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ChatGPT as Teacher Assistant for Physics Teaching

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Abstract: This study explores the integration of ChatGPT as a teaching assistant in physics education, emphasizing its potential to transform traditional pedagogical approaches. ChatGPT facilitates interactive and inquiry-based learning grounded in constructivist learning theory, allowing students to engage actively in experiments and better grasp abstract concepts through hands-on activities. The AI's adaptive dialogue systems promote socio-constructivist learning by encouraging social inter-action and personalized feedback, which is essential for addressing individual learning gaps and enhancing student engagement. The ability of ChatGPT to simulate real-world physics problems and provide immediate feedback fosters experiential learning, making complex concepts more accessible and promoting critical thinking skills. By offering tailored interventions and adapting to individual learning paces, ChatGPT supports a personalized educational experience that caters to the unique needs of each student. This adaptability is particularly beneficial in physics education, where students often struggle with abstract concepts and require immediate clarification to progress effectively. The paper concludes that the synthesis of generative AI and pedagogy has the potential to reshape science education, fostering deeper understanding and curiosity among students. By leveraging innovative methodologies and augmented data, ChatGPT enriches teacher-student interactions, creating a comprehensive educational experience that promotes a culture of curiosity and exploration, thereby nurturing future scientists and engineers. Ultimately, the integration of ChatGPT into physics education offers a valuable opportunity to enhance student engagement and understanding of scientific concepts through interactive and personalized support.

Keywords: ChatGPT; physics education; interactive learning; AI integration

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1. Introduction

Integrating technology into teaching practices has become increasingly vital in contemporary educational contexts, particularly science education. One innovative approach harnesses the capabilities of artificial intelligence, specifically ChatGPT, to serve as a teaching assistant in physics classrooms. This utilization enhances student engagement through interactive experiments and bridges the gap between abstract theoretical concepts and tangible, hands-on learning experiences. By employing ChatGPT, educators can provide personalized guidance and support tailored to the unique learning styles of individual students, fostering a more inclusive educational environment. The immediate feedback mechanism can stimulate inquiry-based learning (Pishtari et al., 2023), encouraging students to explore, question, and experiment beyond the traditional curriculum boundaries. Thus, the potential of ChatGPT transcends mere in-formation delivery, positioning it as a dynamic facilitator of experiential learning in science education.

Integrating ChatGPT into educational environments, particularly as a teaching assistant for physics, presents a promising avenue for enhancing student engagement and learning outcomes. By leveraging advanced natural language processing capabilities, ChatGPT can interact with students in real-time, offering clarification, responding to queries, and providing tailored feedback on experiments conducted in the classroom (Samara & Kotsis, 2024). This interactive element democratizes access to information and fosters a collaborative learning atmosphere, encouraging students to explore physics concepts inquisitively. The adaptability of ChatGPT allows it to cater to diverse learning styles and paces, ensuring that all students can benefit from its support. While the potential advantages are significant, it is essential to

address inherent limitations, such as the risk of providing misleading information or inadvertently stifling critical thinking skills. These concerns necessitate careful consideration and strategic implementation (Sidiropoulos & Anagnostopoulos, 2024).

Understanding the theoretical framework within which ChatGPT operates as a physics teaching assistant is pivotal for evaluating its efficacy in engaging students. Central to this framework is constructivist learning theory (Bada & Olusegun, 2015), which posits that knowledge is constructed through interactive experiences rather than passively received through traditional instruction. ChatGPT adaptive dialogue systems facilitate this interaction by encouraging students to participate actively in experiments, reflecting that learners better grasp abstract concepts through hands-on activities and inquiry-based learning (Trnova & Trna, 2017). Additionally, socio-constructivist elements within this framework emphasize the importance of social interaction in learning (Ibañez & Pentang, 2021). ChatGPT can simulate peer-to-peer engagement through its conversational capabilities, thus fostering a collaborative learning environment that enhances comprehension and retention (Redish & Vicentini, 2004). Ultimately, grounding the utilization of ChatGPT in these educational theories provides a robust rationale for its integration into physics teaching, highlighting its potential to offer personalized and engaging learning experiences for young students.

This study's research method is a critical review of the existing literature, which includes suggesting uses of ChatGPT in physics teaching. It also discusses the integration of ChatGPT in educational settings, suggesting an exploratory approach to understanding its impact on physics teaching. The focus is leveraging ChatGPT's capabilities to enhance student engagement and understanding through interactive and personalized learning experiences.

2. Capabilities of ChatGPT as a Teaching Assistant

Leveraging ChatGPT as a teaching assistant introduces a transformative approach to pedagogy, especially in science education. By facilitating personalized learning experiences, ChatGPT can adapt its responses to cater to diverse student needs, promoting engagement through interactive dialogues (Abas et al., 2023). This adaptability is critical in maintaining interest in complex subjects such as physics, which often challenges young learners. Furthermore, ChatGPT can assist in designing and executing simple experiments, providing clear, step-by-step instructions that align with age-appropriate learning objectives (Kotsis, 2024a). The immediacy of feedback offered through this technology fosters a dynamic learning environment, enabling students to ask questions and receive answers in real-time. By cultivating inquiry-based learning, ChatGPT supports the development of scientific reasoning skills, ultimately encouraging students to explore and understand fundamental physics concepts in a meaningful context (Kotsis, 2024b). In addition to enhancing student engagement, ChatGPT is a resource for educators, streamlining lesson planning and facilitating differentiated instruction. Teachers can utilize ChatGPT to generate creative experiment ideas that align with curriculum standards, saving valuable time and ensuring that student needs are met effectively. Furthermore, the AI can offer supplementary materials, such as quizzes or discussion prompts, which help to reinforce learned concepts and assess student comprehension (Chen et al., 2023). The potential for ChatGPT to serve as a collaborative partner in the educational process not only supports teachers in fostering curiosity and creativity among students but empowers them to adopt more innovative teaching methods. Thus, ChatGPT contributes significantly to the educational ecosystem by bridging the gap between technology and pedagogy, ultimately enriching the learning experience for both teachers and students (Farley, 2004). The integration of ChatGPT into education stands to reshape how students approach subjects such as physics, instilling a sense of wonder and inquiry from an early age. It invites students to experiment with ideas as an interactive platform, fostering an environment where exploration and creativity are paramount. This ability to stimulate curiosity is essential in physics, which can seem distant or intimidating to young learners. By utilizing ChatGPT to demystify scientific principles through relatable experiments and engaging discussions, educators can cultivate a more profound appreciation for the subject matter (Kotsis, 2024a). Ultimately, the incorporation of ChatGPT as a teaching assistant reflects a commitment to enhancing educational opportunities by leveraging technology to create interactive, supportive, and innovative learning experiences that resonate with the interests and capabilities of students.

The potential for customization in educational contexts has gained substantial traction, mainly through interactive dialogue, which can significantly enhance student engagement and learning outcomes. By utilizing AI-driven dialogue systems like ChatGPT, educators can tailor

learning experiences to individual student's unique needs and interests, fostering an adaptive learning environment (Kotsis, 2024c). This approach mirrors findings from research that underscore the role of dialogic interactions in concept acquisition, whereby adults facilitate learning by engaging with children's interests even when their verbal contributions are limited (Myklebust & Fagerbakke, 2024). Such customization supports higher engagement and cultivates a sense of agency among learners. Furthermore, humor and empathy incorporated into dialogues can make learning more relatable and enjoyable, addressing the emotional dimensions of education, which are often overlooked (Zhai et al., 2024). Thus, integrating interactive dialogue into learning experiences personalizes education and actively motivates students, positioning them as key participants in their learning journeys.

The immediacy of real-time feedback during experiments is essential in enhancing students' learning experience (Alrashidi et al., 2017). By utilizing advanced technologies, such as ChatGPT, educators can offer instant insights that guide students through their exploratory physics experiments. This interactive support facilitates a deeper understanding of complex concepts by allowing learners to address misconceptions as they arise rather than waiting for post-experiment evaluations. For instance, when students observe an unexpected result, immediate feedback can help them analyze their hypothesis and experimental setup effectively, fostering critical thinking skills essential in scientific inquiry. Furthermore, persistent support promotes engagement and reduces frustration, allowing students to develop resilience in overcoming experimental challenges. By merging real-time assistance with hands-on experiments, students not only grasp theoretical concepts more firmly but also cultivate a genuine interest in the scientific process itself, underscoring the transformative potential of technology in education (Walker, 2024).

3. Benefits of the ChatGPT as Teacher Assistant for Physics Education

When the Physics teacher uses the ChatGPT during his teaching, there are several benefits. The following paragraphs describe them.

3.1. ChatGPT Integrates with Hands-on Experiments

Integrating ChatGPT with hands-on experiments in physics education can significantly enhance students' understanding of complex concepts by combining interactive digital tools with experiential learning. This approach leverages artificial intelligence's (AI) strengths in providing personalized, immediate feedback and explanations while maintaining the tangible benefits of hands-on experimentation. Firstly, ChatGPT can serve as an interactive tutor that complements physical experiments (Wang, Burkholder et al., 2024). It can provide real-time explanations and answer students' questions while conducting experiments, helping them understand the underlying physics principles. For instance, when students experiment on gravity, ChatGPT can explain the concept of gravitational force and its effects on different objects, thus reinforcing theoretical knowledge with practical experience (Liang et al., 2023). ChatGPT can facilitate a deeper engagement with the material by encouraging inquiry-based learning. It can prompt students to make predictions, hypothesize outcomes, and reflect on their observations during experiments (Santos, 2023). This aligns with the constructivist approach to learning, where students build knowledge through active exploration and reflection (Lee & Zhai, 2024). ChatGPT can guide students to discover answers independently by asking probing questions and providing hints, fostering critical thinking and problem-solving skills (Kieser et al., 2024). Additionally, ChatGPT can be integrated into the classroom as a tool for differentiated instruction (Kotsis, 2024a). It can adapt its responses based on the individual student's level of under-standing, offering more detailed explanations or simplified concepts as needed. This personalized approach ensures that all students can grasp complex physics concepts effectively, regardless of their initial proficiency (Bruneau et al., 2023). The integration of ChatGPT with hands-on experiments can enhance collaborative learning. Students can work in groups to conduct experiments and use ChatGPT to discuss their findings and interpretations. This collaborative environment encourages peer learning and communication skills as students articulate their understanding and challenge each other's ideas with the support of AI (Bitzenbauer, 2023). However, there are challenges and limitations to consider. The effectiveness of ChatGPT in educational settings depends on the quality of its training data and its ability to provide accurate and contextually appropriate responses. Teachers must ensure that AI is used as a supplementary tool rather than a replacement for human instruction, maintaining a balance between digital and traditional

teaching methods (Kotsis, 2024b; Wang, Burkholder et al., 2024a). In conclusion, integrating ChatGPT with hands-on experiments offers a promising approach to enhancing students' understanding of physics concepts. By providing real-time support, fostering inquiry-based learning, and enabling personalized instruction, ChatGPT can significantly enrich the educational experience. However, careful implementation and ongoing evaluation are essential to maximize its benefits and address potential limitations. This integration supports the development of scientific literacy and prepares students for a future where digital literacy is increasingly important.

3.2. ChatGPT Simulates Virtual Physics Experiments

To effectively simulate virtual physics experiments, ChatGPT can leverage several strategies based on insights from the provided research abstracts. Integrating advanced natural language processing (NLP) capabilities with physics simulation frameworks is crucial. ChatGPT can utilize its NLP strengths to interpret user queries and provide detailed explanations of physics concepts, which is essential for setting up and understanding virtual experiments (Kotsis, 2024a). One approach is incorporating existing physics engines and simulation software into the ChatGPT framework. This integration allows ChatGPT to describe and execute simulations, providing users with interactive and visual representations of physical phenomena. Such a system can enhance learning by allowing users to manipulate variables and observe outcomes in real time, thereby deepening their understanding of complex concepts (Kotsis, 2024b). Moreover, ChatGPT can be programmed to simulate a wide range of physics experiments by accessing a database of pre-defined scenarios and parameters. This capability can be expanded by using machine learning algorithms to predict outcomes based on historical data and user inputs, thus offering personalized and adaptive learning experiences (Hettiarachchilagea & Haldolaarachchige, 2023). Virtual reality (VR) and augmented reality (AR) tech-nologies can further enhance the simulation experience. By integrating these technologies, ChatGPT can provide immersive environments where users can interact with virtual objects and experiments as if they are real, thereby increasing engagement and retention of information (Hettiarachchilagea & Haldolaarachchige, 2023). However, there are limitations to consider. The accuracy of simulations depends heavily on the quality of the underlying physics models and data. Ensuring that these models are up-to-date and validated is essential for reliable simulations. Additionally, the computational resources required for real-time simulations can be significant, necessitating efficient algorithms and cloud-based solutions to manage the load (West, 2023). ChatGPT can effectively simulate virtual physics experiments by integrating NLP with physics engines, utilizing machine learning for adaptive learning, and incorporating VR/AR for immersive experiences. These strategies, while promising, require careful consideration of model accuracy and computational efficiency to ensure effective and reliable simulations.

3.3. The Interactive Features of ChatGPT in Physics Education

ChatGPT can offer a range of interactive features for physics education, enhancing both engagement and understanding among students. One of the primary features is the ability to simulate physics experiments and phenomena, allowing students to visualize complex concepts dynamically and interactively. This capability is highlighted by Kotsis, who emphasizes the potential of AI-driven platforms to create immersive learning environments that can adapt to individual learning paces and styles (Kotsis, 2024b; Kotsis, 2024c). Furthermore, ChatGPT can facilitate personalized learning experiences by providing tailored feedback and explanations based on students' specific queries and misconceptions. This adaptability is crucial in physics education, where students often struggle with abstract concepts and require immediate clarification to progress effectively (Liang et al., 2023). Liang et al. (2023) discuss how AI can identify learning gaps and offer targeted interventions, enhancing learning. Another interactive feature is the integration of problem-solving exercises that can be adjusted in real-time based on student performance. This feature helps reinforce theoretical knowledge and develop critical thinking and problem-solving skills, essential in physics (Santos, 2023). Santos' research (2023) supports using AI in creating adaptive learning paths that respond to student inputs, ensuring that learners remain engaged and challenged at appropriate levels. Moreover, ChatGPT can support collaborative learning by facilitating discussions and group problem-solving activities. This is particularly beneficial in physics education, where peer interaction can lead to deeper under-standing and retention of concepts. Bruneau et al. highlight the role of AI in fostering collaborative environments that encourage students to share ideas and solutions, thus promoting a more interactive and

participatory learning experience (Bruneau et al., 2023). ChatGPT can significantly enhance physics education through interactive simulations, personalized feedback, adaptive problem-solving exercises, and collaborative learning opportunities. These features make learning more engaging and cater to diverse learning needs, ultimately improving educational outcomes in physics.

3.4. The Enhancement of ChatGPT to the Interactive Understanding of Physics Concepts

ChatGPT enhances the understanding of physics concepts interactively by providing a dynamic and engaging learning environment that leverages its natural language processing capabilities. According to Kotsis, ChatGPT can simulate interactive dialogues that allow students to explore physics concepts through question-and-answer sessions, which can help clarify complex ideas and promote deeper understanding (Kotsis, 2024a). This interactive approach is particularly beneficial in physics education, where conceptual understanding is often challenging due to the abstract nature of the subject matter. Furthermore, Mustofa et al. highlight that ChatGPT can serve as a virtual tutor, offering personalized feedback and explanations tailored to the learner's level of understanding (Mustofa et al., 2024). This adaptability ensures that students receive the appropriate level of challenge and support, which is crucial for effective learning. ChatGPT's ability to provide instant feedback and alternative explanations can help students overcome misconceptions and reinforce correct understanding. Kotsis also notes that ChatGPT's interactive capabilities can be integrated into existing educational platforms, enhancing traditional teaching methods with AI-driven interactivity (Kotsis, 2024c). This integration allows for a blended learning experience where students can benefit from human instruction and AI assistance, potentially leading to improved educational outcomes. Kazi and Sayyad's research suggests that using AI tools like ChatGPT in education can increase student engagement and motivation by making learning more interactive and less intimidating (Kazi & Sayyad, 2024). The conversational nature of ChatGPT can reduce the fear of making mistakes, encouraging students to explore and experiment with physics concepts without the pressure of formal assessment. However, Kay points out potential limitations, such as the need for careful moderation to ensure that the information provided by ChatGPT is accurate and aligned with educational standards (Santos, 2023). While ChatGPT can enhance learning, it is essential to complement its use with human oversight to address inaccuracies and provide context-specific guidance. ChatGPT enhances the understanding of physics concepts interactively by offering personalized, engaging, and adaptive learning experiences. Its integration into educational settings can complement traditional teaching methods, although it requires careful implementation to ensure accuracy and effectiveness.

3.5. ChatGPT Creates Personalized Physics Learning Experiences

ChatGPT can potentially create personalized physics learning experiences for students, as evidenced by several research findings. The ability of AI models like ChatGPT to tailor educational content is supported by their capacity to process and generate human-like text, which can be adapted to individual learning needs and preferences. Firstly, the adaptability of AI in educational settings is highlighted by Gouia-Zarrad and Gunn, who discuss the potential of AI to enhance learning by providing personalized feedback and adapting to the learner's pace and style (Gouia-Zarrad & Gunn, 2024). This adaptability is crucial in physics education, where students often require tailored explanations and problem-solving strategies to grasp complex concepts. Moreover, Kotsis emphasizes the role of AI in facilitating interactive learning environments. AI can simulate real-world physics problems, allowing students to engage in experiential learning, a key component of personalized education (Kotsis, 2024b). This inter-active capability can help students understand abstract physics concepts through practical application, enhancing their learning experience. Achour et al. (2024) further support the use of AI in education by highlighting its ability to analyze student performance data to identify learning gaps and provide targeted interventions. This data-driven approach enables ChatGPT to offer personalized learning paths, ensuring that students receive the support they need to overcome specific challenges in physics. However, there are limitations to consider. Adel et al. point out that while AI can offer personalized content, it may lack the nuanced understanding of human educators, particularly in addressing the emotional and motivational aspects of learning (Adel et al., 2024). This limitation suggests that while ChatGPT can enhance personalized learning, it should ideally be used with human educators to provide a comprehensive educational experience. Also, Kotsis notes the importance of continuous updates and improvements to AI models to ensure they remain practical and relevant in

educational contexts (Kotsis, 2024a). This ongoing development is essential for maintaining the quality and personalization of learning experiences provided by ChatGPT. In conclusion, ChatGPT can create personalized physics learning experiences by leveraging its adaptability, interactive capabilities, and data-driven insights. However, its effectiveness is maximized when used alongside human educators and with regular updates to its algorithms.

3.6. ChatGPT Provides Real-time Feedback during Experiments

ChatGPT can provide real-time feedback during experiments in several ways, leveraging its natural language processing and data analysis capabilities. According to Tyni et al., ChatGPT can be integrated into experimental setups to offer immediate responses to user queries, helping researchers troubleshoot issues as they arise. This real-time interaction can enhance the efficiency of experiments by reducing downtime and facilitating a smoother workflow (Tyni et al., 2024). Kotsis highlights that ChatGPT's ability to process and analyze large datasets quickly allows it to offer insights and suggestions based on the data generated during experiments. This capability can be instrumental in identifying patterns or anomalies that may not be immediately apparent to human researchers, thus providing valuable feedback that can guide the direction of ongoing experiments (Kotsis, 2024b). Speer et al. discuss the potential of ChatGPT to assist in hypothesis testing by providing real-time feedback on experimental design and methodology. By evaluating the experimental setup against existing literature and data, ChatGPT can suggest modifications or improvements that could enhance the validity and reliability of the results. This proactive feedback mechanism can be crucial in refining experimental approaches and ensuring robust outcomes (Speer et al., 2024). Zhang et al. emphasize the role of ChatGPT in facilitating collaborative research environments. By acting as a mediator in discussions, ChatGPT can provide real-time feedback that synthesizes input from multiple researchers, helping to align experimental goals and methodologies. This collaborative feedback can lead to more cohesive and coordinated experimental efforts (Zhang et al., 2024). Finally, Cao and Zhong note that ChatGPT can be programmed to monitor experimental parameters continuously, alerting researchers to deviations from expected outcomes. This real-time monitoring and feedback can prevent potential errors and ensure that experiments remain on track, thereby improving the overall quality and reliability of the research process (Cao & Zhong, 2023). ChatGPT's ability to provide real-time feedback during experiments is multifaceted, encompassing troubleshooting, data analysis, hypothesis testing, collaborative facilitation, and continuous monitoring. These capabilities can significantly enhance experimental research's efficiency, accuracy, and collaboration.

3.7. The role of ChatGPT in Facilitating Group Experiments

ChatGPT can significantly facilitate group experiments by enhancing communication, providing real-time data analysis, and supporting collaborative learning environments. According to Kim and Moon, ChatGPT can serve as an interactive tool that aids in the clarification of complex concepts and procedures during group experiments, thereby improving the overall understanding and efficiency of the group's work (Kim & Moon, 2024). This capability is particularly beneficial in educational settings where students may need additional support to grasp experimental methodologies. Cajo-Torres et al. highlight that ChatGPT can be utilized to simulate experimental scenarios, allowing groups to explore various outcomes without needing physical resources. This virtual experimentation can lead to a deeper understanding of the subject matter and foster innovative thinking among participants (Cajo-Torres et al., 2024). The ability to simulate experiments also provides a cost-effective solution for educational institutions with limited resources. Alanezi's research suggests that ChatGPT can facilitate group experiments by mediating discussions and ensuring all group members are engaged and con-tributing to the experiment. This function helps maintain a balanced dialogue and encourages the sharing of diverse perspectives, which is crucial for the success of collaborative experiments (Alanezi, 2024). Additionally, Kipp et al. emphasize the role of ChatGPT in data management and analysis. The AI can assist groups in organizing and interpreting experimental data, providing insights that human participants might overlook. This capability not only speeds up the experimental process but also enhances the accuracy of the results (Kipp et al., 2024). However, Ammu et al. caution that while ChatGPT offers numerous advantages, it is essential to consider the limitations of AI, such as potential biases in data interpretation and the need for human oversight to ensure ethical standards are maintained during experiments (Ammu et al., 2024). Therefore, while ChatGPT can significantly enhance group experiments, it should be used as a complementary tool alongside human expertise to maximize its benefits.

4. Discussion

As we venture into an era increasingly dominated by digital innovation, the transformative potential of technology in education becomes ever more apparent. Integrating artificial intelligence, such as ChatGPT, into the classroom can redefine pedagogical approaches, particularly in subjects like physics, which often pose significant challenges for young learners. By utilizing interactive AI-driven platforms, educators can create a more personalized learning environment that caters to the unique needs of each student, enhancing engagement and understanding. Such technologies enable hands-on experimentation and simulation, allowing students to visualize complex concepts and apply theoretical knowledge to practical scenarios. However, this shift necessitates careful consideration of the implications for teacher training and curriculum development, as educators must be equipped with the skills to effectively incorporate these tools into their teaching strategies. Embracing this technological evolution is crucial for fostering a generation of learners with critical thinking and problem-solving skills essential for future scientific endeavors.

ChatGPT can effectively assist in teaching complex physics concepts to students by leveraging its capabilities as a large language model to enhance engagement, provide personalized feedback, and facilitate a deeper understanding of the subject matter. The integration of ChatGPT in educational settings has shown promising results in improving academic performance and motivation among students, as evidenced by studies where students using ChatGPT and gamification in a physics course outperformed those in a control group, demonstrating increased interest, usefulness, self-efficacy, and active participation (Beltozar-Clemente & Díaz, 2024). ChatGPT's ability to offer real-time assistance, personalized feedback, and dynamic content generation has been highlighted as beneficial in foundational engineering courses. However, caution is advised due to occasional inaccuracies in the results (Rezvani-Rad & Davis, 2024). ChatGPT can help correct students' misconceptions about physics by facilitating experiment-designing activities, which promote critical thinking and a deeper understanding of scientific processes (Kotsis, 2024b). The systematic review of ChatGPT's use in education underscores its potential to improve student engagement and accessibility while addressing challenges such as response quality and bias (Ali et al., 2024). ChatGPT's applications in education include personalized tutoring and research assistance, which have positively impacted various educational audiences (Wang, Li et al., 2024). In physics education specifically, ChatGPT has demonstrated the ability to solve calculation problems, explain solutions, and generate new exercises, thus supporting the learning process at a human level (Liang et al., 2023). ChatGPT has been explored in high school settings for its potential to respond to physics topics effectively, offering insights from both teacher and student perspectives (Bessas et al., 2023). ChatGPT's integration with student-centered pedagogies and ICT has been examined in Vietnamese high schools, highlighting its role in enhancing physics education (Bruneau et al., 2023). Comparative studies of AI-powered chatbots, including ChatGPT, have shown that these tools can foster critical thinking and problem-solving skills. However, human intervention remains necessary to address inconsistencies and ensure effective learning (Santos, 2023). Finally, the development of online physics courses utilizing ChatGPT emphasizes personalized learning experiences, effective feedback, and real-life ap-plications, which contribute to a positive learning environment and improved student performance (Hettiarachchilagea & Haldolaarachchige, 2023). Overall, the most effective strategies for using ChatGPT in teaching complex physics concepts include incorporating it as a personalized learning tool, designing interactive and engaging activities, and combining it with human oversight to ensure accuracy and foster critical thinking.

In advancing the integration of ChatGPT as a physics teaching assistant, further research must prioritize longitudinal studies assessing its impact on student engagement and comprehension over extended periods. Such investigations should examine academic performance and psychological indicators of motivation and curiosity toward physics. Additionally, implementation strategies should emphasize professional development for educators, equipping them with the skills to effectively incorporate AI into their teaching methodologies. This professional training should focus on developing lesson plans strategically by integrating ChatGPT and ensuring that teachers remain learning facilitators rather than mere technology operators. Continuous feedback loops involving educators and students will be crucial in re-fining these strategies, allowing for iterative improvements based on classroom experiences. Ultimately, this approach will foster an educational environment where AI enriches the learning experience, promoting deeper understanding and lasting

enthusiasm for physics among students.

5. Conclusions

In conclusion, integrating ChatGPT as a physics teaching assistant presents a valuable opportunity to enhance student engagement and understanding of scientific concepts through hands-on experiments. The findings suggest that emergent technologies, such as generative AI, can provide unique pedagogical advantages by allowing students to explore fundamental principles in an interactive environment. For example, traditional learning models often rely on static datasets, which may not fully capture the dynamic nature of student reasoning. By leveraging innovative methodologies such as those detailed in (Martin & Graulich, 2024), where teacher-student interactions are enriched through augmented data, we can create a more comprehensive educational experience. Additionally, as noted by (Riemer & Peter, 2024), viewing generative AI through a lens of style rather than strict computation allows for greater creativity in presenting physics concepts. Ultimately, this synthesis of technology and pedagogy has the potential to reshape how science education is delivered, fostering deeper understanding and curiosity.

Incorporating ChatGPT into physics education can significantly enhance the learning experience for students by providing interactive and personalized support. This advanced AI tool facilitates real-time dialogue, allowing students to ask questions and receive immediate feedback on their understanding of complex concepts, such as Newton's laws or the principles of energy transfer. Such immediacy can promote a deeper conceptual grasp, especially for young learners who struggle with traditional instructional methods. Furthermore, ChatGPT can assist in designing experiments tailored to individual student interests, making physics more engaging and approachable. By simulating various experimental scenarios, students can visualize outcomes and better comprehend theoretical concepts, which fosters an inquiry-based learning environment. Ultimately, leveraging ChatGPT enriches the educational framework and pro-motes a culture of curiosity and exploration in physics, essential for nurturing future scientists and engineers.

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