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CHATGPT IN TEACHING PHYSICS HANDS-ON EXPERIMENTS IN PRIMARY SCHOOL

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Abstract:
This study explores the incorporation of artificial intelligence, specifically ChatGPT, to enhance the teaching of physics to primary school students. Using AI-driven simulations and interactive learning activities, the research demonstrates how these tools can convert abstract physics concepts into concrete educational experiences. The results suggest that ChatGPT promotes student involvement, inquisitiveness, and analytical thinking by offering personalized feedback and encouraging practical learning tasks. ChatGPT also significantly contributes to nurturing a positive attitude towards learning physics. ChatGPT helps students overcome the perceived challenges of the subject by providing instant feedback and clarification on physics principles, fostering a more enjoyable learning experience. The investigation underscores the importance of connecting theoretical understanding with real-world application through AI-supported experiments, reinforcing comprehension and nurturing a deeper understanding of the natural world. Additionally, the paper emphasizes the necessity for continuous evaluation of student engagement and academic achievements to gauge the impact of AI in the educational field. This ongoing assessment is crucial for understanding AI's effectiveness in education and making informed decisions about its future use. The study also addresses moral considerations related to data privacy and algorithm biases, highlighting the crucial need for ethical AI deployment in educational contexts. By stressing the importance of ethical AI deployment, the study aims to reassure the audience about the responsible use of technology in education. In conclusion, the study asserts that when integrated thoughtfully, ChatGPT can greatly enhance the educational environment, making physics more accessible and enjoyable for young students while preparing them for future scientific pursuits.

Keywords: ChatGPT, primary school, physics education, hands-on experiments

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1. Introduction

Technology integration in educational settings has transformed traditional pedagogical approaches, particularly in science education (Barak, 2017). With the emergence of intelligent tools, educators are increasingly exploring innovative methods to convey complex concepts effectively. One significant advancement in this domain is using AI-driven platforms like ChatGPT, which offer an interactive and adaptive learning experience (Rasul *et al.*, 2023). These tools are particularly potent in teaching hands-on physics, a subject often perceived as challenging due to its abstract principles and mathematical foundations. By leveraging ChatGPT, instructors can facilitate deeper student engagement, create tailored learning experiences, and promote active problem-solving skills, fostering a more comprehensive understanding of physics. The role of ChatGPT in promoting active problem-solving skills is particularly noteworthy, as it equips students with practical skills essential for understanding and applying physics concepts. Moreover, the application of ChatGPT in primary school settings presents unique opportunities to bridge the gap between theoretical knowledge and practical application (Javaid *et al.*, 2023). Children, often naturally curious and eager to experiment, benefit from guided interactions with AI that encourage exploration and inquiry (Zimmerman, 2018). ChatGPT can provide instant feedback and clarification on physics principles through simulative dialogues or structured problem-solving scenarios, enabling young learners to engage in experimentation and discovery. This immediate support enhances their comprehension and nurtures a positive attitude towards learning physics. Consequently, the role of ChatGPT extends beyond mere information dissemination; it catalyzes the development of student's critical thinking and collaborative skills (Opara *et al.*, 2023). Ultimately, the integration of ChatGPT into hands-on physics education in primary schools underscores the necessity of evolving teaching methodologies to include digital advancements. As classroom environments become increasingly hybridized, the potential of AI assistants to transform how physics is taught becomes more pronounced. By combining the strengths of technology with pedagogical expertise, educators can create rich, interactive learning experiences that cater to diverse learning styles (Bizami *et al.*, 2023). In this light, ChatGPT enhances the teaching and learning of physics and prepares students for a future where technology and physics are inextricably linked. The following sections will explore specific methodologies, case studies, and empirical research that highlight the effectiveness of this approach. Policymakers must understand the importance of continuous evaluation of student engagement and academic achievements to gauge the impact of AI in the educational field, making them feel informed and responsible for their decisions.

Incorporating hands-on learning into primary education is a crucial pedagogical strategy, as it fosters active engagement and enhances cognitive development in young learners (Yannier *et al.*, 2021). This experiential approach enables students to grasp complex scientific concepts more effectively through direct manipulation and experimentation. Research indicates that when students interact with materials, they reinforce theoretical knowledge (Altmeyer *et al.*, 2020) and develop critical thinking and

problem-solving skills (Sinaga *et al.*, 2022), essential for future academic success. Moreover, hands-on learning caters to diverse learning styles, making physics accessible to all students and encouraging participation from those struggling with traditional, lecture-based methods (Shrestha *et al.*, 2023). Applying such interactive techniques cultivates a sense of curiosity and confidence in students, equipping them with the necessary tools to explore and understand the world around them. Thus, embracing hands-on learning practices in primary education is imperative to develop well-rounded, scientifically literate individuals.

As educational paradigms shift towards more technology-integrated methodologies, tools like ChatGPT have emerged as promising resources for enhancing learning experiences (Yu, 2023). This AI-based platform is an interactive assistant that responds to student inquiries, facilitates discussions, and comprehensively explains complex concepts in real-time (Atlas, 2023). ChatGPT can bridge the gap between theoretical understanding and practical application (Ali *et al.*, 2023) in teaching hands-on physics to primary school students, making fundamental principles more accessible and engaging. Its adaptability allows educators to tailor interactions based on individual learning styles and levels, fostering a more inclusive environment. The ability of ChatGPT to generate simulations and hypothetical scenarios further supports experiential learning, enabling students to visualize physics phenomena they may not encounter in traditional hands-on environments. Additionally, the continuous feedback loop created through dialogue with ChatGPT encourages critical thinking and deeper exploration of scientific ideas (Streit-Bianchi *et al.*, 2023).

The integration of ChatGPT in teaching physics catalyzes the development of innovative pedagogical strategies that foster deeper student engagement and understanding. By leveraging the capabilities of this AI-driven platform, educators can personalize learning experiences, offering real-time assistance and tailored explanations that address the diverse needs of primary school students (Kotsis, 2024a). This individualized approach enhances comprehension of complex concepts and encourages curiosity and exploration in hands-on physics activities. The significance of such integration extends beyond mere support; it aligns with contemporary educational paradigms that emphasize the importance of technology in learning environments, particularly in promoting interactive and experiential learning. Moreover, as educational stakeholders increasingly recognize the value of digital tools, incorporating ChatGPT can facilitate a shift toward more effective project management and knowledge management in teaching practices, ultimately leading to improved outcomes in students' scientific literacy (Ananikov, 2024).

2. Research Method

The paper employs various methods to explore the integration of ChatGPT in primary physics education. One primary method is using case studies and empirical research to highlight the effectiveness of AI in enhancing student engagement and comprehension. These case studies provide real-world examples of how ChatGPT can be utilized in

classroom settings to support interactive and personalized learning experiences. Another method involves using simulations to enhance conceptual understanding. By employing ChatGPT to produce virtual experiments or scenarios, educators can create immersive learning opportunities that allow students to engage directly with the subject. This hands-on approach promotes active involvement and cultivates an inquiry-driven educational setting, empowering students to investigate and test hypotheses.

Overall, this paper's methods emphasize combining empirical research, interactive simulations, and continuous assessment to evaluate ChatGPT's impact on primary physics education. These approaches aim to create a more effective and inclusive educational framework that leverages AI to support diverse learning styles and enhance student outcomes.

3. The Role of ChatGPT in Enhancing Engagement

Effective primary school physics teaching demands engagement strategies catering to diverse learning styles (Pashler *et al.*, 2009). The integration of ChatGPT in this context serves as a dynamic tool to promote interactive learning environments, enhancing student engagement considerably (Rasul *et al.*, 2023). ChatGPT encourages students to explore physics concepts through inquiry-driven approaches by facilitating real-time dialogue and feedback, fostering a sense of curiosity and inherent motivation to learn. As students interact with the AI, they can ask questions, seek clarifications, and even participate in simulated problem-solving scenarios that reflect real-world applications of physics principles (Chou *et al.*, 2023). This adaptive learning experience nurtures critical thinking and allows educators to tailor their instruction based on individual student needs, creating more personalized learning pathways. Ultimately, ChatGPT's role in the classroom transcends mere content delivery (Hammer, 2024); it reinvigorates student interest and participation in hands-on physics, underscoring its potential as a transformative educational technology in primary education.

The integration of ChatGPT into primary school physics education facilitates interactive learning experiences that engage students on multiple levels. By leveraging its capabilities, instructors can customize learning materials and respond dynamically to students' inquiries, fostering an environment where curiosity and exploration thrive. Data suggest students exhibit high behavioral and cognitive engagement when using AI text revision tools. This indicates that similar methodologies can be employed in a hands-on physics context, where instant feedback can enhance understanding (Koltovskaia *et al.*, 2024). Furthermore, the sentiment analysis from studies highlights a predominance of positive attitudes toward AI tools in educational settings, underscoring ChatGPT’s potential to enrich learning experiences (Gunawan *et al.*, 2024). This interplay between technology and pedagogy allows for personalized learning trajectories, enabling educators to cater to individual student needs while promoting collaborative learning through interactive simulations and quizzes. As a result,

ChatGPT serves not only to enhance content delivery but also to cultivate critical thinking and problem-solving skills essential in scientific inquiry.

A significant benefit of employing adaptive responses in educational settings is facilitating personalized learning experiences, which can enhance student engagement and comprehension. By leveraging technology like ChatGPT, educators can tailor instructional strategies to meet individual students' needs, adjusting content and complexity in real-time based on their performance and feedback (ElSayary, 2024). This adaptability addresses diverse learning styles and empowers students to take ownership of their educational journeys, fostering a sense of agency and motivation. Tailored responses can remediate knowledge gaps while challenging advanced learners to push their boundaries. Furthermore, this personalized approach resonates with contemporary pedagogical theories that advocate for student-centered learning environments, wherein the timing and nature of instruction are calibrated to each learner's unique context and pace, thus promoting iterative feedback loops that enhance learning outcomes (Yu *et al.*, 2023). Ultimately, adaptive personalization in learning fosters a more inclusive educational landscape, better preparing students for the complexities of modern problem-solving.

Fostering a spirit of curiosity and exploration in young learners is essential for cultivating their intrinsic motivation and enhancing their engagement in hands-on physics activities (Ostroff, 2016). Developing a classroom environment that encourages inquisitive thinking facilitates students' natural desire to explore the world around them, making complex concepts more approachable and relatable. Interactive demonstrations, guided experiments, and open-ended questions can catalyze this exploration, prompting students to engage deeply with the subject matter. Using tools like ChatGPT, educators can tailor their instructional approaches to address individual learners' curiosities, guiding them to discover physics principles through inquiry-based learning. This method promotes critical thinking and nurtures a collaborative spirit among students, allowing them to learn from one another while pursuing their interests in a supportive atmosphere. Ultimately, this approach lays the groundwork for lifelong curiosity and adaptability in various academic and real-world contexts (Wu *et al.*, 2018).

4. Implementing ChatGPT in Hands-On Physics Activities

Integrating ChatGPT into hands-on physics activities provides educators with an innovative tool that enhances students' exploratory learning experiences. By harnessing generative AI's ability to simulate complex scenarios and respond to diverse queries, instructors can significantly improve student engagement and comprehension in physics. For instance, when students encounter challenges in understanding concepts such as forces or motion, ChatGPT can offer tailored explanations or suggest experiments that reinforce theoretical knowledge through practical application (Kotsis, 2024b). This aligns with the findings from (Hostetter *et al.*, 2024), which suggest chatbots can effectively deliver critical information in technical fields, potentially revolutionizing educational practices. Furthermore, as generative AI adjusts responses

based on patterns in student interactions, it fosters a responsive learning environment, facilitating immediate feedback. Ultimately, implementing ChatGPT in these activities enriches the learning process and prepares students for a future where technology plays an essential role in scientific inquiry.

The integration of ChatGPT in designing physics experiments ushers in innovative methodologies that enhance experiential learning in primary education. By leveraging ChatGPT's capabilities, educators can develop hands-on experiments that are engaging and tailored to young learners' cognitive levels (Kotsis, 2024c). This generative AI can assist in formulating experiment outlines, predicting outcomes, and suggesting modifications based on student responses or observed results. Moreover, as machines learn and encode patterns from vast datasets, they can inspire creative approaches to physics problems that align with concepts like chair-ness or cat-ness (Riemer & Peter, 2024). This encourages students to explore physics through creativity and inquiry, forming a robust learning experience that aligns with digital tools and fostering innovation in educational practices (Ananikov, 2024). Ultimately, ChatGPT facilitates a dynamic blend of tradition and technology, making hands-on physics education more accessible and impactful for primary school students.

In conducting hands-on experiments in primary school physics, implementing real-time problem-solving and guidance can significantly enhance the learning experience. Educators and students often encounter unexpected challenges during practical tasks, inhibiting their understanding of fundamental concepts. By integrating responsive tools like ChatGPT, learners benefit from immediate access to guidance that addresses specific queries or confusion arising during experiments (Graefen & Fazal, 2024). This interactive support assists in troubleshooting and encourages critical thinking, allowing students to explore alternative solutions and deepen their grasp of scientific methods. Moreover, such assistance fosters a collaborative learning environment where students feel empowered to engage with the material actively. As they navigate challenges in real-time, the immediacy of support from AI tools facilitates a more dynamic and responsive educational experience, which is essential for cultivating scientific inquiry and innovation in young learners (Pedro *et al.*, 2019).

An effective feedback mechanism is essential in fostering an environment conducive to enhanced student understanding, particularly in hands-on learning scenarios like those encountered in primary school physics. By leveraging real-time feedback, educators can assess students' comprehension levels and provide immediate, constructive critiques that guide their learning processes. This form of feedback not only aids in correcting misconceptions but also reinforces positive learning behaviors, thereby promoting a growth mindset (Kotsis, 2024c). Furthermore, integrating tools like ChatGPT can facilitate personalized learning experiences, allowing teachers to tailor their feedback based on individual student needs and learning styles. This adaptability is crucial, empowering learners to engage actively with the material and leading to deeper cognitive connections. Ultimately, incorporating structured feedback systems within primary education can significantly enhance students' conceptual grasp of

physics, preparing them for more complex scientific understanding in later years (Leelavathi & Surendhranatha, 2024).

5. Methods for utilizing the ChatGPT within Physics Education

5.1 Enhancing Conceptual Understanding Through Simulations

Enhancing conceptual understanding through simulations is a key element of effective physics education, especially for primary school students grappling with abstract concepts. Simulations provide a dynamic platform that allows learners to visualize and manipulate physical phenomena, making these abstract concepts more tangible. ChatGPT is an invaluable tool in this context, providing interactive simulations that facilitate deeper comprehension of fundamental principles such as force, motion, energy, and matter.

By employing ChatGPT to produce virtual experiments or scenarios, educators can craft immersive learning opportunities that allow students to directly engage with the subject matter. To illustrate, instead of simply reading about the principles of Newton's laws of motion, students could partake in a simulation in which they manipulate variables like mass and acceleration to observe immediate alterations in motion. This hands-on method promotes active involvement and cultivates an inquiry-driven educational setting that empowers students to investigate and test hypotheses.

Moreover, the adaptability of AI-powered simulations allows for differentiated instruction tailored to individual student needs. ChatGPT can provide personalized feedback and alternative explanations based on each student's interactions within the simulation as learners progress at varying paces and possess diverse backgrounds in physics concepts. This responsiveness enhances conceptual understanding by addressing misconceptions promptly and guiding learners toward accurate interpretations.

Furthermore, simulations enable educators to bridge the gap between theoretical knowledge and practical application. By engaging in simulated experiments that mimic real-world situations—such as calculating trajectories or exploring energy transformations—students develop critical thinking skills essential for scientific inquiry. The experiential nature of these simulations not only solidifies understanding but also cultivates curiosity about the physical world.

Enhancing conceptual understanding through simulations facilitated by ChatGPT holds significant promise for primary school physics education. By transforming abstract ideas into tangible experiences, AI-generated simulations promote engagement while catering to diverse learning styles. Educators embracing this innovative approach can foster a more profound appreciation for physics among young learners while equipping them with essential skills for future scientific endeavors.

5.2 Interactive Learning: ChatGPT as a Teaching Assistant

The role of ChatGPT as a teaching assistant in primary school physics education offers a transformative approach to interactive learning. By leveraging its natural language processing capabilities, ChatGPT can engage students in real-time dialogue, responding to their inquiries and clarifying complex concepts. This interaction reinforces the material and encourages students to participate actively in their learning journey. The ability of ChatGPT to simulate conversations with a knowledgeable assistant creates an environment where students feel comfortable asking questions—an essential component of effective learning.

An important benefit of utilizing ChatGPT as a teaching aide is its ability to offer personalized assistance. Each student brings a distinct set of existing knowledge and varying degrees of comprehension; thus, the artificial intelligence can adjust its feedback according to individual requirements. For instance, in cases where a student encounters challenges in comprehending the concept of gravity, ChatGPT can deliver customized explanations or analogies that are more closely aligned with that student's own experiences or areas of interest. This level of personalization empowers learners to grasp intricate subjects at their speed, promoting self-assurance and stimulating deeper investigation.

Moreover, ChatGPT can facilitate collaborative learning experiences among peers by prompting discussions or guiding group activities related to physics experiments. Posing thought-provoking questions or suggesting hypotheses for experimentation encourages critical thinking and teamwork among students. Such interactions enhance comprehension and develop essential soft skills like communication and collaboration—skills increasingly recognized as vital in modern education.

Additionally, the availability of an AI-powered teaching assistant can alleviate some pressure from educators who may struggle to address every student's question during limited class time. With ChatGPT available for support outside traditional classroom hours, students can access continuous assistance that promotes ongoing engagement with physics concepts beyond scheduled lessons.

Integrating ChatGPT as a teaching assistant within primary school physics education significantly enhances interactive learning opportunities. Its ability to personalize instruction, foster collaboration among peers, and provide consistent support empowers young learners while enriching their educational experience in science. As educators harness this technology's potential, they pave the way for innovative pedagogical practices that resonate well with today's digitally savvy generation.

5.3 Designing Engaging Physics Experiments with AI

Designing engaging physics experiments with artificial intelligence, mainly through tools like ChatGPT, offers a transformative approach to primary school education (Kotsis, 2024b). By leveraging AI's capabilities, educators can create experiments that captivate students' attention and foster a deeper understanding of fundamental physics concepts. One significant advantage of using AI in experiment design is its ability to

generate diverse and innovative experimental scenarios that align with curriculum standards while catering to the interests and curiosities of young learners.

ChatGPT can assist educators in brainstorming creative, experimental setups that incorporate real-world applications of physics principles. For example, rather than conducting traditional experiments focused solely on textbook examples, teachers could collaborate with ChatGPT to develop projects that explore topics such as renewable energy or the physics behind sports. By contextualizing physics within familiar and relevant frameworks, students are more likely to engage deeply with the material and appreciate its practical significance.

Furthermore, AI can facilitate iterative experimentation by providing instant feedback on student-designed experiments. As students hypothesize and test their ideas, they can interact with ChatGPT to refine their approaches based on preliminary results or unexpected outcomes. This dynamic interaction encourages a scientific mindset characterized by inquiry and adaptability—critical components of effective learning in science education.

Moreover, integrating AI into the experiment design allows for differentiation tailored to various learning styles in any classroom. ChatGPT can suggest modifications or alternative methods for conducting experiments based on individual student needs or preferences, such as offering visual aids for visual learners or step-by-step instructions for those who require more structured guidance. Such customization ensures that all students are actively involved in hands-on learning experiences regardless of their prior knowledge or comfort level with scientific inquiry.

Designing engaging physics experiments through AI tools like ChatGPT enriches primary school education by fostering creativity and adaptability while addressing diverse learning needs. As educators embrace these innovative methodologies, they cultivate an environment where young learners can thrive as inquisitive scientists capable of exploring the physical world around them.

5.4 Addressing Diverse Learning Styles in Physics

Addressing a variety of learning styles within the realm of physics education is fundamental to cultivating an inclusive and efficient learning atmosphere (Kotsis, 2024d). Elementary school pupils demonstrate a broad spectrum of learning preferences, which can profoundly influence their involvement and comprehension of intricate scientific principles. By employing artificial intelligence tools like ChatGPT, educators can customize instruction to cater to these diverse requirements, ultimately enriching the educational journey in physics.

Integrating ChatGPT into physics teaching offers a principal benefit in its capacity to deliver individualized assistance that caters to distinct learning styles. For example, visual learners could benefit from simulations and visual representations produced by ChatGPT, enabling them to conceptualize abstract notions like force or energy transmission. Conversely, auditory learners might interact more effectively through dynamic conversations with the AI, enabling them to answer queries and

obtain clarifications promptly. This flexibility guarantees all students can access materials aligned with their favored learning modes.

Moreover, AI-assisted experiment design can also cater to kinesthetic learners—who thrive on hands-on experiences. ChatGPT can suggest practical activities or experiments that align with curricular goals while appealing to students who learn best through tactile engagement. By proposing modifications or alternative approaches based on individual student preferences, educators can create opportunities for active participation that enhance comprehension and retention.

Addressing diverse learning styles also involves recognizing students' varying levels of prior knowledge. Some may have a foundational understanding of certain physics principles, while others struggle with basic concepts. ChatGPT's capacity for differentiation allows it to provide targeted feedback and tailored explanations based on each student's unique background and progress within the subject matter. This responsiveness clarifies misunderstandings and empowers students by reinforcing their strengths.

Leveraging AI tools like ChatGPT in primary school physics education presents a significant opportunity to effectively address diverse learning styles. By personalizing instruction through visual aids, interactive dialogue, and hands-on experimentation suggestions, educators can create an inclusive atmosphere where every student has the potential to thrive academically in their exploration of physics concepts. Embracing this approach enhances engagement and fosters a deeper appreciation for science among young learners.

6. Assessing Student Engagement and Outcomes

Assessing student engagement and outcomes in utilizing ChatGPT as a tool for teaching physics through experiments is crucial for understanding its effectiveness as an educational resource. Integrating AI into the classroom transforms instructional practices and necessitates a robust framework for evaluating its impact on student learning. This assessment can be approached through various metrics, including qualitative observations, quantitative data, and feedback mechanisms (Parsons & Taylor, 2011).

Educators can use direct and indirect measures to gauge student engagement (D'Mello *et al.*, 2017). Observational strategies such as monitoring student participation during interactive sessions with ChatGPT can provide insights into their level of interest and involvement. For instance, tracking how often students pose questions or seek clarification from the AI can indicate their curiosity and willingness to engage with complex concepts (Ramprakash *et al.*, 2024). Tools like surveys or questionnaires administered post-interaction can also solicit students' perceptions of their learning experiences, offering valuable qualitative data regarding engagement (Hadi Mogavi *et al.*, 2023).

Moreover, assessing academic outcomes requires analyzing performance indicators that reflect students' understanding of physics concepts. Pre- and post-

assessment tests can be utilized to measure knowledge gains attributable to using ChatGPT in experimental learning contexts. These assessments should focus not only on rote memorization but also on conceptual understanding. In this area, AI-assisted simulations may significantly enhance comprehension by allowing students to visualize and experiment with physical phenomena.

Furthermore, it is essential to consider the diverse backgrounds and learning styles present within primary school classrooms when interpreting assessment results. Engaging all learners means recognizing that some may excel while others struggle despite similar exposure to AI tools (Long & Magerko, 2020). Therefore, disaggregating data based on demographic factors or prior knowledge levels could yield more profound insights into how effectively ChatGPT meets varied educational needs.

Ultimately, a comprehensive approach to assessing student engagement and outcomes will illuminate the potential benefits and limitations of integrating AI into physics education. By systematically evaluating qualitative experiences and quantitative achievements, educators can make informed decisions about continuing or adjusting their pedagogical strategies involving tools like ChatGPT in pursuit of enhanced learning environments for young physicists.

7. Discussion

As the integration of artificial intelligence (AI) continues to transform educational landscapes, future research must focus on harnessing its potential to enhance pedagogical practices, particularly in primary education. Investigating the efficacy of AI-driven tools in fostering conceptual understanding of complex subjects, such as physics, will be essential for refining instructional strategies and ensuring accessibility for diverse learning styles. Furthermore, exploring the ethical implications and biases inherent in AI applications is crucial; addressing these issues will promote equitable learning environments and safeguard student well-being. Research should also examine the long-term impact of AI on students' critical thinking skills and problem-solving abilities, ensuring that technological advancements complement foundational pedagogical principles rather than undermine them. Ultimately, a collaborative approach engaging educators, technologists, and policymakers will be necessary to create robust frameworks that facilitate meaningful AI applications in education, paving the way for a future where technology supports—and not supplants—human ingenuity in teaching and learning (Miao *et al.*, 2021).

The integration of ChatGPT into primary physics education holds remarkable potential to revolutionize how young learners engage with complex concepts. By offering real-time responses and personalized explanations, the AI can serve as both an assistant and a tutor, catering to diverse learning styles and paces. This adaptability fosters a deeper understanding of physics principles through interactive dialogue and stimulates curiosity and critical thinking in students. Furthermore, the accessibility of such technology can bridge gaps in resource availability, enabling educators to implement innovative, hands-on experiments that might otherwise remain unfeasible in

underfunded classrooms. As we contemplate the future of educational methodologies, the role of AI tools like ChatGPT must not merely be seen as supplementary; instead, they should be embraced as integral components of a holistic educational framework aimed at nurturing scientifically literate and inquisitive citizens. Ultimately, the transformative impact of ChatGPT in primary physics education appears promising and necessary for developing a generation of engaged learners.

8. Ethical Considerations of AI in Education

The ethical considerations surrounding using artificial intelligence in education are paramount, particularly when employing tools like ChatGPT in primary school physics instruction. As AI technologies become increasingly integrated into educational practices, addressing potential ethical dilemmas arising from their implementation is essential.

One significant concern is data privacy and security. Students interacting with AI systems often share personal information and learning behaviors. To protect students' privacy rights, it is crucial to ensure that this data is handled responsibly, stored securely, and used solely for educational purposes. Educators must be vigilant in selecting AI tools that comply with relevant regulations and prioritize student confidentiality. This responsibility extends to informing parents about how their children's data will be utilized and ensuring transparency in data management practices.

Another ethical consideration pertains to the potential bias embedded within AI algorithms. These technologies can inadvertently perpetuate existing biases or inequalities in training datasets if not carefully monitored. For example, suppose an AI tool has been trained predominantly on a specific demographic's responses or learning styles. In that case, it may not adequately cater to diverse learners from different backgrounds or abilities. This could result in inequitable learning experiences where certain groups are disadvantaged or misrepresented. To mitigate this risk, educators should critically evaluate the sources of training data for AI systems and advocate for continuous updates that reflect a broad spectrum of perspectives.

Additionally, reliance on AI as a teaching assistant raises questions about the role of human educators in the classroom. While ChatGPT can enhance instructional methods through personalized support and interactive engagement, there remains a risk that teachers might over-rely on such tools at the expense of their professional judgment and interpersonal connections with students. The importance of fostering meaningful relationships between educators and learners cannot be understated; therefore, it is imperative to balance leveraging technology for efficiency and maintaining essential human elements within education.

As educators explore the integration of ChatGPT into primary school physics instruction, they must navigate complex ethical considerations involving data privacy, algorithmic bias, and the preservation of teacher-student relationships. Addressing

these issues proactively will ensure that AI is an equitable tool for enhancing educational outcomes rather than compromising them.

9. Suggestions for Future Research

Future research should focus on the long-term impact of AI tools like ChatGPT on students' critical thinking skills and problem-solving abilities. It is essential to ensure that these technological advancements complement foundational pedagogical principles rather than undermine them. Longitudinal studies could provide insights into how sustained use of AI influences the development of these crucial skills over time.

Another critical area for future research is investigating the efficacy of AI-driven tools in fostering a conceptual understanding of complex subjects, such as physics. This includes examining how AI can enhance students' ability to think critically about scientific concepts and apply them in various contexts. Such research will help refine instructional strategies and ensure accessibility for diverse learning styles.

Exploring the ethical implications and inherent biases in AI applications is crucial for promoting equitable learning environments. Future research should address how these biases might affect the development of critical thinking skills and propose solutions to mitigate any negative impacts. This will help safeguard student well-being and ensure that AI tools are used responsibly in educational settings.

A collaborative approach involving educators, technologists, and policymakers is necessary to create robust frameworks for meaningful AI applications in education. Future research should explore how these stakeholders can work together to develop and implement AI tools that support, rather than supplant, human ingenuity in teaching and learning. This collaboration will be vital for fostering critical thinking skills in students.

Finally, continuous evaluation of student engagement and academic achievements is essential to gauge AI's impact on critical thinking. Ongoing assessments will provide valuable data on the effectiveness of AI tools and inform decisions about their future use in education. This will ensure that AI integration remains beneficial and aligned with educational goals.

In summary, future research on critical thinking should focus on AI's long-term impact, the efficacy of AI-driven tools, ethical implications, collaborative approaches, and continuous evaluation. These areas will help ensure that AI tools like ChatGPT enhance rather than hinder students' development of critical thinking skills.

10. Conclusion

The incorporation of ChatGPT into the delivery of hands-on physics education at the elementary level signifies a novel amalgamation of technology and educational methodology. This methodology effectively involves students and encourages a profound comprehension of intricate ideas through interactive conversations and

personalized learning encounters. Through artificial intelligence, instructors can customize teaching methods to cater to various student needs, thus allowing all students to investigate scientific occurrences in manners that align with their individual learning preferences. Moreover, the capability to replicate authentic situations heightens students' analytical thinking and problem-solving abilities, which are fundamental elements of comprehensive physics instruction. This investigation suggests that with a deliberate implementation, ChatGPT can notably enhance the educational setting, rendering physics more attainable and pleasurable for young students.

In conclusion, as educational technology evolves, embracing tools like ChatGPT offers a transformative pathway toward a more effective and inclusive physics education framework (Fazio & Logman, 2024). In addition, the integration of ChatGPT in teaching hands-on physics in primary school revealed several transformative outcomes, particularly in enhancing student engagement and comprehension of complex concepts. Key findings indicate that students exhibited increased motivation and enthusiasm for physics when interacting with ChatGPT, which provided instant feedback and tailored explanations. This personalized approach facilitated a deeper understanding of the material and fostered a collaborative learning environment, allowing students to explore ideas more freely and creatively. Furthermore, educators noted a significant reduction in the time required to address conceptual misunderstandings, as the AI effectively clarified challenging topics in real time. The implications of these findings suggest that incorporating AI tools in educational settings can revolutionize teaching methodologies, promoting an inquiry-based approach that prioritizes student agency and critical thinking. Continued exploration into the relationship between AI and pedagogical practices could yield even more significant advancements in educational efficacy.

Conflict of Interest Statement

The author declares no conflicts of interest.

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