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Making a revolution in physics learning in high schools with ChatGPT: A case study in UAE

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Abstract

This study aims to investigate the impact of ChatGPT on enhancing the learning outcomes and academic performance of high school students in physics, specifically focusing on its role in aiding the understanding of challenging topics such as Newton's second law of motion. This study employs a quasi-experimental quantitative methodology that involves two groups from different schools in the United Arab Emirates (UAE) and comprises both genders of students. The research findings reveal that ChatGPT has significantly improved the academic performance of both male and female students, with a slightly greater improvement observed among the latter, as indicated by the pre-test and post-test scores. Moreover, the experiments demonstrate high student engagement and interaction, which have improved their learning and achievements. The contributions and implications for research and practical applications are highlighted and discussed.

Keywords: ChatGPT, physics, education, learning, high school, UAE

INTRODUCTION

According to previous studies, many students find physics difficult because of the intricate concepts and mathematical calculations involved in its study (Ayasrah et al., 2024; Erfan & Ratu, 2018; Radlovi-Ubrilo et al., 2014; Stern et al., 2017). Many students struggle to comprehend the material and may require additional assistance to succeed in class (AlArabi et al., 2022b). According to Roth and Roychoudhury (1993), a primary objective of physics education is to equip students with the knowledge necessary to apply physics concepts and principles for solving problems and developing an understanding of the universe. However, in some research findings, students have trouble comprehending the fundamentals of physics, including the notions about force, acceleration, displacement, and the acceleration of gravity (AlArabi et al., 2022a; Rahman & Watanobe, 2023; Şahin & Yağbasan, 2012). One of the cited reasons that most students struggle to understand Newton's second law of motion (NSLOM) is its dependence on the aforementioned elements. According to AlAbidi et al. (2023b), NSLOM states that an object's acceleration (a) is directly proportional to the net force (F) acting on it and inversely proportional to its mass (m). The equation $F = m.a$ expresses this relationship. Notably, most physics students have misconceptions about complex topics such as NSLOM, which makes ChatGPT a crucial tool that can potentially redress this misconception (AlArabi et al., 2022b). Several industries, including education, have recently incorporated artificial intelligence (AI). A cutting-edge tool has diverged from it called ChatGPT, an AI language model that produces human-like responses to questions (Adiguzel et al., 2023; Dergaa et al., 2023). Open AI created ChatGPT, an abbreviation for chat generative pre-trained transformer, a general-purpose conversation chatbot (AlAbidi et al., 2023a;

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Contribution to the literature

- It focuses on ChatGPT role in aiding students' understanding of challenging topics like NSLOM.
- It examines how ChatGPT enhances students' learning outcomes and academic performance in physics.
- The ChatGPT program is significantly improving academic performance, student engagement, and interaction, which leads to an improvement in learning and achievement.

Baidoo-Anu & Owusu, 2023; Gilson, 2023). There are already many industrial applications for GPT models. However, research confirms that using chatbots in teaching settings is still in its early stages (Hwang & Chang, 2021; Smutny & Schreiberova, 2020). Nevertheless, the field of physics education is in an excellent position to investigate the functionality and applications of ChatGPT and other AI systems (AlAbidi et al., 2023a; Alneyadi & Wardat, 2023; Bitzenbauer, 2023). This study investigates the potential use of ChatGPT in high schools in the United Arab Emirates (UAE) to enhance physics students' learning and success. The UAE has emerged as a prominent player in advancing and integrating AI, actively striving to position itself as a leading global authority. The government of the UAE has officially sanctioned a strategic initiative for optimizing operational efficiency by incorporating AI technology (Faccia et al., 2023; Khan, 2019; Omar & Mahdjoubi, 2023). The strategy encompasses a collection of guidelines designed to enhance the productivity and efficacy of diverse enterprises, enhance the caliber of governmental services, and offer additional avenues for employee training (Khaleej Times, 2023; Khan, 2019). The primary goal of this study is to investigate the potential of ChatGPT to improve high school students' learning outcomes and academic performance in physics. Specifically, the study focuses on assessing ChatGPT's effectiveness in facilitating students' comprehension and application of physics concepts in a classroom setting. This study recommends optimizing instructional practices for teaching physics to high school students.

Problem Statement

While high school physics students face a common challenge, effective teaching strategies and targeted support can unlock its power and illuminate the interconnectedness of the fundamental principles in physics. Nevertheless, physics is notoriously challenging and requires a solid grasp of mathematical concepts. In this light, it is undoubtedly challenging to master NSLOM purely through memorization. It involves active participation and understanding, which only exacerbates the issue. Moreover, traditional teaching techniques like lectures and textbooks may be insufficient to ensure that students fully understand this concept. The challenge is developing an innovative and efficient method for teaching physics to high school physics students to improve their academic performance and learning outcomes. The UAE vision 2021's strategic framework views education as a crucial element of national progress and a highly beneficial investment for the youth. The UAE vision 2021 aims to guarantee that the education systems adequately provide students with the essential skills applicable in the contemporary global context (Khan, 2019; Khassawneh & Abaker, 2022; Matsumoto, 2019). Therefore, this issue might have a viable answer in the form of ChatGPT, an AI-powered language model that offers students individualized and engaging learning opportunities. Students across various academic subjects, such as arithmetic and language development, have demonstrated ChatGPT's helpfulness. However, ChatGPT's potential for teaching physics principles has not yet been thoroughly investigated. Therefore, this study aims to determine whether ChatGPT successfully enhances high school students' comprehension and mastery of essential physics concepts or not. It intends to provide students with a fresh and successful method of learning physics that will enhance their academic performance and learning outcomes by utilizing ChatGPT's distinctive features. Therefore, the following research questions provide a detailed outline of these objectives:

1. Does ChatGPT positively impact the performance of high school students in physics?
2. Is there a statistically significant difference in physics performance between students who utilize ChatGPT and those who follow the c instructional method?
3. Is there an interaction between students' gender and the use of ChatGPT as a teaching method in teaching physics?

Significance of the Study

Balfakih (2003) has observed that students in the UAE exhibit comparable challenges, such as subpar academic performance and unfavorable attitudes towards scientific disciplines. These challenges consequently contribute to a significant attrition rate among high school physics students. In addition, due to students' poor performance in the trends in international mathematics and science study (Wardat et al., 2022), there is a call for enhancing physics instruction and learning by addressing such impediments to quality performance in physics. A study on the effectiveness of introducing physics education in UAE schools is also necessary to address these issues. Therefore, this study responds to a call for additional research on ChatGPT's

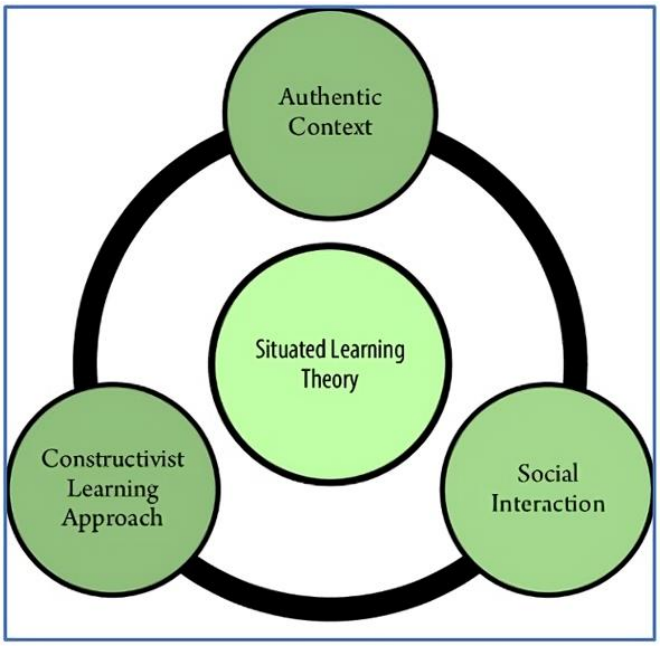

Figure 1. The key element of SCT (Green et al., 2018)

efficacy in physics education (AlArabi et al., 2022a; Bin-Hady et al., 2023; Khan, 2019; Kortemeyer, 2023; Lo, 2023). The primary goal of this study is to address the knowledge gap regarding ChatGPT's effectiveness in enhancing the academic performance of high school students in physics in the UAE. To date, there has been a lack of research examining the effects of ChatGPT on students' academic performance, particularly in physics. Therefore, this study is likely to have significant implications for the pedagogy of physics instruction. It presents empirical evidence supporting the efficacy of ChatGPT as a pedagogical tool for improving the quality of physics instruction in a classroom setting. The study also allows teachers to explore contemporary pedagogical approaches that have demonstrated effectiveness in enhancing students' comprehension of scientific principles, fostering critical thinking skills, and promoting active participation inside the classroom. Furthermore, the study emphasizes the significance of using AI and technology in the realm of education. This exemplifies the ability to use ChatGPT to facilitate interactive education, improve student academic achievements, and equip students with the necessary competencies to succeed in the digital age. In light of the technologically changing educational landscapes nowadays, this study is likely to provide a vision and a roadmap for AI-enhanced teaching that embraces technology, which is in line with the current pedagogical philosophies, and prepares students for the challenges of the twenty-first century.

LITERATURE REVIEW

Theoretical Framework

Situated cognition theory (SCT) principles form the foundation of this study's theoretical framework. The theory's core tenets center on constructivist learning, situated in a genuine environment, and integrating social interaction (Bell et al., 2013; Green et al., 2018) (see **Figure 1**). In the 1980s, Brown and his coworkers proposed the SCT, which suggests that learning occurs in the context of actual events. The real-world application of knowledge increases retention and comprehension (Brown et al., 1989).

By focusing on real-world contexts, hands-on activities, collaborative learning, and self-reflection, SCT offers a framework for deeper physics understanding (Alsalhi, 2020; Applefield et al., 2001; Hannafin & Land, 1997; Russell & Martin, 2023). Integrating this approach allows teachers to create a richer and more meaningful learning environment. This, in turn, equips students to apply physics concepts to solve real-world problems. Furthermore, SCT fosters a lifelong love of learning and scientific discipline by cultivating a sense of wonder and continuous curiosity about the subject (Danielson & Lind, 2009). The following examples will showcase how ChatGPT can be utilized to enhance physics education:

- According to Bitzenbauer (2023) and Santos (2023), ChatGPT offers a unique way to learn physics. It creates simulations of experiments that are not only realistic but also engaging. These simulations can significantly improve student understanding by providing clear explanations and real-world demonstrations of physics concepts.
- ChatGPT can provide tailored instructional support to students, allowing them to participate in self-paced learning and meet their unique educational needs effectively (Firat, 2023; Lin, 2023).
- ChatGPT goes beyond explanations by offering students practice problems and assessments. This allows them to actively test their understanding of physics concepts (Küchemann et al., 2023).
- Students have the opportunity to engage in meaningful physics discussions using ChatGPT. This involvement can be advantageous as it encourages the development of critical thinking skills and the constructive evaluation of ideas presented by their peers (AlAbidi et al., 2023a; Gregorcic & Pendrill, 2023; Santos, 2023). To sum up, when employed judiciously and ethically, ChatGPT has the potential to serve as a valuable cognitive tool in the educational setting, enriching the roles of teachers and enhancing the learning experiences of students.

The Impact of ChatGPT on Student Learning

ChatGPT, as outlined by Bitzenbauer (2023), stands as a sophisticated deep learning-based generative language model crafted from extensive text data for training purposes. Heralded for its proficiency in natural

language processing, this innovative tool demonstrates the capacity to generate coherent and contextually fitting responses to textual queries (Yang et al., 2024). Functioning as an AI-driven chatbot, ChatGPT engages in conversations with users, offering advice and information on a wide array of subjects, thereby positioning itself as one of the foremost chatbots available today (Mallow, 2023). Distinguished by its integration of machine learning and natural language processing, ChatGPT serves as an effective ally for students seeking assistance in various academic domains (Rathore, 2023). Whether grappling with challenging subjects or in need of time-management suggestions, students can turn to ChatGPT for personalized support (Adiguzel et al., 2023). The chatbot employs machine learning and natural language processing to understand and respond to students' queries, delivering precise information in return (George & George, 2023). Moreover, it leverages learning trajectories to provide tailored recommendations aimed at enhancing academic performance (Almusaed et al., 2023; Javaid et al., 2023). An inherent advantage of ChatGPT lies in its continuous availability, operating seamlessly in both synchronous and asynchronous modes to provide students with timely guidance (Mallow, 2023). Designed for prompt and accurate responses, ChatGPT becomes a reliable source of knowledge, offering assistance with specific subject queries or aiding comprehension of complex concepts (Almusaed et al., 2023). The system's algorithmic analysis of learning histories ensures personalized recommendations, enabling users to access expert guidance for performance improvement in specific subjects (George & George, 2023). Beyond individualized support, ChatGPT has the potential to contribute to academic success by reducing dropouts and bridging knowledge gaps between students and teachers (Cooper, 2023; Furini et al., 2022). Research suggests that ChatGPT plays a role in fostering critical thinking skills among students (Chakraborty et al., 2023). These skills are particularly crucial in disciplines like physics, where abstract concepts are prevalent, as they contribute to the development of problem-solving abilities (Adiguzel et al., 2023; Khalil et al., 2023). Bitzenbauer (2023) highlights that ChatGPT generates diverse outputs that prompt students to reflect, enhancing their critical thinking capabilities. Understanding the core features and potential applications of ChatGPT raises awareness of its transformative impact, positioning it as a valuable tool with critical features for the educational landscape (Gregorcic & Pendrill, 2023; Santos, 2023).

Obstacles to Employing ChatGPT in Education

While ChatGPT offers exciting possibilities for education, there are challenges to overcome before it can be fully embraced. One major concern is bias. The tool can generate inaccurate or misleading information, potentially hindering learning (Bitzenbauer, 2023; Grassini, 2023). To mitigate this, educators need high-quality data for training ChatGPT and robust systems to identify and correct biases in its responses (Dwivedi et al., 2023). Another concern is student privacy. ChatGPT requires access to data, raising questions about security and student vulnerability (Qureshi, 2023). Schools need robust data protection measures and clear guidelines for how ChatGPT interacts with students (Mallow, 2023). Finally, not all schools may have the resources needed for ChatGPT. Limited internet access, computers, and servers could create a digital divide, disadvantaging students in certain locations (Garlinska et al., 2023). For successful integration, schools require the necessary infrastructure and equitable access to technology. Unlocking ChatGPT's potential in education requires educators, policymakers, and developers to work together and address current limitations.

METHODOLOGY

Research Design and Sampling

This study employs a quasi-experimental quantitative methodology that incorporates a pre, post-test, and control group (CG) for examining the efficacy of ChatGPT in improving the student's academic performance. Two Ministry of Education (MOE)-approved schools, all operating as single-sex schools, have hosted the study. One of the schools was a boys' school, and its teachers were men; the other was a girls' school with female teachers. Both schools are located in the same UAE emirate and use the MOE curriculum. The study population consisted of students enrolled in high school (11th grade). The sample has 90 male students that are divided among four classes; a random selection has been made to designate one classroom as the "CG" with 23 students and another as the "experimental group (EG)" with 21 students. On the other hand, four classes make up the second school, which has 97 female students. One of these classes is chosen randomly to be the CG (24 students), and another is the EG (25 students). The students in the EG utilized ChatGPT as a study tool, while the students in the CG engaged in learning activities without using ChatGPT. **Table 1** summarizes the characteristics of the participants in the study groups. All the participants exhibit similar demographic characteristics and adhere to the same school hours. The research was conducted in conventional high-school classrooms that are equipped with internet-enabled gadgets for the use of ChatGPT. Both EGs received equal amounts of physics training, which highly experienced physics teachers have delivered. Furthermore, both cohorts have been on the advanced academic track for the 2022–2023 academic year.

Table 1. Groups of the study

Study groups	Gender	N	Total
Control groups	Female	24	47
	Male	23	
Experimental groups	Female	25	46
	Male	21	

Steps to Use ChatGPT

The first step in using ChatGPT is to locate a platform or website that provides users with access to the model. One can use ChatGPT on various sites, such as Hugging Face's Transformers library, the OpenAI website, and Google (Chakraborty et al., 2023). Once a person has access, the next step is to type a question or prompt into the input field. The prompt should be clear and straightforward, ranging from a single sentence to a lengthy paragraph. Questions, statements, and orders are just a few of the inputs that ChatGPT can comprehend and reply to. After the user has entered the prompt, ChatGPT will review it and produce an answer based on the text it operates on (Almusaed et al., 2023; Rahman & Watanobe, 2023). During this stage, one must wait for the model to respond. The solution will appear in the output area, where it could be downloaded, copied, or edited if necessary. The responses from ChatGPT are not always flawless; so, it is critical to assess the response and see if it satisfies either the user's needs or expectations (Dergaa et al., 2023; Rahman & Watanobe, 2023). If the user is satisfied with the answer, they can extend the dialogue by adding another input. Otherwise, they may try rephrasing the earlier comment or coming up with an alternative question. However, using ChatGPT is not without its challenges, and it is crucial to examine some of these obstacles.

Materials

Newton's second law of motion

The physics curriculum incorporates NSLOM as a fundamental subject. NSLOM was chosen based on its extensive applicability and intriguing nature (AlAbidi et al., 2023b), making it a noteworthy subject for ChatGPT to address. Conventional physics textbooks and educational resources have been employed to maintain adherence to the established pedagogical methods and as a comprehensive subject matter presentation. A web-based interface allowed the ChatGPT group to access the system. Students could interact with ChatGPT by writing text inquiries and then receiving responses in a familiar language. Then, the teacher instructed the students in the traditional-technique group on NSLOM. To ensure the trustworthiness of the results, the study employed a well-established physics test developed by Alarabi (2023) with 16 multiple-choice questions. Previous research has successfully confirmed the validity and reliability of this test. This choice guaranteed the accuracy and consistency of the data collected for this study.

Table 2. Reliability statistics of data

Cronbach's alpha	Number of items
0.758	16

Data collection

All EGs and CGs students were given a pre-test to assess their baseline grasp of NSLOM before the intervention. The pre-test consisted of a series of topic-related conceptual questions and problem-solving tasks. For five weeks, the students in the EG had access to ChatGPT. During that period, they were able to use ChatGPT to study NSLOM. Face-to-face classroom instruction has provided conventional physics instruction to the group using traditional methods. This group has used standard physics textbooks, lecture notes, and teacher-led discussions as resources. Five weeks following the intervention, both groups completed an identical post-test with questions similar to those on the pre-test but with different values and scenarios.

AlArabi (2023) uses Cronbach's alpha to establish the reliability of the collected data (**Table 2**). The Cronbach's alpha value of 0.758 indicates that it has a high level of reliability and is therefore suitable for any statistical analysis. Students' test results were collected and examined statistically before and after the intervention. Descriptive statistics (mean [M] and standard deviation [SD]) and inferential statistics (t-tests and one-way analysis of variance [ANOVA]) have been used to analyze the data and draw conclusions about the significant differences in performance between the EGs and CGs.

FINDINGS

Concerning the first question: "Does ChatGPT positively impact the performance of high school students in physics?" A statistical analysis using an independent sample t-test has been conducted to evaluate the initial similarity between the two groups before performing the intervention. At the $p < .05$ level, the results showed that the pre-test scores of the two groups were not statistically different: $t(91) = .084$, $p = .735$. This suggests that the students in both groups could be deemed comparable regarding knowledge about NSLOM, as seen in **Table 3**.

Table 4 presents the pre- and post-treatment test scores separately for each group. The students in the CGs ($M = 16.50$, $SD = 3.14$) and EGs ($M = 17.00$, $SD = 2.01$) perform similarly on the pre-test, as shown in **Table 4**. The mean post-test scores of the CGs ($M = 17.00$, $SD = 3.32$) and EGs ($M = 19.00$, $SD = 1.87$) have been higher than the pre-test. Effect sizes on knowledge gains have been computed to examine the impact of ChatGPT on

Table 3. Comparing the two groups' pre-test using an independent-samples t-test

Study groups	N	M	SD	t	df	Sig.
CGs	47	16.50	3.04	.084	91	.735
EGs	46	17.00	2.01			

Table 4. Group-based NSLOM performance

Study group	Pre-test		Post-test		Cohen's d*
	M	SD	M	SD	
EGs	17.00	2.01	19.00	1.87	1.03
CGs	16.50	3.14	17.00	3.32	0.16

Note. *d: Effect size

Table 5. Scores from the post-test using one-way ANOVA

	Sum of squares	df	Mean square	F	Sig.
Between groups	760.30	1	740.40	62.618	0.000
Within groups	1,120.68	91	15.88		
Total	1,120.88	92			

students' performance in each group (**Table 4**). Cohen (1992) describes the degree of these impacts, with effect sizes ranging from d = 0.20 for a small effect to d = 0.50 for a medium effect and d = 0.80 for a large effect. The ChatGPT-based learning environment significantly increased students' knowledge of NSLOM topics (d = 1.03) in contrast to the small impact of traditional education on students' understanding (d = 0.16).

As for the second question, "Is there a statistically significant difference in physics performance between students who utilized ChatGPT and those who followed the traditional instructional method?" A one-way ANOVA has been used to determine if the EGs differed significantly from the CGs in the post-test after the intervention. A normality test has been performed to verify whether the data was normally distributed or not. Given that the p-value of the Kolmogorov-Smirnov test is greater than 0.05, it can be concluded that the dataset follows a normal distribution. Additionally, the homogeneity of the variance has been analyzed using the Levene test for equality of variances, and the result was not statistically significant ($p > .05$). This suggests that the pre-test upheld Levene's test for the students. As shown in **Table 5**, there has been a statistically significant difference between the post-test scores of the two groups at the level of $p < .05$ ($F [1, 92] = 62.618$, $p = .000$).

The pre- and post-test mean scores for CGs and EGs have been compared using a paired-sample t-test to see if there was a statistically significant difference. **Table 6** shows the results of the SPSS paired sample t-test. In the CGs, the absence of ChatGPT has not enhanced students' performance on NSLOM ($t [45] = 2.21$, $p = .313$ [$p > .05$]). However, the study's findings suggest that ChatGPT improves students' performance on NSLOM in EGs ($t [44] = 4.26$, $p = .015$ [$p < .05$]).

Table 6. Paired-sample t-test based on groups

Group	Pre-test		Post-test		t	df	Sig.
	M	SD	M	SD			
EGs	17.00	2.01	19.00	1.87	4.26	44	.015
CGs	16.50	3.04	17.00	3.32	2.21	45	.313

Table 7. One-way ANOVA of two-gender pre-test scores

	Sum of squares	df	Mean square	F	Sig.
Between groups	.029	1	0.031	.012	.651
Within groups	148.87	91	2.430		
Total	148.95	92			

Table 8. Gender-based EG paired-sample t-test

Gender	Pre-test		Post-test		t	df	Sig.
	M	SD	M	SD			
Male	14.00	3.04	15.5	2.89	0.51	6.12	42
Female	16.00	2,20	18.5	3.09	0.93	5.44	47

Concerning the third question, "Is there an interaction between students' gender and the use of ChatGPT as a teaching method in teaching physics?" The two genders have been compared before the intervention of a one-way ANOVA. According to **Table 7**, there has been no significant difference in pre-test scores across genders at the $p < .05$ level ($F [1, 92] = .012$, $p = .651$). This suggests that the two genders were comparable and that there had been no difference between the two groups of male and female students before intervention.

A paired-sample t-test is employed to assess whether the performance has significantly differed between the pre-test and post-test or not. The assessment of homogeneity of variance has been conducted using Levene's test for equality of variances, and the obtained result is not statistically significant ($p > 0.05$). The results of Levene's test indicate that there has been no violation of the assumption of homogeneity of variances among the learners in the post-test. The Kolmogorov-Smirnov test concludes that the data sets exhibit a normal distribution based on the obtained p-values exceeding the significance level of 0.05.

Table 8 displays a statistically significant difference between the pre- and post-test scores of male students in the ChatGPT group (M = 14.00, SD = 3.04, and M = 15.5, SD = 2.89, respectively). Female students show a statistically significant improvement from their pre- to post-test scores (M = 16.00, SD = 2.20 to M = 18.50, SD = 3.09). After incorporating ChatGPT into their instruction, male students have a statistically significant mean difference of -1.00 points compared to female students. It appears that ChatGPT impacted both female and male students. These findings suggest that ChatGPT facilitated NSLOM learning for both male and female students. The EGs' scores before and after the test were significantly different, as shown in **Table 8**. These findings suggest that using ChatGPT could enhance

female performers' NSLOM scores (t [47] = 5.44, p =.004 [p < .05], and d = 0.93), which is a large effect. Furthermore, based on these male group findings, using ChatGPT helped males score better on the NSLOM's test (t [42] = 6.12, p = .022 [p < .05], d = 0.51 [moderate effect], see **Table 8**). These findings also imply that ChatGPT improved male and female students' understanding of NSLOM.

DISCUSSION

This study aims to investigate whether integrating ChatGPT into the instructional process could improve students' understanding of and proficiency in learning the fundamental principles of physics. The findings relate to comparing the pre- and post-test, as well as the feedback from students, and they provide valuable insights into the usefulness of ChatGPT as an educational learning technology. Comparing the test scores before and after using ChatGPT shows a statistically significant increase in performance, indicating that the tool has contributed to its users' understanding of NSLOM. As discussed by several researchers, the interactive nature of ChatGPT may be responsible for the observed improvements in students' understanding of physics concepts (Firat, 2023; Gregorcic & Pendrill, 2023; Küchemann et al., 2023; Lin, 2023; Santos, 2023). The fact that it is consistent with earlier studies has shown the value of interactive and contextually situated learning experiences for enhancing comprehension (Applefield et al., 2001; Bell et al., 2013; Danielsson & Linder, 2009; Green et al., 2018; Hannafin & Land, 1997; Russell & Martin, 2023). These results support the importance of providing students with such opportunities.

The findings of this study suggest that utilizing ChatGPT has the potential to serve as a valuable instructional tool in augmenting the educational experiences and academic achievements of high school students studying physics. Furat (2023) and Lin (2023) have both argued that students could receive individualized support and clarifications from ChatGPT, which facilitates their comprehension of intricate concepts. To enhance their skills and expand their knowledge, students can derive advantages from practicing physics questions and tests through ChatGPT (Küchemann et al., 2023). ChatGPT, as an instructional tool, also offers the potential for individualized instruction and tailored educational experiences. ChatGPT's ability to tailor feedback and instruction based on students' needs enables focused coaching and scaffolding (Almusaed et al., 2023; Mallow, 2023). For instance, advanced students can handle more challenging issues, while students having trouble grasping a particular concept may be provided with more tools and information. This customized method promotes inclusive education and aids in addressing the various learning requirements of students. The findings reveal that students who have participated in the ChatGPT groups demonstrate high involvement in collaborative learning activities and engage in meaningful peer interactions. According to Firat (2023) and Lin (2023), ChatGPT functions as an online educational tool that provides instructional support to students by assisting them in problem-solving tasks and fostering collaborative dialogue among peers. Moreover, it implements a collaborative learning environment, which facilitates knowledge acquisition through the interchange of opinions and ideas among students, thus leading to the collective construction of knowledge. These findings support the proposition that ChatGPT, as a supportive instrument, can successfully execute the application of SCT, which emphasizes social interaction and collaborative problem-solving. Overall, the findings of this study indicate that ChatGPT has the potential to be a valuable tool for assisting high school physics students in their learning and academic success. However, it is important to note that the study limitations include only a small, specific number of participants, potential post-test influence, and curriculum misalignment impacting results. Additionally, teacher differences and modified assessments may have influenced the findings. Therefore, additional research is required to confirm this study's findings with a larger sample size.

Implications

This study aims to enhance student engagement and optimize learning outcomes. The utilization of ChatGPT as an instructional tool for physics has the potential to exert a substantial influence on student engagement levels and academic achievements. Qureshi (2023) contends that providing an interactive and individualized learning experience is associated with increased motivation, active participation in scientific research, and an enhanced understanding of scientific themes among students. ChatGPT facilitates students' participation in virtual dialogues that provide prompt feedback and direction, fostering the cultivation of essential cognitive abilities such as critical thinking and problem-solving. Furthermore, AI-driven assessments can individualize instruction and tailor learning encounters. ChatGPT allows for focused education and knowledge cultivation by customizing notes and instructions to meet the specific needs of individual students. For instance, students with difficulties comprehending a specific idea should be provided with supplementary knowledge and resources. In contrast, academically proficient students should engage in tackling more intricate assignments. This study aims to operationalize a customized methodology for efficiently addressing students' heterogeneous learning requirements and fostering inclusive educational implementations. The study's findings suggest that educators and science teachers can use ChatGPT as an

effective mechanism for boosting their students' academic engagement and, consequently, performance. For instance, teachers can use ChatGPT to design activities where students practice NSLOM, receive rapid feedback, and monitor their progress. The findings also suggest that ChatGPT is an interactive tool that teachers might use as a means of student involvement. According to Mhlanga (2023), the findings about privacy concerns and challenges arising from using ChatGPT in educational settings suggest that policymakers and teachers should consider these matters thoroughly. There is a pressing need for establishing ethical guidelines and regulatory frameworks to ensure the appropriate utilization of AI-driven educational technologies. Using ChatGPT technology is one potential approach to improving student engagement and information retention in the classroom setting. Furthermore, this study underscores the significance of considering the ethical implications of AI-driven technologies in education. Teachers must prioritize the safety and privacy of their students while utilizing these tools. One of the primary recommendations for ensuring the ethical application of AI in education is the establishment of explicit regulations and moral frameworks by institutions.

CONCLUSIONS

High school physics students can benefit from ChatGPT, especially while learning and using NSLOM. ChatGPT can increase students' interest in learning physics by offering engaging and customized learning opportunities. Additionally, it can give students quick feedback and enable them to recognize and fix their misunderstandings and mistakes. Students studying physics in high school benefit significantly from how simple it is to use ChatGPT for learning. ChatGPT, accessible from any device and requiring only an internet connection, allows students to use it at any time and at any speed.

Recommendations

Given the potential advantages of employing ChatGPT in physics instruction, a few suggestions are put forward. First, the teacher must create rules for using ChatGPT that guide students about its proper use. The teacher must inform the learners about the use and benefits of ChatGPT as an aid to instruction. In this context, the teacher should clearly define the purpose of using this tool in class. Second, teachers and educators should monitor their students' use of ChatGPT to ensure that it promotes and supplements their education rather than substituting it (Mhlanga, 2023). Additionally, they should give students chances to reflect on and consider how they use ChatGPT to foster critical thinking and metacognitive abilities. Teachers can employ low-tech methods such as printed materials, CDs or DVDs with pre-recorded ChatGPT lectures, or simulations to overcome the accessibility barrier, especially in remote areas without internet connectivity. Third, ChatGPT developers should collaborate with educational specialists and physics teachers to create high-quality educational content that aligns with the curriculum and learning objectives. Through systematic testing and quality assurance procedures, they should also guarantee the dependability and accuracy of the AI's responses. There is a need for school-wide training for both students and teachers. Since ChatGPT is a new AI technology, users need to be more aware of its ethical use and how to tailor it for science lessons. Teachers need professional development to train them on how to integrate the tool into the lesson. Finally, it is suggested that more collaborative research be conducted using ChatGPT as an instructional strategy. In this context, AI-based education's efficacy and long-term effects on physics education require further investigation. Researchers, educators, and policymakers can collaborate to successfully integrate AI into education by identifying the best practices, developing guidelines, and formulating policies. This partnership could inspire a community of learners by facilitating the exchange of creative concepts, tools, and experiences.

Delimitations

- Subject limits: The study was limited to the topic of NSLOM.
- Human limits: The study was limited to students enrolled in high school (11th grade).
- Spatial limits: Abu Dhabi education zone, MOE, UAE.
- Time limits: Academic year (2023/2024).

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