI websites. The promptings were based on well-known misconceptions in physics education. The same prompts were given to different AI tools. The responses given by the AI tools were compared, and their scientific accuracy was discussed

in the literature. AI tools that students are likely to use frequently and can easily access free versions were preferred. These are (in alphabetical order): ChatGPT, DeepSeek, Gemini, and Grok.

Data were collected from the free versions of all AI tools, assuming that students would use these free versions. The free AI versions used are GPT-4o, DeepSeek-V3, Gemini 2.0 Flash, and Grok 3. AI chatbots tend to respond differently to each user. Users' past prompts are influential in differentiating responses. They can also update their responses over time and give a different response later for the same prompt from the same user. To minimize these variables, we generated prompt input from new accounts that had never been used before.

The responses received from the AI tools constitute the study data. Prompts were provided in English, and responses were received in the same language. Descriptive analysis was applied to the data. The analysis sought answers to two questions: (i) Do the responses conform to scientific theories or contain misconceptions, and (ii) are there differences between the responses given by different AI tools in conformity with scientific theories? While examining conformity with scientific theories, it was also investigated whether the responses contained misconceptions. The parts of the responses that overlapped with the misconceptions in the literature were identified.

The prompts given to the AI tools were selected from different branches of physics within the high school curriculum. Topics known to be conceptually challenging for high school students in basic physics and where misconceptions are common (e.g., Kızılcık & Tan, 2018; Koray & Tatar, 2003; Goodman, 2015) have been selected. The following questions were given to AI tools as prompts. The prompts given to AI tools are as follows:

On mass and weight

- What is mass?
- How do you define the concept of weight?
- Is weight a vector quantity or a scalar quantity?

On the concepts of heat and temperature

- What are the differences between the concepts of heat and temperature?

On capacitors

- What do capacitors store?
- Do capacitors store charge?

Three researchers specializing in physics education individually reviewed the responses to determine whether they contained scientifically accurate information or misconceptions. Following this initial review, the researchers discussed the topic among themselves and developed an analysis scheme, considering misconceptions documented in the literature (e.g., heat/thermal energy distinction, mass and weight). To increase consistency among the researchers, full agreement (100% agreement) was achieved in the final coding and interpretation.

The responses to the prompts for the three AI tools (ChatGPT, Gemini, and Grok) are shown in the public links in Appendix A. However, DeepSeek does not allow the sharing of public links. For this reason, screenshots of DeepSeek's responses are provided in Appendix B. The validity and reliability of the results were enhanced by using direct quotes. The researchers discussed and agreed on the interpretation of the data. Where the researchers disagreed, an expert opinion was sought from another PhD researcher in physics education.

Results

The responses to the AI tools are discussed and compared by topic.

Responses about Mass and Weight

Three prompts about mass and weight were given to the AI tools as prompts: (i) What is mass? (ii) How do you define the concept of weight? (iii) Is weight a vector quantity or a scalar quantity?

As a result of the researchers' analysis, the statements containing scientific accuracy or misconceptions in the AI tools' responses to the prompts on mass and weight are shown comparatively in Table 1.

Table 1. Comparison of Responses to Mass and Weight of AI Tools (Statements Containing Only the Main Idea or Incorrect Statements)

Prompts	ChatGPT	DeepSeek	Gemini	Grok
What is mass?	• Mass is a measure of the amount of matter in an object. It determines an object's resistance to acceleration when a force is applied (inertia) and also influences the gravitational force it experiences.	• Mass is a fundamental property of physical objects that quantifies the amount of matter they contain. It is a measure of an object's resistance to acceleration when a force is applied (inertial mass) and also determines the strength of its gravitational attraction to other objects (gravitational mass).	• At its core, mass is a measure of how much "stuff" is in an object. This "stuff" is made up of atoms and subatomic particles. • Inertia: Mass also relates to an object's inertia, which is its resistance to changes in motion. A more massive object is harder to accelerate or decelerate. • Mass tells you how much "stuff" an object is made of. • The more mass an object has, the harder it is to move or stop.	• Mass is a fundamental property of matter that quantifies the amount of substance in an object. It's essentially a measure of how much "stuff" something contains. • This is about how resistant an object is to acceleration when a force is applied. • This determines how strongly an object interacts with a gravitational field. • In everyday terms, we often measure mass in kilograms or pounds, though weight (a force) and mass (an intrinsic property) get conflated in casual talk. • So, mass can also be thought of as a form of concentrated energy. This gets wild at cosmic scales or in particle physics, where tiny particles

Prompts	ChatGPT	DeepSeek	Gemini	Grok
				can have mass from mechanisms like the Higgs field.
How do you define the concept of weight?	• Weight is the force exerted on an object due to gravity. • Weight is a vector quantity, meaning it has both magnitude and direction (always directed toward the center of the gravitational source).	• Weight is a measure of the force exerted on an object due to gravity. • It's important to note that weight is a force, and its SI unit is the newton (N).	• Mass is the amount of matter in an object, and it remains constant regardless of location. • In simpler terms, weight is the downward pull you feel due to gravity.	• In physics, weight is the force exerted by gravity on an object's mass. • Weight is a force, so it's measured in units like newtons (N) or pounds (lb).
Is weight a vector quantity or a scalar quantity?	• Weight is a vector quantity because it has both magnitude and direction.	• Weight is a vector quantity.	• Weight is a vector quantity.	• Weight is a vector quantity.

Although all four AI tools have different definitions of mass, they all first attempted to define mass in terms of the amount of matter. However, this definition is more appropriate for molarity than for mass. It neglects density differences and the structure of matter by focusing only on the number of molecules/atoms. They defined inertial mass as a second definition. ChatGPT and DeepSeek used the term resistance to acceleration. Gemini similarly defined it as resistance to change in motion. Grok explained it in terms of Newton's second law. All four AI tools also define gravitational mass. Unlike the other AI tools, Grok used the phrase a form of concentrated energy and referred to Einstein's theory of mass relativity and the Standard Model with the phrase mass from mechanisms such as the Higgs field.

All four AI tools correctly defined weight in terms of gravity. They all emphasized that weight is a force. In construct, Gemini first defined mass in terms of the amount of matter and then defined weight. Grok has pointed out that the pound (lb) is incorrectly used as a unit of weight. However, the pound (lb) is a unit of mass, and the unit of weight should be specified as pound-force (lbf). When defining weight, ChatGPT and Gemini either specified the direction of the weight or explicitly stated that it is a vector quantity. However, DeepSeek and Grok do not specify whether the weight is a vector quantity. Therefore, another prompt was given to determine whether the weight is a vector or a scalar. In response to this prompt, all four AIs indicated that weight is a vector quantity.

Responses about Heat and Temperature

A prompt about heat and temperature was given: What are the differences between the concepts of heat and temperature? In their responses to this prompt, all four AI tools defined the concepts of heat and temperature and explained their units and their uses. The misconceptions in the AI implementations' responses are shown in Table 2.

Table 2. Comparison of AI tools: statements aligning with heat-thermal energy misconceptions

AI tool	Response
ChatGPT	A large glass of hot water and a small cup of hot water may have the same temperature, but the larger one contains more heat energy because it has more water molecules. Heat: Depends on mass, temperature change, and specific heat capacity of a substance.
DeepSeek	Nature: Temperature: It represents the intensity of heat. Dependence on Mass: Heat: The amount of heat in a system depends on the mass of the substance.
Gemini	Heat is related to the total amount of energy. Therefore, a large object can have a lot of heat, but a low temperature. And a small object can have a high temperature, but very little heat.
Grok	Dependence: Heat depends on the amount of substance (mass), specific heat capacity (c), and temperature change (e.g., $Q = m.c.\Delta t$)

Although ChatGPT and Gemini correctly defined heat at the outset, in their examples, they treated heat as a quantity stored by matter. This is a common misconception that arises from confusing the concept of heat with that of thermal energy. DeepSeek and Grok did not mention a similar misconception. However, DeepSeek used the phrase it represents the intensity of heat to describe the nature of heat. This statement implies the misconception that heat is the total energy of matter. In other words, it confuses thermal energy with heat. On the contrary, DeepSeek and Grok especially emphasized that heat is not a property of a system but rather a process of energy transfer. However, ChatGPT, DeepSeek, and Grok, while trying to explain the formula for the heat transferred, included the expression depends on the mass. While this is correct for calculating the amount of heat given or received, it is a statement that supports the misconception that heat is the total energy of matter. All four of them gave contradictory responses and implied misconceptions about heat.

Responses about Capacitors

Two prompts were given to AI tools about capacitors: What do capacitors store? and Do capacitors store charge? One of the responses to the first prompt necessitated the second prompt. The responses of the AI tools to the prompts about capacitors are shown in Table 3.

Table 3. Comparison of AI Tools Expressions that Contain Misconceptions About Capacitors

AI tool	What do capacitors store?	Do capacitors store charge?
ChatGPT	• Capacitors store electrical energy in the form of electric field between their plates.	-
DeepSeek	• Capacitors store electrical energy in the form of electric field.	• Yes, capacitors store charge. When the voltage is removed, the capacitor can retain the stored charge for a period of

AI tool	What do capacitors store?	Do capacitors store charge?
		time, depending on the leakage resistance of the dielectric and the external circuit.
Gemini	• Capacitors store electrical energy in the form of electric field.	• In simpler terms, think of it like this: a capacitor doesn't store "extra" electricity like a battery.
Grok	• Capacitors store electrical energy in the form of an electric charge.	• Yes, capacitors do store charge. • When a voltage is applied across the plates, positive charge accumulates on one plate and negative charge on the other, effectively "storing" the charge. The amount of charge a capacitor can store is determined by its capacitance, measured in farads (F), and the voltage applied to it, according to the formula: $Q = C \times V$ Q is the charge stored (in coulombs) So, in short, yes, capacitors store charge by holding it on their plates until it's released or discharged in a circuit!

All four AI tools state that the capacitor stores energy. They even emphasized that it stores energy in an electric field. However, Grok used the phrase electrical energy in the form of an electric charge in its response. ChatGPT, DeepSeek, and Gemini used the exact phrase: Capacitors store electrical energy in the form of electric field. This statement implies that an electric field is a form of energy. This is scientifically incorrect; capacitors store energy within the electric field, not as an electric field.

There is a misconception that capacitors store charge. Therefore, a second prompt was given. Although DeepSeek gave the correct response to the first prompt, it said that a capacitor stores charge. Grok also consistently responded, although incorrectly, that a capacitor stores charge. Interestingly, both cite the formula for the charge accumulated on a plate as evidence for their argument.

Furthermore, Gemini's response states that the batteries store extra electricity. Electricity is a branch of physics that studies the behavior of charge. The use of the word electricity here can be confusing. Electricity can refer to different concepts such as electric charge, electric energy, and electric current. There is an ambiguity here.

Discussion

In this study, the responses provided by the free versions of different AI chatbots were comparatively analyzed in terms of scientific accuracy and the potential to propagate misconceptions. The concepts analyzed were selected

according to the prevalence of students' misconceptions in physics education: mass, weight, heat, temperature, and capacitors. Although the responses were not always scientifically accurate, specific patterns of similarity were observed across platforms. Sometimes, the chatbots provided identical or nearly identical sentences in their responses. Nevertheless, there were also notable divergences, with some tools providing conflicting explanations for the same prompts.

Elmas et al. (2024) showed in their study in the field of biology education that ChatGPT has misconceptions. This study also showed that AI tools can potentially be a source of misconceptions for students. The most uniform error observed across all four platforms concerns the concept of mass. Every chatbot initially defined mass as the "amount of matter" or "substance". This definition is a persistent conceptual error in physics education, as it is fundamentally more appropriate for the chemical concept of molarity (Koray & Tatar, 2003). By focusing solely on the count of molecules or atoms, this definition inherently fails to account for density differences and the internal structure of matter, a common pitfall that AI tools are now perpetuating.

ChatGPT, DeepSeek, and Gemini responded similarly to the prompts regarding the concepts of mass and weight, specifically emphasizing that weight is a vector in terms of force. Conversely, Grok introduced more advanced perspectives by referencing Einstein’s approach to mass and the Higgs field mechanism. These variations highlight the potential and limitations of current AI tools in physics education.

AI chatbots have not considered these different approaches in literature and have only responded from one perspective. This inconsistency is not unique to AI tools. Taşkın and Karadağ (2022) found significant discrepancies in the treatment of the concept of weight in international university physics textbooks. In their analysis of fifty-three textbooks, 69.8% emphasized the vector nature of weight, while the rest did not. They have also found that the gravitational and operational definitions have different interpretations, both as vectors and as scalars. However, textbooks offer a single perspective on weight and do not include these different interpretations. There is also confusion about weight among students at different levels of education and among educators (Dostal, 2005; Feeley, 2007; Galili & Bar, 1997; Galili & Lehavi, 2003; Gönen, 2008; Ruggiero et al., 1985; Watts, 1982). Furthermore, although ChatGPT and Gemini define heat correctly at the beginning, they refer to it as a quantity stored by matter in their later examples. Therefore, they may address the misconception that a large object can have much heat. It is a common misconception that a substance stores heat (Kızılcık & Tan, 2018).

Finally, while all four AI tools correctly stated that capacitors store electrical energy, a follow-up prompt revealed a critical vulnerability: DeepSeek and Grok reverted to the fundamental misconception by incorrectly confirming that capacitors "store charge" (Goodman, 2015). It is known that charged capacitors do not have a net charge; instead, they store energy by maintaining a potential difference between their plates. This paradoxical result is arguably the study's most significant finding, directly demonstrating that the scientific accuracy of AI tools is highly dependent on prompt sequencing and formulation. It underscores the absolute necessity of "prompt engineering" literacy for students and educators alike, as a slight change in questioning can transform a correct response into a reinforcing misconception.

This result, which is that different AI tools may give different responses to the same prompts, poses a challenge to the reliability of these tools. Therefore, it is crucial to recognize that the objectivity and accuracy of the AI tools depend on the quality of the training data (Mhlanga, 2023). However, regarding the resources used by AI tools, Ding et al. (2023) argued that there is a lack of transparency in how the AI selects and analyzes data. ChatGPT is trained on the existing datasets and relies on the information it receives (Chatterjee & Dethlefs, 2023). Lim et al. (2023) reported that ChatGPT is unable to choose the references to support the information correctly and the responses provided. Unlike other chatbots, Gemini provides references for its responses. It is an important feature that Gemini provides reference information in footnote style at the end of sentences. However, the scientific accuracy and reliability of the references is questionable. This is because she has been observed to use sources such as Wikipedia in her responses. Wikipedia is not a reliable scientific source (Damlı & Kızılcık, 2012).

There are similar comparative studies of AI tools in physics education in literature. For example, when the same prompts were posed to several chatbots, including ChatGPT-4, Bing, and Bard, it was observed that ChatGPT-4 was found to outperform both its predecessor and the other chatbots (dos Santos, 2023). Yeadon and Halliday (2023) observed that while ChatGPT-3.5 and 4 demonstrated competencies in specific tasks, particularly in FCI or essay writing, they were often unreliable when addressing a broader range of physics topics. It has been suggested that ChatGPT-4's performance on introductory physics tasks could be improved by focusing on conceptual tasks that require minimal or no computation and by applying specific prompting techniques (such as providing precise prompts, framing the question more clearly, or asking in a specific context) (Polverini & Gregorcithe, 2024).

Despite these strengths, several studies have raised concerns about the ability of AI tools to monitor complex academic content (Adetayo, 2023; Eysenbach, 2023; Neumann et al., 2023). Chatbots may struggle to grasp the contextual nuances of scientific problems, misinterpret user intent, or provide incomplete and sometimes inaccurate explanations (Clark,2023). ChatGPT may not have the necessary expertise in controversial topics (Souza & Weigang, 2025). Therefore, it may not offer precise and accurate responses.

In addition, one of the biggest criticisms in the responses to the open-ended questions is the system's inability to provide concrete evidence to support its output. When ChatGPT was asked to provide references, it was reported to cite inaccurate or non-existent studies, which is misleading (Cooper, 2023). Elmas et al. (2024) also claimed that ChatGPT's ability to provide scientifically rigorous responses is limited. The overall accuracy of the responses provided by ChatGPT was 85%, and ChatGPT sometimes changed its correct responses to incorrect ones when additional questions were asked (Ding et al., 2023). On the other hand, many students blindly trust ChatGPT’s responses (Ding et al., 2023) without criticizing their accuracy.

This study showed that AI tools have the potential to be a source of misconception in physics education. On the other hand, Kotsis (2024) claimed that the experiments designed by ChatGPT can be used to remediate misconceptions about mechanics. In addition, Demirezen et al. (2023) claimed that they could identify misconceptions about the atom with high accuracy using open-ended questions, aided by an AI-supported machine. Using this method, the researchers claimed to eliminate the biases and errors inherent in expert opinion,

as well as the time required to evaluate the responses of many students, by utilizing machine learning.

Limitations and Suggestions

This study is limited to four popular AI tools (ChatGPT, Gemini, DeepSeek, and Grok) that are chatbots. In addition, this study was designed based on misconceptions of some physics concepts known in literature. In addition to the positive contributions of AI tools in education reported in the literature, they also have negative aspects, such as causing students to develop misconceptions about certain physics concepts, as observed in the results of this study. Considering the importance of AI tools in every field, it has become necessary to acquire AI literacy within the framework of technological literacy. Crucially, given that many students blindly trust AI responses as infallible, educators must urgently integrate AI literacy and critical thinking skills into the curriculum. Future research and pedagogical design should focus on the strategic use of prompt engineering to navigate AI's limitations, ensuring that questions are detailed enough to elicit scientifically accurate and comprehensive responses.

As AI-driven chatbots evolve, they will continue to introduce unique capabilities. Therefore, the results of this study will contribute to the development of AI-based research by highlighting its shortcomings. Studies can be conducted on various physics concepts, misconceptions, and AI tools.

Conclusion

In their responses to the prompts related to mass, all four AI tools confused molarity with mass in one of their definitions. In their responses to the prompts, ChatGPT and Gemini used statements that supported their misconceptions that heat is something that can be stored in matter. Four of them used phrases suggesting that they confused heat and thermal energy. DeepSeek and Grok used statements supporting their misconceptions that capacitors store charge. Therefore, all four AI tools showed the potential to address misconceptions in some way. They may have used similar resources on different topics. However, it is not clear what these sources are, and their accuracy is questionable. The most significant difference is that Grok responded to the definition of mass by considering modern approaches, although it made a mistake about the unit of weight.

AI tools can easily fall into misconceptions that are well-known in literature. In conclusion, this comparative analysis unequivocally finds that despite their advanced capabilities, the examined AI chatbots are far from being a reliable educational resource or scientifically validated resource for addressing or preventing misconceptions in high school physics. Rather than serving as an objective scientific authority, these tools frequently mirror the very misconceptions prevalent in student populations, suggesting they are simply reflecting flawed data within their training sets. Rather than acting as a scientific authority figure, they resemble ordinary students with internet access who can reflect misconceptions.

Statements and Declarations

Acknowledgments/Notes: Not applicable.

During the preparation of this article, the authors used AI tools as part of the study described in the Methods section. All AI-generated outputs were critically reviewed, interpreted, and refined by the research team. Final analytic decisions and theoretical interpretations were made exclusively by the authors.

In addition, generative AI tools were used in a limited capacity to support language clarity and proofreading. After using these tools, the authors carefully reviewed and edited the content as needed and take full responsibility for the accuracy, integrity, and content of the publication.

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Ethics Approval: No human interaction was foreseen in this study. The manuscript has not been submitted to more than one journal for simultaneous consideration. The submitted work is original and has not been published elsewhere.

Informed Consent: In this study, human interaction has not been foreseen. Statement regarding research involving human participants and/or Animals. Human interaction has not been foreseen in this study.

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Appendix A. The Links to AI Tools' Responses to Prompts

- Prompt: What is mass?
- ChatGPT: https://chatgpt.com/share/67d820a7-3fd4-8003-86f1-fc9cd4d24e08
- Gemini: https://g.co/gemini/share/e8169a163e4d
- Grok: https://grok.com/share/bGVnYWN5_4dc3d68f-7177-46a7-848c-732b103f4caf

- Prompt: How do you define the concept of weight?
- ChatGPT: https://chatgpt.com/share/67cd84b1-9bd0-8003-b1e9-58961d94d2e8
- Gemini: https://g.co/gemini/share/d51c1b9c2cd4
- Grok: https://grok.com/share/bGVnYWN5_f9dc0c78-ed41-4051-ab85-c6296ded4eb8

- Prompt: Is weight a vector quantity or a scalar quantity?
- ChatGPT: https://chatgpt.com/share/67d82009-58cc-8003-9090-eb0d6020834d
- Gemini: https://g.co/gemini/share/82fc2af5095d
- Grok: https://grok.com/share/bGVnYWN5_f6412b91-ff3e-4415-a6c9-a9a3c4c7e4fa

- Prompt: What are the differences between the concepts of heat and temperature?
- ChatGPT: https://chatgpt.com/share/67d820d0-467c-8003-bccb-a9d315f4bee0
- Gemini: https://g.co/gemini/share/99461ade6185
- Grok: https://grok.com/share/bGVnYWN5_325e22e8-e9bd-4921-b26d-80d7bd22ad70

- Prompt: What do capacitors store?
- ChatGPT: https://chatgpt.com/share/67d8206c-2944-8003-b62b-dae71cbf4b1d
- Gemini: https://g.co/gemini/share/a85778580366
- Grok: https://grok.com/share/bGVnYWN5_299f5bc0-d64e-4b2d-b59e-01869e688f83

- Prompt: Do capacitors store charge?
- ChatGPT: https://chatgpt.com/share/67d82044-560c-8003-9d6b-c680050c19c6
- Gemini: https://g.co/gemini/share/c9de09f69011
- Grok: https://grok.com/share/bGVnYWN5_00cc37ed-a9a8-43fd-a2d4-580b868ad532

Appendix B. Screenshots of DeepSeek's Responses

- Prompt: What is mass?

What is mass?

Mass is a fundamental property of physical objects that quantifies the amount of matter they contain. It is a measure of an object's resistance to acceleration when a force is applied (inertial mass) and also determines the strength of its gravitational attraction to other objects (gravitational mass). In everyday terms, mass is often conflated with weight, but they are distinct concepts: weight is the force exerted on an object due to gravity and can vary depending on the gravitational field, whereas mass remains constant regardless of location.

The standard unit of mass in the International System of Units (SI) is the kilogram (kg). Mass can be measured using balances and scales, and it plays a crucial role in various physical laws and equations, such as Newton's second law of motion ($F = ma$) and Einstein's theory of relativity ($E = mc^2$).

In summary, mass is an intrinsic property of matter that reflects the quantity of matter in an object and its inertia.

- Prompt: How do you define the concept of weight?

How do you define the concept of weight?

Weight is a measure of the force exerted on an object due to gravity. It is typically quantified as the product of an object's mass and the acceleration due to gravity. The formula for weight is:

$$\text{Weight} = \text{mass} \times \text{acceleration due to gravity}$$

In mathematical terms, this is often expressed as:

$$W = m \times g$$

Where:

- W is the weight,
- m is the mass of the object,
- g is the acceleration due to gravity.

On Earth, the standard acceleration due to gravity is approximately $9.81\ \text{m/s}^2$. Therefore, the weight of an object on Earth can be calculated by multiplying its mass by $9.81\ \text{m/s}^2$.

It's important to note that weight is a force, and its SI unit is the newton (N). In everyday language, people often use the term "weight" to refer to mass, but in physics and engineering, the distinction between mass (a measure of the amount of matter in an object) and weight (the force exerted on that matter by gravity) is crucial.

For example, an object with a mass of 10 kilograms has a weight of approximately 98.1 newtons on Earth:

$$W = 10\ \text{kg} \times 9.81\ \text{m/s}^2 = 98.1\ \text{N}$$

On different celestial bodies, where the acceleration due to gravity differs from that on Earth, the weight of the same object would change, even though its mass remains constant. For instance, on the Moon, where the acceleration due to gravity is about $1.625\ \text{m/s}^2$, the same 10-kilogram object would weigh approximately 16.25 newtons.

- Prompt: Is weight a vector quantity or a scalar quantity?

Is weight a vector quantity or a scalar quantity?

Weight is a **vector quantity**.

Weight is the force exerted on an object due to gravity and is calculated as $\mathbf{W} = m\mathbf{g}$, where:

- m is the mass of the object (a scalar quantity),
- $\mathbf{g}$ is the acceleration due to gravity (a vector quantity, pointing downward toward the center of the Earth).

Since weight has both magnitude (measured in newtons, N) and direction (downward), it is a vector quantity.

- Prompt: What are the differences between the concepts of heat and temperature?

What are the differences between the concepts of heat and temperature?

Heat and temperature are related concepts in thermodynamics, but they refer to different physical quantities and have distinct meanings. Here are the key differences between them:

1. **Definition:**

- **Heat:** Heat is a form of energy transfer between systems or objects due to a temperature difference. It is the energy that flows from a hotter object to a cooler one.
- **Temperature:** Temperature is a measure of the average kinetic energy of the particles (atoms or molecules) in a substance. It indicates how hot or cold an object is.

2. **Nature:**

- **Heat:** Heat is energy in transit. It is not a property of a system but rather a process of energy transfer.
- **Temperature:** Temperature is an intrinsic property of a system. It is a state variable that describes the thermal state of matter.

3. **Units:**

- **Heat:** Heat is measured in joules (J) or calories (cal) in the metric system. It represents the amount of energy transferred.
- **Temperature:** Temperature is measured in degrees Celsius (°C), Kelvin (K), or Fahrenheit (°F). It represents the intensity of heat.

4. **Dependence on Mass:**

- **Heat:** The amount of heat in a system depends on the mass of the substance. For example, a larger amount of water requires more heat to raise its temperature compared to a smaller amount.
- **Temperature:** Temperature does not depend on the mass of the substance. It is an intensive property, meaning it is independent of the quantity of matter.

5. **Direction of Flow:**

- **Heat:** Heat always flows from a region of higher temperature to a region of lower temperature until thermal equilibrium is reached.
- **Temperature:** Temperature does not flow; it is a measure that determines the direction of heat flow.

6. **Example:**

- **Heat:** When you boil water, heat is transferred from the stove to the water, increasing the water's internal energy.
- **Temperature:** The temperature of the water increases as it absorbs heat, and you can measure it using a thermometer.

7. **Mathematical Relationship:**

- **Heat:** The relationship between heat (Q), mass (m), specific heat capacity (c), and temperature change (ΔT) is given by the equation:

$$Q = m \cdot c \cdot \Delta T$$

- **Temperature:** Temperature is a scalar quantity that can be directly measured using a thermometer.

Summary:

- **Heat** is the energy transferred due to a temperature difference.
- **Temperature** is a measure of the average kinetic energy of particles in a substance.

Understanding these differences is crucial in fields like physics, engineering, and environmental science, where heat transfer and temperature regulation play key roles.

- Prompt: What do capacitors store?

What do capacitors store?

Capacitors store electrical energy in the form of an electric field. They consist of two conductive plates separated by an insulating material called a dielectric. When a voltage is applied across the plates, an electric field develops across the dielectric, causing positive charges to accumulate on one plate and negative charges on the other. This separation of charges stores potential energy, which can be released when needed. Capacitors are commonly used in electronic circuits for functions such as filtering, energy storage, and signal processing.

- Prompt: Do capacitors store charge?

Do capacitors store charge?

Yes, capacitors store charge. A capacitor is a passive electronic component that stores electrical energy in an electric field. It consists of two conductive plates separated by an insulating material called a dielectric. When a voltage is applied across the plates, an electric field develops across the dielectric, causing positive charge to accumulate on one plate and negative charge to accumulate on the other plate. This separation of charge stores electrical energy in the capacitor.

The amount of charge Q stored in a capacitor is directly proportional to the voltage V applied across it and is given by the equation:

$$Q = C \times V$$

where:

- Q is the charge stored in coulombs (C),
- C is the capacitance in farads (F),
- V is the voltage across the capacitor in volts (V).

The capacitance C depends on the physical characteristics of the capacitor, such as the area of the plates, the distance between them, and the properties of the dielectric material.

When the voltage is removed, the capacitor can retain the stored charge for a period of time, depending on the leakage resistance of the dielectric and the external circuit. Capacitors are widely used in electronic circuits for various purposes, including energy storage, filtering, and timing applications.