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Artificial intelligence integration and teachers' self-efficacy in physics classrooms

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Abstract

The United Arab Emirates (UAE), in its vision 2021 and the UAE centennial 2071 plan, highlights the essential role of artificial intelligence (AI) and technology in shaping a knowledge-based, future-ready society. This study explores the integration of AI in physics classrooms, focusing on secondary education in the UAE. It also investigates the perceptions and self-efficacy of physics teachers regarding the use of AI tools in classroom settings. A qualitative research design was employed to gather in-depth insights from 15 physics teachers across schools in Sharjah, assessing their confidence and readiness for AI integration through the lens of the attitude and value, pedagogical, technical, and social (APTS) model. This model served as the theoretical framework, guiding the exploration of how AI affects teachers' emotional, behavioral, and cognitive engagement in education. Themes such as teachers' familiarity with AI, their confidence in implementing AI tools, challenges faced during integration, and the impact of AI on student engagement and learning outcomes were examined. The findings revealed that while the majority of teachers expressed positive attitudes toward using AI technologies, the integration of AI into the teaching of physics remains limited, with challenges including a lack of training, infrastructure, and time. The study recommends incorporating AI training for teachers, both pre-service and in-service, to ensure that educators are prepared to create learning environments that align with the UAE's vision for a technologically advanced education system.

Keywords: AI integration, self-efficacy, physics education, APTS model

INTRODUCTION

Physics is a challenging subject due to its concept-heavy nature. In secondary school curricula, topics such as electricity, mechanics, heat, waves, optics, cryogenics, astrophysics, plasma physics, nuclear physics, and solids-state physics dominate the teaching landscape. These core concepts are not only essential to physics but also central to the development of critical thinking and problem-solving skills needed in disciplines like engineering, technology, and medicine. The numerous applications to which these concepts are being put together to improve our environment make it occupy a unique position among other science subjects (Irving & Sayre, 2016). Physics as an academic discipline is an important subject in science and technology since it studies the essence of natural phenomena and helps people understand the increasingly technologically changing society (Bunkure, 2015; Mwambela et al., 2019). It has many applications in the medical field and information technology and in many other sectors of human actions. As technology continues to shape our society, it is crucial for physics education to adapt, fostering students' understanding of these complex concepts in ways that are engaging and accessible.

In this context, artificial intelligence (AI) is introduced as a transformative tool in education. AI's potential to enhance teaching and learning by offering adaptive learning environments, real-time feedback, and personalized learning experiences is well-documented

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Contribution to the literature

- This study introduces and validates the AIME-B scale to assess AI learning, metacognitive, and epistemic barriers specifically for secondary school administrators.
- The unified theory-driven scale is an integration of multidimensional barriers into a single framework, providing a more holistic understanding of resistance to AI integration in schools.
- This study contributes to the literature by presenting a robust framework that sets a precedent for future development of psychometric instruments in educational technology.

across various disciplines (Chen et al., 2020). AI is the creation of systems able to reason, think, and learn the way humans do. According to Sharma and Garg (2021), AI imitates human intelligence and can perform tasks such as playing games, driving a vehicle, suggesting a shopping list, etc. AI is capable of accomplishing work usually performed by human intelligence, including problem-solving, learning, and decision-making. One of the objectives of AI implementation in the United Arab Emirates (UAE), as outlined in the UAE's artificial intelligence strategy 2031, is to integrate AI into the mainstream of education and training (Alkhaldi & Altaei, 2021). The objectives of this policy include but are not limited to transforming the UAE into an economy of knowledge, thereby equipping its students with AI skills so that these students can be competitive globally and, at the same time, contribute to capacity building in secondary education settings through the use of AI-based education. Yet, the adoption of AI tools in the teaching of complex physics concepts has not fully realized its potential.

It has been demonstrably effective in using studies on the implementation of AI in teaching and learning as a means to equip learners with the competencies and skills required to function successfully in a changing job market (Pedro et al., 2019; Saputra et al., 2023). Research also shows the important role that educators play in successful technology and AI integration in education (Yehya, 2020b). The success of AI adoption is primarily founded on academic teachers' competence and self-efficacy in using AI technologies (Dai, 2023; Ojo, 2024).

Teacher self-efficacy refers to a teacher's belief in their capacity to effectively guide and shape student learning results (Lazarides & Warner, 2020). It has a pivotal function in the implementation of AI-based technologies in the classroom since teachers with high self-efficacy are willing to experiment and use new tools to improve teaching (Yehya, 2020a). When it comes to AI, which can introduce complex and innovative teaching methods, self-efficacy ensures that teachers feel capable of integrating these technologies into their pedagogy. Teachers with a high degree of self-efficacy are more likely to motivate students, tailor learning activities to individual requirements, and modify AI-based technologies to address individual differences observed in disciplines such as physics (Umali, 2024). After all, self-efficacy inspires teachers in a way to learn how they will face all possible difficulties, and it leads to establishing a more adaptive, student-centered environment, together with the help of AI. According to Nieves et al. (2024), these contribute to the way teachers think about and embed AI within their teaching practice. Certainly, as AI technology is not easily seen by educators as being related to the subject matter with which educators are working, educators are unlikely to accept AI-assisted pedagogy passionately.

Through AI, teachers can move beyond traditional boundaries of teaching, allowing students to participate more actively in the learning process and to develop educational environments in which experimentation and exploration are welcome. Integration, as defined by Spencer and Charsley (2021), involves the art of bringing different components into a common unity. In countries such as China and the USA, integrating AI and advanced technologies into education has led to significant advancements in both efficiency and student outcomes (Bhutoria, 2022). On the other hand, in countries with limited use of AI, the absence of technological integration has hindered students from effectively exploiting those technologies for their learning benefit in terms of achievement and global performance (Yehya et al., 2018).

The UAE's commitment to AI use is an innovative step towards assuring that its students will be trained and equipped to cope with a technological future (Jain, 2024). By emphasizing teacher AI training and AI self-efficacy, the UAE can contribute to a new generation of AI learners who are not just AI-trained but who can use AI to innovate and thrive in the globalized landscape. Accordingly, the aim of this investigation is to examine the relationship between AI adoption and teachers' sense of self-efficacy in teaching physics.

The integration of AI tools and their effects on the provision of knowledge in secondary schools in the UAE is a topic that warrants close attention. The UAE government has invested and spent many resources on designing and developing new educational policies and programs to encourage the use of AI within education (Shwedeh et al., 2024). However, considering these efforts and attempts, the productivity of using AI in teaching and the specific context of physics education in a classroom setting is still openly debated (Al Darayseh, 2023). Initial observations propose that, although a significant proportion of the physics teaching community feels confident about the use of AI and technology, technology in teaching practice remains quite restricted. This inconsistency can be explained by a lack of preparation and mentoring of teachers, which prevents them from properly integrating AI into their pedagogy. In addition, teachers' mismatch between their self-efficacy for using AI and how it is actually put to work in the classroom poses an obstacle to the implementation of the educational goals defined in the vision 2021 and centennial 2071 plans (Hendawy & Kumar, 2024). The aim of this study is to fill these gaps by investigating the degree to which AI is embedded in the different physics concepts taught at secondary school and how teachers perceive their self-efficacy for implementing this provision.

Despite growing investment in AI for education in the UAE, the actual integration of AI tools in physics classrooms remains inconsistent and poorly understood. Many teachers express positive attitudes toward AI but struggle to implement it effectively due to a lack of training, technical knowledge, and access to resources. This disconnect between policy vision and classroom reality highlights a significant gap in understanding how prepared teachers feel and use AI in meaningful ways. This study addresses that gap by exploring how self-efficacy influences AI integration in secondary physics teaching.

Purpose of the Study

This research aims to investigate the degree of AI integration by physics teachers in secondary schools in the UAE and also to investigate their perceptions of self-efficacy for integrating such advanced technologies. Through gaining an understanding of the experiences and difficulties that educators encounter, this study seeks to generate insights that will be able to inform the design and delivery of future teacher apprenticeship programs and improve the practical and successful use of AI in the educational system. Accordingly, the following research questions (RQs) were developed to guide this study:

RQ1. To what extent do physics teachers integrate AI technologies in their teaching activities?

RQ2. How do physics teachers perceive their self-efficacy in implementing AI tools in their instruction, and what key factors impact their self-confidence in integrating these tools into their teaching process?

RQ3. What do physics teachers believe concerning the impact of AI integration on students' engagement and learning outcomes, and what barriers do they encounter when integrating AI technologies in their classrooms?

Physics is a foundational subject that is a prerequisite for many engineering and technical courses. As such, the results of the present study are expected to be of interest to a range of stakeholders involved in scientific and educational development in the UAE. This research seeks to provide input to educational policymakers, curriculum developers, and teacher-training programs through the investigation of the integration of AI in physics education and the self-efficacy of educators. Findings will also support the overarching goal of improving educational approaches, encouraging innovation, and developing students to face a tech-oriented world in accordance with the UAE vision 2021 and centennial 2071 directives.

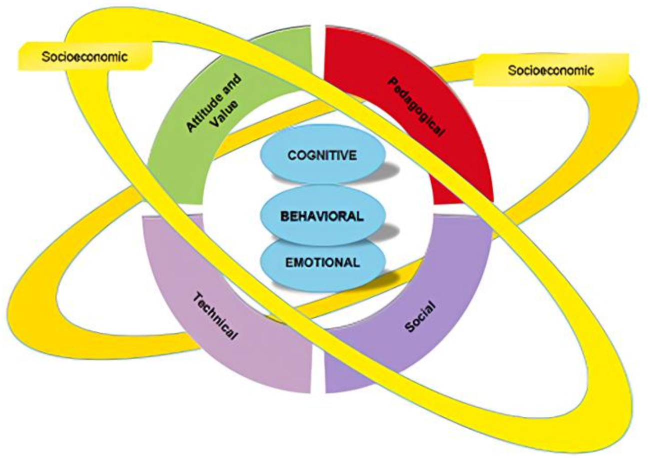

Figure 1. APTS paradigm for effective technology implementation (Yehya, 2020a)

THEORETICAL FRAMEWORK: APTS PARADIGM FOR AI INTEGRATION

The integration of AI into the UAE secondary school system, especially in physics, can be tackled holistically (Yehya, 2020a) using the attitude and value, pedagogical, technical, and social (APTS) paradigm as the framework (see **Figure 1**). The APTS model, which directs the implementation of technology to engage students on the emotional, behavioral, and cognitive levels, has good synergy with the vision of UAE for a future-ready education system.

Attitude and Value Dimension

The attitude and value dimension refers to the beliefs and perceptions that teachers have regarding the integration of AI into their teaching practices. In the context of physics education in the UAE, teachers' attitudes toward AI can significantly impact the extent to which they adopt and implement AI tools in their classrooms. Many teachers in the UAE express a positive attitude towards technology, seeing AI as a potential tool to improve teaching and student engagement. However, some teachers remain uncertain about its effectiveness in teaching complex physics concepts, such as mechanics and optics.

For example, while some teachers believe that AI could help visualize abstract concepts, others feel that AI integration might be too technical or disruptive to traditional pedagogies. Encouraging a positive attitude towards AI integration is critical to overcoming resistance, and this requires fostering teacher buy-in through increased awareness and education about AI's practical benefits in physics education. Additionally, cultural factors and local values around technology and education play a role in shaping how teachers perceive AI's role in their teaching practices.

Pedagogical Dimension

From a pedagogical point of view, successful integration of AI in physics cannot simply layer content on top of the existing curriculum and instead must embrace AI-enhanced pedagogical approaches that drive cognitive, emotional, and behavioral engagement (ElSayary, 2023). AI tools offer interactive simulations, adaptive learning systems, and real-time data analysis that can deepen students' understanding of difficult concepts like electricity, mechanics, and waves. In physics, where visualization is often key to grasping complex theories, AI can transform traditional classroom settings into more engaging and effective learning environments.

For instance, AI-driven simulations can allow students to experiment with virtual physics experiments, such as understanding the laws of motion or electromagnetic fields, which are traditionally challenging to demonstrate in physical classrooms. Furthermore, AI-enabled personalized learning systems can tailor content to individual student needs, helping students who struggle with physics or advancing those who excel. This approach is particularly important in physics classrooms where students often have diverse levels of comprehension. Teachers must be equipped to use these tools to align lessons with curriculum goals while also adapting to students' unique learning styles. To implement these strategies effectively, teachers must have both the technical and pedagogical skills to use AI tools effectively. This includes understanding the differentiation between AI tools and traditional ICT tools like basic simulations or animations, as AI tools can offer deeper interactivity and learning outcomes.

Technical Dimension

The technical dimension concerns the practical aspects of integrating AI into the classroom, including the infrastructure, tools, and resources required to make AI-based learning successful. In the UAE, where AI integration is prioritized in education, schools must provide sufficient technical support to ensure AI tools function properly. This includes ensuring that classrooms are equipped with high-quality devices, stable internet connectivity, and AI-specific software tailored to subjects like physics (Yehya, 2021).

Currently, the lack of accessible AI resources and training opportunities for teachers remains a barrier to effective AI integration. For example, AI platforms for real-time data analysis in physics experiments, such as virtual labs and predictive modeling tools, need to be readily available. However, many teachers report limited access to such technologies, which impacts their ability to fully integrate AI into their lessons.

The technical competence of teachers is also essential. While some teachers are familiar with basic AI tools like ChatGPT or simulation software, they may not know how to apply more advanced AI-based tools that offer personalized learning pathways or intelligent feedback. As such, training programs need to provide educators with hands-on experience with AI tools tailored to physics teaching, along with support in troubleshooting technical issues and understanding AI's potential beyond basic applications.

Social Dimension

The social dimension emphasizes the role of collaboration and community support in successfully integrating AI into the classroom. AI is not just a tool for teachers to use in isolation; it can facilitate collaborative learning among students, encouraging teamwork and collective problem-solving (Yehya, 2021). For example, AI platforms that allow students to collaborate on virtual physics experiments, share data, and discuss results can help create a socially dynamic learning environment. This aspect is particularly important in physics, where discussions around scientific principles and data analysis benefit from group interactions.

Additionally, peer support and the development of professional learning communities are critical for teachers to share experiences and best practices for using AI in their teaching. Teacher networks within schools or regions can help create a culture of innovation and collaboration around AI tools, fostering a shared understanding of how to maximize the technology's benefits in the classroom.

In the UAE context, government-led initiatives to create AI-friendly educational ecosystems can help by offering platforms for teachers to connect, share ideas, and access professional development resources. By fostering a social learning network that includes both teachers and students, AI integration can move beyond the classroom to influence community-wide education reforms in line with the UAE's AI vision.

This study contributes to the existing literature by addressing a specific gap in the integration of AI in physics education within the UAE context, an area that remains under-explored. While previous research has generally focused on technology adoption in broad educational contexts, this study uniquely examines the perceptions and self-efficacy of physics teachers using the APTS framework. The findings provide evidence of how teachers differentiate between AI and traditional ICT tools, offering a prioritized set of challenges that can guide targeted professional development. This research contributes to the conversation on AI-readiness among subject-specific educators, informing future educational policy and training initiatives.

METHODOLOGY

The researcher employed an interpretivism research philosophy and a qualitative approach, using open-ended interviews to investigate the implementation of AI technologies by physics teachers in the secondary classroom. Both philosophy and methodology place the central emphasis on subjective meaning and context and consequently permit a rich understanding of teachers' experience, perception, and self-efficacy in integrating AI. The richness and descriptive nature of the content provided by the open-ended interviews gives researchers insight into the complexity of their practices and associated challenges. Also, open-ended interviews enable participants to express their thoughts and feelings freely in ways that align closely with the study's objectives.

Participants

The study sample consists of all physics teachers in the targeted government secondary schools in Sharjah, UAE. A purposive sampling technique was employed to select 15 physics teachers who have demonstrated varying levels of experience with technology and AI integration. This sampling procedure was selected to guarantee that the participants' viewpoints are representative of the spectrum of views in the teaching profession. To maintain anonymity and address logistical constraints, the selected teachers participated from various schools, creating a sample that is both diverse and cohesive.

Instrumentation

The main tool for data collection was an open-ended semi-structured interview, which was implemented to obtain specific information about their integration of AI technologies in physics classrooms. Open-ended interviews are a means of gathering in-depth data (Mears, 2009). Interview questions were designed to match the study objectives and goals, focusing on key themes such as teachers' knowledge about AI, confidence when it comes to the use of AI tools, challenges during the AI integration process, and the perceived impact of AI on student engagement and AI on learning outcomes. Such open-ended questions with their own scope were meant to allow a deep consideration of teachers' experience and perception, which in turn should lead to a better understanding of AI in the scope of physics education. The validity and reliability of the open-ended interview questions were confirmed through a pilot of the questions by a panel of teachers not included in the sample. Their feedback ensured that the interview questions effectively targeted the key themes associated with the use of a variety of AI technologies in physics instruction, thus strengthening the overall credibility of the research instrument.

Data Analysis

The data collected from the open-ended interviews was analyzed using a thematic analysis approach to explore the relationship between AI integration and teachers' self-efficacy. The interview transcription was systematically coded as substantial patterns and recurring concepts about participants' experiences and conceptions of the integration of AI in classrooms. These codes were subsequently grouped into main themes that encompass the main aspects of self-efficacy and the barriers to AI adoption.

Limitations of the Study

This study is limited by sample size, which could limit the generalizability of the results. Additionally, obtaining consent from several schools and teachers for participation in the interviews proved challenging, potentially impacting the diversity of perspectives gathered. In order to overcome these limitations, future work should include increasing the sample size and investigating a wider range of disciplines and subjects. Gaining more subjects including more participants and manipulating the foci in subsequent studies can lead to a richer understanding of AI integration in educational settings, so increasing the depth of the data and user implications.

RESULTS ANALYSIS AND DISCUSSION

The qualitative study involved 15 physics teachers from various secondary schools in Sharjah, UAE. The open-ended interviews revealed significant insights regarding the integration of AI technologies in physics education and the teachers' self-efficacy in utilizing these tools. The qualitative data collected from the open-ended interviews were analyzed thematically to reveal key insights related to teachers' integration of AI technologies and their perceptions of self-efficacy. The analysis was organized into four main themes that address the main research questions of the study:

(1) integration of AI technologies and challenges,

(2) self-efficacy in using AI,

(3) perceived impact of AI on student engagement,

(4) challenges to AI Implementation from the teachers' perspectives, and

(5) categorization and prioritization of teachers' perceptions.

RQ1. To What Extent Do Physics Teachers Integrate AI Technologies in Their Teaching Activities?

Theme 1–Integration of AI technologies in physics teaching

Teachers provided varied responses regarding their integration of AI technologies and levels of AI integration into their physics classrooms. Most of the teachers have a positive intention to use technology, but they are not aware of the difference between AI as an adaptive tool and the ICT tools that can be used as simulations or animations. Several teachers showed confusion between simple ICT tools, such as simulations and gamification, and the advanced capabilities of AI tools. This mirrors findings from Gillani et al. (2023), who noted similar confusion among educators in distinguishing between traditional and AI-specific technologies. Their statements illustrate a common misunderstanding about the transformative potential of AI compared to traditional ICT applications. Their answers pivoted around the use of simulation in physics classes. One of the teachers stated,

> "I have used simulations to explain difficult concepts like electricity and mechanics. The visual characteristics of simulations help students grasp difficult ideas."

Another teacher claimed,

> "I have started integrating AI tools such as YouTube and simulations to explain complex concepts in mechanics and electricity, but it is still an effort in progress."

In the context of AI integration, a teacher noted,

> "I occasionally use AI-driven resources, but I feel there is so much potential that I am not using yet."

In the same context, one of the teachers mentioned,

> "I don't use AI-driven resources as often as I should since I haven't explored its potential yet."

This discrepancy aligns with results from multiple studies (Liu et al., 2020) revealing that teachers believe in AI's potential, yet implementation fails in practice due to unfamiliarity or lack of resources (Pedro et al., 2019).

Additionally, a few educators resonated with concerns regarding the limited application of AI technologies in their teaching. Another added,

> "I know that AI can improve learning, but I am yet to embed it into my lessons because of time."

A similar sentiment was echoed by another teacher when she said,

> "Finding relevant resources is tough and I end up mostly using ChatGPT as a resource instead of the textbook in these conventional teaching approaches."

A fellow teacher added,

> "Keeping up with technology is like drinking from a firehose. Keeping up with developments in AI that could benefit my students has been difficult."

These views underline the many barriers identified by researchers (Gillani et al., 2023; Pedro et al., 2019), who argue that teachers find it challenging to use technology in ways that overtly transform learning.

RQ2. How Do Physics Teachers Perceive Their Self-Efficacy in Implementing AI Tools in Their Instruction, and What Key Factors Impact Their Self-Confidence in Integrating These Tools Into Their Teaching Process?

Theme 2–Self-efficacy in using AI

The implementation of AI in education varied significantly among teachers, influenced largely by their self-efficacy. Many educators highlighted the importance of professional development in AI technologies. As one teacher expressed,

> "I think I can use AI tools for my subject, but I don't feel confident enough yet."

Another teacher shared,

> "I can easily use AI tools like ChatGPT to prepare questions and activities. However, I still need more training to feel fully prepared and confident in using the right tools effectively."

In contrast, 4 out of the 15 teachers were uncertain about applying AI tools to physics lessons and questioned their impact on student learning outcomes. One teacher wrote,

> "I'm hesitant about using AI in my physics classes. While it might enhance learning in some ways, I worry it could become more of a distraction. Honestly, I'm not entirely convinced by the technology yet."

Another teacher said,

> "I am hesitating to use AI in my physics lessons as I do not think it can really make any difference with what I already do."

Furthermore, 3 of the teachers surveyed expressed that they felt something like,

> "I doubt I have the necessary skills to respond to all my students' questions about use of AI applications in physics."

This reflects Bandura's (1997) assertion that self-efficacy is one of the most important considerations when a teacher does not want to use any new technology. This is confirmed by the APTS model as well. As per the APTS model, the attitude of a teacher is crucial for technology integration to maintain pedagogical, technical, and social support. Yehya (2020b) and Ojo (2024) similarly emphasized the role of teacher self-efficacy in successful AI integration. It suggests that high self-efficacy correlated with each of the APTS dimensions, creating a favorable environment for AI adoption in the classroom. Ongoing conversations with additional teachers revealed more profound experiences as well. Similarly, one of the teachers stated,

> "I have confidence to use AI in grading and providing feedback but it's hard to see how can we get critical thinking with AI."

This shows that although a few teachers are content with the basic functions of AI however, they still need to know more about how to use it for teaching purposes in-depth. Likewise, one other instructor said,

> "Maybe I can plan some AI tools into my lesson plans but If there are any technical issues in the live classroom then I feel unprepared to solve the matter."

This demonstrates a rising demand not just for learning tools pertaining to AI but also skills relating to managing classroom dynamics around AI. One of the teachers showed a bit more confidence with,

> "I have started using AI in my class and I find it to be able to increase student engagement. On the other hand, I still require much more support around understanding exactly how to explain the ethical implications of AI–and what the students can do about them."

This shows that even quite confident teachers are looking to improve in certain aspects, i.e., the safe use of AI. Lastly, one of the teachers remarked on the disparity of AI-related understanding across subject areas,

> "I feel competent in using AI in relation to language, but in physics and mathematics, I am out of my depth when it comes to applications."

This difference and inconsistency in teachers' self-efficacy and perceptions of AI highlight the need for tailored professional development (Roberts et al., 2019) that provides instruction not only on the technical aspects of AI but also defines how it differs from regular ICT tools. This mirrors the professional development element of the APTS framework; specifically, pedagogical, which highlights the ability to use technology in a way that positively impacts learning outcomes is not enough, and teachers benefit from targeted professional development rather than being 'spoon fed' information.

RQ3. What Do the Physics Teachers Believe Concerning the Impact of AI Integration on Students' Engagement and Learning Outcomes, and What Barriers Do They Encounter When Integrating AI Technologies in Their Classrooms?

Theme 3–Perceived impact of AI on student engagement

One teacher said,

> "AI tools allow me to tailor lessons to meet the needs of my students. I have noticed that students who are opposed to traditional methods of success when they enter a special AI environment, when students want."

In addition, a teacher said,

> "I found that when we used artificial intelligence in lab simulations, students not only understood what was going on quickly, but they also retained the information well. It seems to me that the interactive effects of AI really excite them."

This is consistent with the argument that the use of technology is said to improve understanding and retention of what has been taught (Chen et al., 2020; Xu, 2024). Multiple teachers have confirmed how AI can get students interested in physics classes. They all believe that AI can help create more fruitful learning. A teacher, for example, commented,

> "AI can facilitate learning. I find my students are more engaged with their learning when they use simulations or even AI projects."

Likewise, one teacher said,

> "When I teach via AI tools, the student is interested in the content of the lesson."

This is associated with the APTS model under behavior and value dimensions, where teachers view AI as stimulating and useful to students. Others said it can make their open-ended lessons easier to manage.

> "AI tools enable me to personally customize the modified lesson as desired for students."

One teacher said,

> "I have noticed that when students used artificial intelligence in lab simulations, students not only

> understood what was going on, but they also retained the information quickly."

He continues,

> "I think it is the interactive effects of AI that are what really excite them."

This aligns with the notion that technology use is deemed to promote comprehension and memory of learned content (Xu, 2024). Others said something like,

> "The possibilities are endless! I see AI being used to create virtual exams that students can interact with."

This may reflect the new activities that the APTS system encourages and reflect the need for teachers to integrate technology in meaningful ways. In addition, some teachers see AI as an enabler of cooperative learning.

> "Technical activities can improve cooperation between students."

This will meet the social nature of the APTS model, as it is not enough to engage students but also to create collaboration and communication, following the work of George (2023), which shows that AI can create collaboration. and empower and prepare students for an AI-driven world. Based on these teachers' opinions, it shows that AI can transform physics education into a more integrated, flexible, and cooperative one based on the APTS system and beneficial for students in the learning process.

Theme 4–Barriers to implementation

Despite the positive keenness to integrate AI, several teachers mentioned barriers to AI's effectiveness in engagement. One teacher said,

> "Despite the potential, our school doesn't have the necessary infrastructure and resources to fully utilize AI technologies."

This is a big challenge in the technical dimension of the APTS model, as a lack of access to reliable technology and hardware can undermine even the most innovative AI-driven teaching strategies. Without the right tools or access to AI resources, teachers can't fully realize AI's potential to enhance learning. Another teacher said,

> "Connectivity issues sometimes prevent me from using online AI tools during physics class."

This is in line with the broader literature on technology integration, which emphasizes the importance of supportive infrastructure for effective technology use (Bećirović, 2023) since connectivity problems not only frustrate teachers but also interrupt the flow of lessons, limiting opportunities for interactive and engaging activities (Dridi et al., 2020). Similarly, this highlights the pedagogical and technical intersection in the APTS model where technological barriers disrupt the intended learning processes. When technical issues become a regular occurrence, it erodes teachers' confidence in AI and reduces the overall effectiveness of technology-based lessons. In the same context, one of the teachers added,

> "Even when I want to use AI tools, I sometimes feel that my own understanding of these tools is insufficient to help students when technical issues arise."

This might be a deeper barrier at the level of both the technical and attitude value dimensions of the APTS model. While some teachers recognize AI's potential, their confidence is diluted by a lack of expertise in troubleshooting AI tools, which impacts both teacher and student engagement. Another barrier to AI integration was mentioned by a teacher who said,

> "I don't have enough professional development opportunities focused on AI. Most training is on general ICT tools but not on advanced AI technologies that we are expected to use."

Though teachers want to integrate AI into their classrooms, lack of training diminishes their self-efficacy and makes it difficult to distinguish between basic ICT tools and more sophisticated AI applications. These challenges confirm the need for professional development that is both inclusive and tailored to AI's unique competencies to ensure that teachers can confidently and effectively use AI to enhance students' meaningful learning. The results confirm trends seen in prior research. Like Pedro et al. (2019) and Saputra et al. (2023), this study identifies training, infrastructure, and confusion over tool capabilities as barriers to AI integration. In contrast, this study adds to the literature by focusing specifically on physics teachers in the UAE, where national strategies are aggressively promoting AI adoption (Al Darayseh, 2023; Hendawy & Kumar, 2024).

Theme 5–Categorization and prioritization of teachers' perceptions

To enhance the clarity of findings, teachers' perceptions regarding AI integration were categorized into four main themes, as outlined in **Table 1**. These categorizations and weightings help clarify which areas require the most urgent attention in future interventions and teacher training initiatives.

Table 1. Categorization of teachers' perceptions

Theme	Description	F	PR
Need for professional development	Teachers expressed a strong desire for targeted training.	12	1
Confusion between ICT and AI tools	Misunderstandings about differences in tools and usage.	10	2
Positive intentions and limited implementation	Teachers are willing but face barriers in practical use.	9	3
Lack of technical confidence	Concerns about troubleshooting and applying AI effectively.	6	4

Note. F: Frequency (out of 15) & PR: Priority rank

CONCLUSION AND RECOMMENDATIONS

This study explored the integration of AI tools in physics classrooms in the UAE, with a specific focus on the self-efficacy of teachers. The findings indicated that although physics teachers in Sharjah acknowledge the potential advantages of AI technologies in the realm of physics education, their integration is still quite limited. Teachers have expressed a desire for more training and resources because they want to enhance their confidence and self-efficacy in utilizing AI. The perceived impact of AI on student engagement is positive; however, challenges, such as the availability of AI resources and support for professional development, remain and still need to be addressed.

Thus, based on the findings presented in this paper, several recommendations are proposed. First, professional development opportunities offered in schools and educational institutions need to be aligned with how AI will play a role in physics education in order to bridge the gap in teachers' self-efficacy and their ability to integrate AI into physics teaching. It is essential to provide targeted professional development programs that emphasize the pedagogies mandated by the APTS framework. Educators must understand the potential of AI to analyze student data and modify learning materials instantly. However, they must also remain aware of the differences between conventional ICT tools and cutting-edge AI systems. The training should be directed towards the specific abilities of AI, namely, data-driven personalization, autonomous decision-making based on a combination of human and machine analysis, and intelligent feedback that will not be available with traditional ICT tools. This training needs to be tailored to the specific needs of physics teachers to focus on practical AI tools that can be directly applied in the classroom. It is also important to include workshops that offer hands-on experience with AI-driven tools like virtual labs and interactive simulations, enabling teachers to gain confidence in using AI technologies. Additionally, incorporating online courses for continuous learning allows teachers to stay updated on the latest trends and innovations in education (ElSayary, 2023). Furthermore, establishing a community of practices allows for collaborative teacher networks to share experiences, best practices, and challenges related to AI integration, fostering a community of learning and support.

Second, educational authorities ought to ensure that schools possess the necessary technology and infrastructure for effective AI integration in classes. Schools must confront the technical and infrastructural barriers that may hinder full AI adoption. This includes ensuring

(1) reliable internet connectivity to support AI-based applications in the classrooms,

(2) provision of AI hardware (e.g., computers, interactive whiteboards) that can handle the data-heavy demands of AI tools, and

(3) availability of appropriate AI software that can support differentiated instruction and provide real-time feedback to students.

In the UAE context, where cultural and contextual challenges are present, addressing these factors is crucial to the successful adoption of AI in education. Cultural sensitivity should be embedded in AI training programs to ensure teachers understand how AI can align with local values and educational goals. AI tools can be designed to incorporate elements of the UAE's cultural heritage, making the learning experience more relevant and engaging for students. Additionally, community involvement plays a vital role in AI adoption. Teachers, parents, and students must be actively engaged in discussions about the benefits and ethical implications of AI in education, ensuring that AI adoption is embraced at all levels. To help teachers overcome any hesitation or overwhelm they may feel due to rapid technological advancements, ongoing support is necessary. This can include mentoring programs, where experienced AI users guide less experienced teachers through the integration process.

Furthermore, teachers must be equipped with more than just technical skills. They need a deep understanding of the ethical implications of AI, particularly in how AI tools interact with student data and influence learning outcomes. To support this, professional development programs should include workshops on AI ethics tailored to the educational context, focusing on key considerations like data privacy, transparency, and the responsible use of AI. Teachers should also be given the tools to integrate ethical discussions into their physics lessons, helping students to critically engage with the technologies they use in a meaningful way.

Finally, to maximize the impact of AI in physics education, it is essential to align AI tools with the existing curriculum. AI should not be viewed as a supplementary tool but as an integral part of the teaching and learning process. Teachers must be trained to use AI in ways that enhance and complement the physics curriculum rather than introducing it as an isolated addition. Developing curricular frameworks that incorporate AI-driven activities, assessments, and interactive modules will ensure that AI is effectively integrated into physics lessons. By aligning AI tools with curriculum goals, teachers can create a more engaging, personalized, and adaptive learning environment for students. In conclusion, considering these recommendations, the UAE can enhance the effectiveness of AI integration in physics education, ultimately supporting the goals outlined in its vision 2021 and UAE centennial 2071 plan for a knowledge-based society.

Implications of the Study

This study has several practical implications for educational policy, teacher training, and curriculum design. First, it highlights the critical need to address the conceptual gap among teachers in distinguishing between ICT and AI tools. Without this clarity, educators may fail to utilize AI's full capabilities, thus limiting its impact on student learning outcomes. Embedding this differentiation into both pre-service teacher education and in-service professional development is essential for fostering AI-literate teaching communities.

Second, the findings suggest that AI integration must be approached as a systemic transformation rather than a classroom-level innovation. Professional development must not only train teachers in using tools but also develop their confidence and problem-solving abilities in the context of technological disruptions. This supports the implementation of sustained, iterative training models that are embedded into school culture, including mentorship, peer collaboration, and reflective practices.

Third, the study highlights the importance of ethical and culturally contextualized AI education. In a diverse and rapidly modernizing society like the UAE, AI tools must align with local values and educational goals. This implies that policymakers should ensure AI tools and frameworks are culturally responsive and that ethics, data privacy, and responsible use are embedded in AI pedagogy.

Furthermore, this research serves as a call to action for stakeholders at all levels, including teachers, administrators, policymakers, and edtech developers, to collaborate in developing environments that support ongoing innovation. The systemic barriers identified in this study, such as infrastructure gaps and fragmented support networks, point to the need for national-level strategies that align school-level realities with the UAE's ambitious AI vision.

Limitations and Future Research

Although this study relied on open-ended interviews to explore teacher perceptions and self-efficacy, the absence of quantitative tools such as standardized self-efficacy scales represents a limitation. Future research could employ a mixed methods approach by incorporating descriptive statistical tools alongside qualitative data to provide deeper and more generalizable insights. This would allow a more comprehensive understanding of the relationship between AI integration and teacher self-efficacy.

Additionally, future research could explore subject-specific AI applications beyond physics to identify domain-dependent challenges and innovations. Comparative studies across subjects like mathematics, biology, and languages may reveal unique integration pathways or resistance patterns. Furthermore, longitudinal studies would be beneficial to track changes in teacher attitudes, competencies, and classroom practices over time, offering insight into how sustained professional development and policy interventions influence AI integration outcomes.

Another valuable direction would be to investigate the role of school leadership and institutional culture in shaping AI adoption. Understanding how leadership support, resource allocation, and collaborative school environments affect teacher efficacy and willingness to innovate could provide a broader, system-level perspective for reform strategies.

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