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Articles

Educational Neuroscience Meets AI: A Framework for Secondary Science Teaching

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Abstract

This study investigates the transformative potential of integrating artificial intelligence (AI) into secondary school science education from an educational neuroscience perspective. A literature review of studies published between 2013 and 2024 was conducted to identify key trends, challenges, and opportunities. The thematic analysis of selected sources informed the development of a practical framework that highlights applications and ethical considerations for educators. Findings indicate that AI can personalise learning, promote critical thinking, and enhance teacher-student interactions. However, successful implementation requires alignment with neuroscientific principles, ethical safeguards, and comprehensive teacher training. Challenges include data privacy concerns, algorithmic bias, and ensuring equitable access to AI technologies. The proposed framework offers actionable strategies for effectively integrating AI into science education, emphasising teacher preparedness, ethical practices, and ongoing evaluation to optimize AI's impact on student learning. This novel framework bridges AI technology and educational neuroscience, providing valuable insights for educators and policymakers.

Keywords

Artificial intelligence, educational neuroscience, secondary school, science education, teacher framework

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Introduction

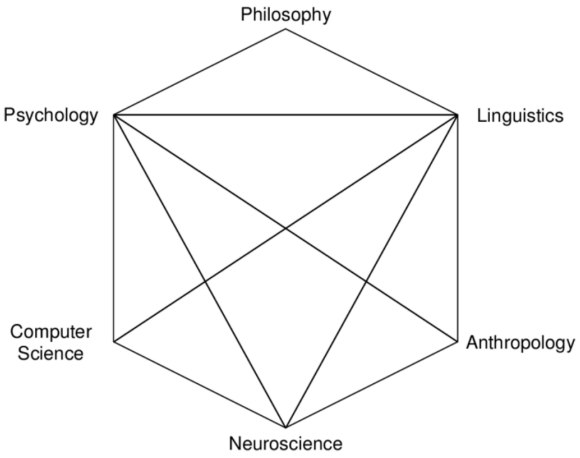
"Artificial intelligence is not a substitute for human intelligence; it is a tool to amplify human creativity and ingenuity". - Dr. Li, Stanford University Professor

Cognitive science is a field that bridges various disciplines and aims to decode the brain's mechanisms that support human cognitive and affective functions, including attention, perception, memory, reasoning, problem-solving, and decision-making (Piwowarski et al., 2019; Palmeri et al., 2017). As reflected in Figure 1, originally the main contributing fields comprised of philosophy, linguistics, anthropology, neuroscience, artificial intelligence, and psychology. However, over time, various areas of application have been included in order to cater for the needs of an everchanging society. One such important area is education.

Within the educational sphere, educational neuroscience refers to the link between brain-based mechanisms of mental activities and behaviours, particularly those related to learning (Howard-Jones et al., 2016). The objective of this particular area of study is to deepen our understanding of how humans learn and perform by merging the latest insights from brain imaging technology with the empirical evidence resulting from behavioural and psychological testing. As an emerging discipline, educational neuroscience finds itself at a pivotal juncture, between those who see great promise in integrating neuroscience and education and those who see the disciplinary divide as insurmountable (Wilcox et al., 2021). Some sceptics, like Bowers (2016), question the potential of neuroscience to enhance teaching methods. On the

Figure 1

The Original Cognitive Science Hexagon According to the Sloan Report (1978) Representing the Links Between Various Fields (Gentner, 2010)



teaching methods. On the other hand, proponents argue that insights into brain function, complemented by behavioural analysis, can indeed enrich our comprehension of learning processes, and potentially foster advancements in teaching and learning strategies (Howard-Jones et al., 2018). This paper proceeds with the argument that, as the brain is the central organ of learning, acquiring a more detailed understanding of its functions holds substantial significance for educational practices.

Building on the foundation laid by cognitive science, it becomes critical to explore the burgeoning interface between neuroscience and the field of computer science that deals with Artificial Intelligence (AI). Broadly defined, AI embodies the development of computer systems capable of performing tasks that typically require human intelligence, encompassing functions like perceptions, recognition, decision-making and control (Russell & Norvig, 2021). Neuroscience and AI share a long history (Macpherson et al., 2021) and the intersection of these disciplines heralds a new era in which the deep, nuanced understanding of brain functions and learning processes afforded by neuroscience converges with the dynamic, data-driven capabilities of AI. In fact, it is argued that a better understanding of the biological brain plays a vital role in building intelligent machines (Hassabis et al., 2017). Beyond this, in a recent scoping review, Surianarayanan et al. (2023) discuss the mutual relationship between neuroscience and AI and argue how neuroscience has in fact been instrumental in building complex applications like robot-based surgery, autonomous vehicles, and gaming applications across a wide range of fields. In turn, the power of AI to analyse complex data and extract patterns has been priceless in supporting and advancing multiple facets of cognitive science research, including an enhanced efficiency of testing hypothesis and interfacing with the brain to control electronic devices like robotic arms (Surianarayanan et al., 2023).

In recent years, as interactive technologies have advanced and become more widespread, their use both in and out of the classroom has increasingly gained popularity. Following this trajectory, the integration of AI within educational settings emerges as a natural progression, leveraging the confluence of neuroscience, AI, and interactive technologies to redefine the landscape of learning and teaching. From its beginnings, AI has been closely linked with education, viewed as a means for understanding human learning processes and applying these insights to advance AI itself (Doroudi, 2023). The infusion of AI into education capitalizes on the deep insights into human cognition provided by neuroscience and the advanced analytical prowess of AI.

The aim of this paper is to adopt an educational neuroscientific perspective in investigating the impact of AI in education, with a particular focus on the teaching and learning of science to secondary school students. It also seeks to propose a working framework to guide teachers through the successful pedagogical integration of AI in their practice.

Methodology

This study employs a narrative literature review approach to synthesise existing research on the intersection of AI, educational neuroscience, and secondary school STEM education. The purpose of this review is to explore key trends, challenges, and opportunities that inform

the development of an evidence-based framework for integrating AI into science education.

The review draws from peer-reviewed journal articles, conference proceedings, and authoritative reports published between 2013 and 2024. Sources were identified through targeted searches in Scopus, Web of Science, and Google Scholar to ensure comprehensive coverage. The search terms included combinations of: *"Artificial Intelligence in Education", "Educational Neuroscience", "STEM education and AI", "Cognitive science in learning", and "AI and teacher-student interactions".*

Studies were included in this review if they:

- Examined AI's impact on cognitive and learning processes in education
- Addressed the integration of AI within STEM classrooms
- Discussed the role of teachers in AI-enhanced education
- Highlighted ethical, pedagogical, or accessibility considerations of AI in schools.

Studies were excluded if they:

- Focused on AI applications outside educational settings
- Did not include a neuroscience or pedagogical perspective
- Lacked empirical or theoretical contributions to AI in education.

The selected studies were analysed using thematic analysis (Braun & Clarke, 2006), which allowed for the identification of patterns related to personalised learning, neuroeducation, teacher-student interactions, ethical concerns, and the role of AI in fostering higher-order cognitive skills. To ensure rigour, two researchers independently reviewed and coded the literature, reconciling any discrepancies through discussion.

Results

As computer science technologies have advanced, coherent and adaptive AI technologies have found widespread application across numerous fields. In this process of deploying AI to enhance innovation, elevate our living standards and safeguard us from danger, it has become essential to also prioritise the implementation of AI in the field of education (Wang et al., 2022). In educational environments, AI technologies have had an extensive impact in supporting educators' teaching methods, enhancing students' learning experiences, and facilitating the transformation of educational systems (Chen et al., 2020; Ouyang & Jiao, 2021). One of the biggest educational challenges of the 21st century, as described by sustainable development goal 4 (UNESCO, 2015), is to develop innovative teaching and learning practices that promote inclusive and equitable quality education and promote lifelong learning. It is firmly believed that AI has the potential of greatly supporting this endeavour. Furthermore, AI is seen to lead a central role in both Education 4.0 and Education 5.0, heralding a pedagogical revolution that is transforming the educational paradigm (Rane et al., 2023).

In Science, Technology, Engineering and Mathematics (STEM) education specifically, automated AI technologies like intelligent tutors, automated assessments, data mining and learning analytics have all been employed to improve the quality of teaching and learning (Hwang et al., 2020; Chen et al., 2020). A systematic review of the application of AI technologies in STEM education conducted by Xu and Ouyang (2022) revealed STEM education as a complex system engaging with the emerging challenges of integrating diverse AI techniques. The paper discusses the potential transformation of teacher-student relationships, the promotion of student-centred learning and the possibilities of using AI to assist teachers in detecting learning patterns and behaviours. They also report on positive impacts of AI technologies on students' academic performance, affective perception, higher-order thinking and learning behaviours (Xu & Ouyang, 2022). Similarly, in a more recent bibliometric analysis of publications on AI in STEM education by Fatimah et al. (2024), the authors continue to confirm the strong, growing trend of AI tools to significantly help teachers automate and optimise teaching and learning activities and analyse students' learning processes to improve teaching patterns. The next section briefly delves into some of the most notable impacts of AI in STEM education as reported in the literature.

Teacher-Student Relationships

One of the areas in which AI has made a major impact is in redefining the roles of teachers and students within the learning environment. Interestingly, Xu and Ouyang (2022) revealed a predominant inclination towards teacher-centred strategies in AI-integrated STEM education, with a scant 5 out of 50 articles highlighting the adoption of project-based learning methodologies. This suggests a slower than anticipated shift from traditional teaching methods to more interactive, student-driven learning experiences. In contrast, findings from a more recent study by Huang and Qiao (2024) illustrate a significant pivot towards project-based initiatives in AI courses that incorporate Science, Technology, Engineering, Arts and Mathematics (STEAM, signalling a move towards more student-centred approaches. Such methodologies empower students to take the helm of their educational journey, engaging them in hands-on projects that not only enhance their understanding of STEM subjects but also nurture their AI literacy which is an increasingly essential skill in the digital age (Holstein and Doroudi, 2022)

Personalised Learning

Advancements in AI have paved the way for personalized learning, a tailored educational approach that accommodates the unique abilities, interests, and specific learning needs of each student (Kaswan et al., 2024). By harnessing the power of AI, educational platforms can now deliver customized content, adjust difficulty levels in real time, and provide targeted feedback, all of which contribute to a more individualized learning experience (Chassignol et al., 2018). The major impact here lies in the possibility of moving from the traditional "one size fits all" model of education, to a system which strives to adapt teaching and learning to fit the individual needs of students and supports them in reaching their full potential, at their own pace. Furthermore, rather than just focusing on extrinsic factors like a reward system, recent adaptive systems are also shifting their focus on learners' emotions (Taurah et al.,

2020). An example of such a system studied in a STEM context is described by Walker et al. (2014), who developed an adaptive system to support students during peer tutoring in high school mathematics classes. More recently, a literature review carried out by Alabdulhadi and Faisal (2021) on the use of self-study simulator-based intelligent tutoring systems in STEM highlighted the importance of feedback and described the feedback traits required to determine positive learning outcomes.

Student Performance

The utilization of AI in educational settings has notably enhanced learner outcomes and attitudes, particularly in fostering creativity, accountability, and critical thinking skills (Zhai et al., 2021). Additionally, these systems excel in streamlining the assessment of student academic performance, significantly increasing the evaluation process's efficiency (Fatimah et al., 2024). Findings from a study by Su et al. (2024), which incorporated STEM principles in the development of an AI educational instrument, demonstrate enhanced student learning outcomes and a deeper comprehension of the taught concepts among students. Their findings also revealed a gender disparity, with girls achieving more substantial learning outcomes compared to boys (Su et al., 2024). In their 2023 study, García-Martínez et al. examined the effects of integrating AI with computational sciences on student performance. Their findings affirm the beneficial influence this integration has on student outcomes, noting an increase in students' enthusiasm for learning and their motivation, particularly within STEM disciplines (García-Martínez et al., 2023). These outcomes align with findings from Huang and Qiao (2024), whose research into the merger of AI with STEAM education revealed that it not only heightened students' enthusiasm for learning but also reinforced their computational thinking skills and boosted their self-efficacy. Other research has similarly highlighted the enhancement of skills such as problem-solving, critical thinking, and creativity, strongly affirming the significant role of AI in elevating the educational experiences of students. (Shumiye, 2024; Wang et al., 2022).

As any other emerging technology, AI also poses various challenges in education in addition to the benefits it offers educators and students alike (Akgun & Greenhow, 2022). It is of utmost importance that awareness is raised about such drawbacks before AI is implemented further within our schools and our classrooms, specifically in science and other STEM subjects.

The Role of the Teacher

First of all, we are living in very particular times in which cycles of innovative technologies are much shorter than the average modern human lifespan (Chng et al., 2023). Thus, unlike previous generations of educators, current STEM teachers need to adapt to the constant fast-paced changes which are not only impacting their lives in general, but also the subjects being taught, their students, and the way they teach. Shifting such mentality might be rather challenging, especially amongst generations of educators who are more experienced, and thus, more used to their own ways of teaching and learning of STEM subjects (Morrison et al., 2021).

It is essential to start by ensuring that the traditional idea of the teacher as the expert who leads students to passively absorb and regurgitate content in exams is not only discouraged theoretically, but also in practice. Despite the numerous research studies backing up active, student-centred teaching and learning in STEM subjects and beyond (Felder & Brent, 2024), conventional practices are still evident, especially when the system adopted remains pretty much exam- and content-oriented. Thus, prior to implementing AI as a pedagogical tool, such fundamental changes need to take place.

Educational neuroscientific research also confirms the importance of fully involving students in their own learning process. This allows for the activation of synapses, which in turn promotes neuroplasticity in the brain, allowing for further connections to be created (Drivas & Doukakis, 2022). Rees et al. (2016) describes neuroplasticity as the brain's capacity to change in a structural and functional manner through the lifespan due to numerous aspects including biological, genetic and even experiential factors. Therefore, as students spend most of their time at school, it is essential that the educational experience offered is conducive to learning and engaging. Despite the fact that the concept of neuroplasticity dates back to the 1890s (James, 1892), only recently was it possible for the living brain to be observed and studied in action due to the advancements in non-invasive neuroimaging techniques. As reflected in the review carried out by Kelly et al., (2008), empirical evidence confirms that such neuroplasticity is driven by experience, especially during adolescence, when the brain is highly susceptible to change, both on a structural and functional level (Lenroot & Giedd, 2006). This confirms that learning is the result of the dynamic interaction between the brain and the individual's environment and experiences (Rees et al., 2016).

Professional Training

It is essential to focus on the teacher's agency in the digitalised STEM classroom (Albion & Tondeur, 2018). A lack of sufficient, high-quality professional development training in the use of AI as a pedagogical tool might lead to more harm than good. Sufficient time needs to be dedicated to such training in order for teachers to feel confident in using AI to teach STEM subjects in their classroom. Additionally, the idea that AI is considered as a replacement to the teacher should be challenged. Importance needs to be given to the educators' self-efficacy as this will ensure that the teacher feels empowered enough to make the best of AI as a useful tool to support their teaching practices.

Costs and Access to Resources

There are various costs associated with the implementation of AI in education. Besides providing professional training to educators, resources such as necessary software, hardware and reliable internet connections all lead to a lot of costs to schools, which at times have limited funding. On the other hand, Martins (2024) highlights how AI can also be used as a cost reduction management tool. Therefore, it is essential to analyse the balance between benefits and costs related to the implementation of AI in schools.

Inclusion and Equity

The costs associated with the adoption of AI as a digital tool can only be one of the factors which can lead to further the divide between education systems, schools and even particular groups of students. Not all schools or families have the same resources and support. Additionally, disadvantaged children might not be provided with the opportunity to learn and use AI which might enable other more privileged children to flourish in their education (Edeni et al., 2024). This can apply to both the home environment and to the opportunities offered at school. On another note, AI can also be the tool which reaches particular students and offers them a personalised learning experience, as highlighted by Holstein & Doroudi (2022). Thus, it is essential for educational institutes to explore this field further.

Privacy

Despite current legislations which exist in order to protect sensitive personal data, violations by AI-based tech companies have led to concerns regarding the security of one's personal data (Murphy, 2019). This is more of an issue in educational settings which involve minors. Despite having various security measures in place, such as consent request, many individuals end up giving their consent without knowing or sharing more detail than they intend to (also known as metadata). This can include geolocation, racial identity and even the preferred language spoken (Regan & Jesse, 2019). Human agency and confidentiality are undermined if not enough attention is given to such matters, even if such data might not be given its due importance. In a school setting, parents and legal guardians also need to be fully aware of any AI system used in order to give their consent.

Surveillance

Most AI systems are equipped with tracking mechanisms based on algorithms and machine-learning models which enable the gathering of data in relation to the preferences and actions of the user (Regan & Jesse, 2019). In an educational setting, such surveillance systems can be useful in identifying students' strengths and weaknesses, as well as foreseeing specific learning patterns and even performances. Additionally, it can also be useful in detecting dangerous online activity, such as cyberbullying or exposure to inappropriate content (Akgun & Greenhow, 2022). Despite it being part of a teacher's duty to monitor and safeguard students from harm, using an AI tracking system might breach ethical boundaries.

Autonomy

As observed by the latest generative AI tools, such as Chat GPT, which can be very powerful in conducting a range of tasks from writing an essay to analysing a data set or even to creating artwork, a user's autonomy can be at risk. First of all, students might not have the necessary skills to sift through the information provided and be critical about what to accept as fact and what to identify as incorrect or misleading. In this case, the prompt used makes a huge difference in the output given. Students might be at risk of blindly plagiarising information which is provided to them based on previous patterns of data. Thus, algorithm-

powered predictive systems can skew an individual's way of thinking and their decision-making process (Kerr & Earle, 2013).

Bias and Discrimination

Issues of bias and discrimination are considered fundamental in debates of AI in education. Various biases are embedded into the machine-learning models upon which AI systems are based (Krutka et al., 2019). These include, but are not limited to, racial bias and gender bias, which can lead to discrimination of a trait over another. Even if they are not included intentionally, these can be observed in numerous AI-based platforms (Stahl & Wright, 2018).

Such challenges should not discourage the implementation of AI in STEM education. However, key stakeholders should not only be aware of these issues but seek to actively solve them and turn these drawbacks into opportunities.

Teaching Science with the Brain in Mind

As reflected in the label associated with the end of the twentieth century, "The Decade of the Brain" (Zeer & Symanyuk, 2021), a lot of prominence has been given to the use and application of the knowledge we have acquired regarding the nervous system, the brain and its functions. Therefore, this application of knowledge has also been proposed in the context of our educational system in order to improve our teaching and learning processes (Piddubna et al., 2023), especially in the field of science and STEM education. Similar to the considerations required for AI to be applied to education effectively, applying neuroeducational principles, or neuropedagogy as it is sometimes referred to, also requires numerous deliberations. The right conditions are essential for the effective implementation of such principles to take place (Mynbayeva et al., 2017). This is based on a number of factors, varying from the social and cultural upbringing of children in our current globalised and everchanging world to the advancements in science and technology around us which impact the way we live and communicate. All of these factors impact the developing brain in various ways. Therefore, knowing the basics of how our brain functions is just a stepping stone to understanding the impact that all these changes have on various brain processes, especially in case of children whose brain might not be developed enough to deal with such changes. In fact, this has been reflected in the heightened rate of psychological, behavioural and emotional disorders that educators need to deal with on a daily basis in their classrooms (Peterson, 2018). Neuroeducation should equip educators with the right tools for them to be able to reach each and every student despite all the challenges.

First of all, science educators need to understand that, by nature, learning is driven by a sense of curiosity and inquiry (Voznyuk, 2019). We tend to focus on eliciting curiosity in early childhood education. However, this remains an essential starting point for learning through the years, even in adulthood and old age. This is what makes an educator grasp an individual's attention and interest them in learning a particular topic, be it in science, mathematics or any other subject. Thus, as educators we need to ensure that all our students are presented with the right environment and with the appropriate learning tasks which are conducive to an

effective learning journey.

Furthermore, as educators we need to keep in mind the role emotions play in the learning experience. Despite the misconceptions, emotional processes are as important as cognitive ones and are strong precursors of learning achievement (Li et al., 2020). Brain imaging techniques have shown that specific parts of the brain, including the amygdala and the hypothalamus, are responsible for feelings which help us make sense of our surroundings and experiences (Šimić et al., 2021). Therefore, these should not be given any less importance in the learning process. Ensuring that a good rapport is built on trust and care with all students is the first step towards identifying any unmet needs which might not allow learning to take place. Therefore, if for example, a child is having issues at home, a teacher cannot expect that child to be able to focus on learning a scientific concept before regulating his emotions and tackling more basic issues first (Blake et al., 2003). It is also essential that the educator is also in touch with their own emotions as this impacts attention and the ability to think, problem-solve and reason things out. Furthermore, eliciting of emotions should be part and parcel of the teaching process. Research shows that positive emotions such as surprise, awe and humour can stimulate attention, motivate students and enhance the learning process (Immordino-Yang & Damasio, 2007; Porcelli et al., 2019). For example, Amran and Bakar (2020) found a strong positive correlation between positive emotions, like enjoyment, hope and pride, and memory in the learning of mathematics.

Another important factor is related to the fact that the brain is multifunctional (Piddubna et al., 2023). As the educator varies the type of activities which tap into the various senses, they do not only reach multiple students but also keep the students engaged as they receive information in a multimodal manner. The brain's interconnectivity also entails that a concept is approached in a multidimensional way in order to engage students in a way that is effective and conducive to learning, especially when it comes to problem-solving and application of knowledge to real-life scenarios (Newton & Miah, 2017). The nature of science and other STEM subjects, which promote the importance of a cross-curricular approach, also helps in this aspect.

As the brain analyses new information in light of prior knowledge, experiences and emotions, the importance of linking concepts is of utmost significance. Thus, the revisiting of previous experiences and the encouragement of making connections which consolidate the new knowledge and skills learnt is very beneficial (Terno, 2011). Despite the fact that learning starts as the result of synapses between neurons, the development of concepts or schemas is mostly related to the organisation of processes in neural networks. Such development of schemas has also been linked to extrinsic stimuli such as social interactions, as the human brain is highly capable of learning by modelling the behaviour observed thanks to mirror neural networks. Thus, the social aspect of learning is also an essential component which has been proven by neuroscientific research (Li et al., 2020).

Another important component of teaching and learning is assessment. In order for new knowledge to be merged with prior knowledge, it is essential for students to be presented with diagnostic formative and summative assessment opportunities (Drivas & Doukakis, 2022). In such a way, an educator can identify the prior knowledge that the individual has and build upon it in order to allow for learning and development to take place (Hwang & Chang, 2011). As educators, we need to move away from the idea of prioritising summative exams, which fail from accurately gathering a holistic image of what the learner truly knows. As previously mentioned, emotions play a crucial role in learning. Thus, how can we expect learners to perform well in an anxiety-inducing exam setup? Assessment should be a tool which provides feedback in a constructive manner that improves memory retention.

As clearly portrayed, teaching with the brain in mind helps educators improve their practices in order to reach all students entrusted within their care. However, how can AI support such an approach towards education? What is the connection between all fields involved?

Bridging the Gap

As highlighted by Doroudi (2023), cognitive science has played a crucial role in the intertwined history of AI and education. Most of the initial pioneers of AI were cognitive scientists who, in addition, also spearheaded significant changes in the field of education. Since the 1950s, such scientists have been united in their objective to discover how both humans and machines think and learn. The human brain has been rigorously studied to understand better ways of developing AI. Additionally, the computational models developed have also been used to describe theories of learning and even to simulate various brain processes in humans (Doroudi, 2023). Thus, the link has not merely focused on the application of AI to solving educational challenges but to adopting an interdisciplinary approach towards the fundamental questions linking education and AI. For instance, the AI pioneer and seminal figure in educational technology, Seymour Papert, highlighted how fundamental questions, such as 'How can we make a machine which will help us understand intelligence in general?' have been put aside and replaced by mere functional applications of AI. Similarly, he remarks how the aim of computer scientists was to bring computer science to children in the classroom, not simply get computers to the classrooms (Wright, 2002). Despite his background in the hard sciences, Papert (1980, as cited in Doroudi, 2023) worked closely with the famous psychologist Jean Piaget who helped him adopt a different perspective, as highlighted in his book *Mindstorms:*

> Two worlds could hardly be more different. But I made the transition because I believed that my new world of machines could provide a perspective that might lead to solutions to problems that had eluded us in the old world of children. Looking back, I see that the cross-fertilization has brought benefits in both directions. (p. 208).

Despite shifting apart through the years, such an interdisciplinary approach between AI and education is of utmost importance. The significance of thinking simultaneously about how our human brain functions and how AI-powered machines work is crucial in progressing further. We believe that educational neuroscience, as a specialized category in cognitive

science, plays a pivotal role in bridging the gap between researchers and educators alike. Therefore, as educators and researchers in the respective fields, we are hereby presenting an evidence-based framework which will guide educators to implement AI as an essential tool in their classroom with a sound understanding of its effects on the teaching and learning process.

Framework

AI has the potential to transform both teaching methods and student learning experiences. Its successful implementation necessitates a thorough examination of its benefits and challenges. This paper proposes a framework focusing on key areas that can leverage AI for educational excellence:

Creating Inclusive and Equitable Learning Opportunities: Utilizing AI to ensure all students have access to tailored educational resources and support, thereby bridging learning gaps.

Detecting Learning Patterns and Behaviours: Employing AI analytics to identify students' learning needs, strengths, and weaknesses, allowing for timely interventions.

Enhancing Student Engagement: Capitalising on AI-driven interactive tools and simulations to captivate and maintain students' interest, thus fostering deeper engagement.

Customization and Personalization of Learning: Providing personalized learning experiences through adaptive learning platforms that cater to individual student needs.

Promoting 21st-Century Skills: Integrating AI to teach critical thinking, problem-solving, and digital literacy, preparing students for the future workforce.

Evaluation and Assessment: Implementing AI to provide more accurate, efficient, and continuous assessment of student performance, aiding teachers in identifying areas needing improvement.

Facilitating Collaboration: Utilizing AI to encourage collaborative learning not just among students but also between teachers and education stakeholders.

Ethical Considerations: Addressing the ethical implications of AI in education, including data privacy, algorithmic bias, and maintaining human oversight in educational decisions.

Conclusion

The findings of this literature review highlight the transformative potential of integrating AI into secondary school science education through an educational neuroscientific lens. The proposed framework addresses key areas such as personalised learning, enhancing teacher-student interactions, and fostering critical thinking and problem-solving skills. However, these findings prompt several points for discussion.

First, the successful implementation of this framework requires a nuanced understanding of the interplay between AI tools and cognitive processes. While AI can personalise learning

experiences, its effectiveness heavily relies on the alignment of AI functionalities with neuroscientific principles, such as promoting neuroeducation and engaging multiple sensory pathways.

Second, ethical considerations remain paramount. The use of AI in classrooms must prioritise data privacy and mitigate potential biases embedded in algorithms. This underscores the need for transparent AI systems and informed consent from all stakeholders, particularly when deploying these technologies with minors.

Finally, the framework emphasises the importance of teacher training and professional development. Teachers must be equipped not only with the technical skills to use AI but also with the pedagogical knowledge to leverage AI in fostering an inclusive and equitable learning environment. Without such preparation, there is a risk of perpetuating existing educational inequities.

Overall, while the framework provides a structured approach to integrating AI in education, further empirical research and iterative feedback from educators are crucial for its refinement and effective implementation.

This study provides a literature-based framework for integrating AI into secondary school science education, grounded in an educational neuroscientific perspective. The framework underscores the potential for AI to foster personalised and engaging learning environments, enhance critical thinking, and improve student-teacher interactions. The discussion highlights that effective implementation depends on aligning AI tools with cognitive and pedagogical principles, addressing ethical concerns, and investing in teacher training.

Despite these promising insights, this study is limited by its reliance on existing literature rather than empirical data. The absence of primary research means that the framework has not been validated in real-world classroom settings. Future research should focus on testing and refining this framework through longitudinal studies and pilot programmes in diverse educational contexts. Additionally, exploring the long-term cognitive and social implications of AI integration will provide a more comprehensive understanding of its impact.

In conclusion, AI has the potential to revolutionise science education by fostering innovative teaching and learning practices. However, realising this potential requires a collaborative effort among educators, policymakers, and researchers to ensure ethical, inclusive, and effective implementation. By addressing the limitations and continuing the dialogue, the educational community can leverage AI to prepare students not only for technological proficiency but also for critical, creative, and collaborative futures.

Notes on Contributors

Clarisse Schembri Frendo is an educator; currently leading the Sciences & VETs department at a local private school. After graduating with a Bachelor of Education, she pursued a Master of Science in Cognitive Science. Besides leading her to a lecturing and supervisory role, this degree also equipped her with the required knowledge and skills to deliver workshops within various entities, such as Esplora. She also graduated with a PGCE in Educational Mentoring which fortified her competences in supporting NQTs. This positive experience has empowered Clarisse to embark on an educational journey leading to a doctoral degree through which she is focusing on science education, technology and educational neuroscience.

Diane Vassallo, PhD, is an academic lecturer at the University of Malta, within the Faculty of Education, Department of Technology and Entrepreneurship Education. Prior to this engagement she worked as a Computing educator. She also served as a curriculum educational leader where she had the opportunity to lead various curriculum initiatives. As part of this tenure, she also served as a member of the committee for the development of the national syllabus in Computing. She is currently involved in a number of research projects, including ERASMUS+ funded projects. Her areas of special interest include Computing Education, Computational Thinking, Curriculum Development and AI in education.

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AI Adoption Among Europe's School Evaluators: Awareness and Challenges

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Abstract

This study examines European external school evaluators' awareness, perceptions, and acceptance of artificial intelligence (AI) in external school evaluation. Drawing on the Technology Acceptance Model (TAM) theoretical framework, this research explores how evaluators' familiarity with AI, perceived ease of use (PEoU), and perceived usefulness (PU) shape their willingness to integrate AI tools. A mixed-methods approach incorporated a questionnaire (n=56) and semi-structured interviews (n=6), revealing moderate awareness of AI's capabilities and an overall optimism about potential efficiency gains. However, adoption remains limited, hindered by insufficient training, infrastructural challenges, and ethical concerns regarding data privacy and algorithmic bias. The findings underscore the importance of targeted professional development, robust ethical frameworks, and adequate technological support for successful AI adoption in external school evaluation processes. By addressing these barriers, policymakers and inspectorates can leverage AI's potential to enhance the accuracy, consistency, and efficacy of external school evaluations.

Keywords

Artificial Intelligence (AI), Technology Acceptance Model (TAM), External School Evaluation, Evaluator Awareness, Educational Inspectors, Mixed-Methods Research, Ethical Considerations, School Improvement

Introduction

The global introduction of ChatGPT by OpenAI in 2022 sparked widespread interest in AI applications across various sectors, including education. AI in Education (AIED) is not a novel concept; its roots stretch back to the 1950s when the first AI program was developed to teach a computer to play checkers. Since then, AIED has focused on developing AI-powered technologies to enhance teaching and learning experiences. Over the past 60 years, AI has evolved from simple applications to sophisticated tools capable of personalising learning environments, grading assignments, and supporting administrative tasks (Lynch, 2023; Guan et al., 2020).

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Today, AI is gaining mainstream attention, propelled by rapid advancements in technology and the enactment of various policies and regulations, like the Artificial Intelligence Act (European Commission, 2025). While AI applications in teaching and learning have garnered increased focus, their adoption in external school evaluation processes remains under-researched. External evaluations are crucial for maintaining standards and promoting school improvement through data-driven assessments. Understanding how external evaluators perceive and accept AI tools is essential for enhancing these evaluation processes and educational outcomes.

This study aims to fill this gap by investigating European school evaluators' awareness and adoption of AI, using the Technology Acceptance Model (TAM) as a theoretical framework. The research addresses the following questions: (1) To what extent are European evaluators aware of AI's capabilities and potential applications in school evaluation? (2) How do European evaluators perceive the ease of use and usefulness of AI-powered tools?

This research contributes to a deeper understanding of the potential integration of AI in external school evaluations by understanding how evaluators approach AI, their level of awareness, and the factors influencing adoption. As education systems worldwide increasingly rely on data-driven assessments to promote school improvement, insights from this study can inform policymakers, inspectorates, and technology developers.

The paper first explores the evolving role of external school evaluators and how European inspectorates are integrating technology into their evaluation processes. It then discusses the relevance of the TAM model in understanding AI integration in educational evaluation. After reviewing relevant literature, the study's methodology is detailed, and the findings are presented. Based on the literature and the TAM, findings indicate key factors impacting AI adoption.

Literature Review

AI in Education and External School Evaluation

While AI has been increasingly adopted in various industries, including education, its application in external school evaluations is still emerging, with limited empirical research addressing this area (Holmes et al., 2019). This nascent stage is due to the recent focus on AI within educational contexts, driven by advancements in machine learning, data analytics, and natural language processing.

Current literature on AIED primarily focuses on its applications in teaching, learning, and administrative processes. AI technologies such as adaptive learning systems, automated grading, and administrative data management have been explored extensively, with studies demonstrating their potential to enhance educational outcomes and efficiency (Guan et al., 2020; Sprenger & Schwaninger, 2021). In recent developments, the Dutch Data Protection Authority has published advice regarding the supervision of AIED, emphasising the need for ethical considerations and regulatory frameworks to manage the deployment

of AI technologies in educational settings (DataGuidance, 2023). OECD (2023) emphasises the effective and equitable use of AIED, providing essential guidelines and guardrails for stakeholders in the educational sector. This report highlights the opportunities and challenges presented by AI technologies, particularly in shaping digital education ecosystems across OECD countries. Additionally, through the Artificial Intelligence Act (European Commission, 2025), the European Parliament has recognised the potential of AIED while also addressing the risks associated with bias and discrimination. It calls for a careful approach to AI deployment, ensuring that it respects fundamental rights and promotes equity in educational access.

The role of inspectorates in holding schools accountable and promoting their improvement constantly evolves, and the boundary between inspecting and advising or supporting is increasingly blurred (OECD, 2013). Recent studies into school inspection across Europe reveal that even though inspectorates hope for the same outcomes, they adopt very different approaches to governing education (Ehren & Baxter, 2021; OECD, 2015). These range from systems that focus on regulation and compliance, such as Sweden, to those that take a more developmental approach, such as Scotland, which largely relies on school self-evaluation to monitor progress (MacBeath, 2019; SICI, n.d.). Countries such as Germany, Estonia, and Sweden have unique approaches to school inspections, with varying emphases on teacher observation, evidence, compliance, and communication with parents. (Greatbatch & Tate, 2019; Baxter & Ehren, 2014). In the UK and elsewhere, evaluators are tasked with observing teaching, assessing learning outcomes, discussing issues with school staff, and preparing reports on teaching quality, student development, and resource management. They also ensure statutory educational requirements are met, verify the maintenance of school facilities, and oversee the provision of medical and meal services (Department for Education, 2023). The role of school evaluators in Europe is influenced by political, historical, social, and economic factors, and there is ongoing research into how inspection promotes good education and student achievement in schools (Baxter & Ehren, 2014; SICI, n.d.). The varying approaches of inspectorates are mirrored in the integration of technology for evaluation processes.

The use of technology in educational evaluations is evolving, particularly in the digitisation of inspection processes. Specific European inspectorates, such as Ofsted, the official body for inspecting schools in England, have begun using digital tools to streamline administrative tasks and enhance data collection during inspections (Harford, 2018). School evaluators are increasingly using technology as part of their inspection process. They often interact with various technological tools and systems for data collection and analysis, reporting, and communication as part of their responsibilities. For instance, in the past years, Ofsted has transitioned to digital tools, with evaluators using digital devices instead of pen and paper during school inspections (Harford, 2018). Ofsted acknowledges the integral role of digital technology in modern educational settings, encouraging its use for various purposes, such as recording observations and tracking progress (Ofsted, 2024). This indicates a clear shift towards the integration of digital technology in the school inspection process for various purposes (Kooser, n.d.), including recording observations, gathering evidence digitally, taking notes, and analysing data.

Overall, integrating technology in the school inspection process significantly improves efficiency, accuracy, and productivity, benefitting both entities and evaluators alike (SafetyStratus, n.d.). The integration of technology modernises the inspection process, enabling evaluators to work more effectively and provide more comprehensive evaluations. (Martínez-Serrano et al., 2023). Integrating digital technology into school external quality assurance processes offers multiple benefits:

- Efficiency: Digital tools streamline evaluation procedures by automating data collection and analysis, reducing administrative burdens and saving time (Joint Research Centre, 2023; Selwyn, 2016).

- Personalisation: Technology enables evaluators to tailor feedback and assessment methods to each school's specific needs, enhancing the relevance and effectiveness of evaluations (Holmes et al., 2019).

- Data-driven insights: Advanced analytics provide evaluators with real-time data and trends, allowing for more informed decision-making and targeted interventions (Chen et al., 2020).

- Collaboration: Digital platforms facilitate communication among educators, administrators, and external evaluators, promoting transparency and shared understanding (Fullan & Langworthy, 2014).

- Continuous Improvement: Ongoing access to data and feedback loops supported by technology fosters a culture of continuous improvement, helping schools to adapt and enhance their practices over time (Bryk et al., 2015).

The benefits of employing digital technology in schools' external quality assurance support the argument for its integration to enhance educational outcomes (European Commission, 2020; EACEA(Eurydice), 2019).

Evaluators' level of digital competence and ability to analyse large volumes of data are very relevant to improving the educational system (Martínez-Serrano et al., 2023). Martínez-Serrano et al. (2023) highlight the necessity for educational evaluators to develop digital competence as part of their professional skills. This competence is essential for effectively collecting and analysing evidence during inspections and supporting school improvement efforts. The research underscores the importance of ongoing training in digital literacy for evaluators to enhance their inspection practices (Martínez-Serrano et al., 2023).

Inspectorates and educational bodies worldwide are exploring or implementing AI to enhance their inspection and evaluation processes. For instance, in England, there are plans for training school evaluators on AI applications to enhance decision-making, and they are using AI in risk assessments to determine whether 'good' schools require full inspections or shorter visits (Ofsted, 2023). This highlights AI's potential to automate processes and analyse large datasets, particularly text, to generate insights supporting inspections and regulatory

activities while maintaining ethical standards (Ofsted, 2023).

Technological advancements by inspectorates demonstrate a growing recognition of the potential for digital tools to improve the efficiency and accuracy of school evaluations (Harford, 2018; Martínez-Serrano et al., 2023; UNESCO, 2019). However, these practices primarily involve existing digital technologies, with AI integration still in its early stages. The use of AI for more complex tasks, such as predictive analytics or automated report generation, has yet to be widely adopted or studied within these inspectorates. This gap presents an opportunity for research to explore how AI can build on these existing technologies to enhance further external school evaluations (OECD, 2023; Zawacki-Richter et al., 2019). As the OECD (2023) notes, integrating AI into educational evaluation requires careful consideration but holds significant promise for improving the effectiveness of evaluation processes.

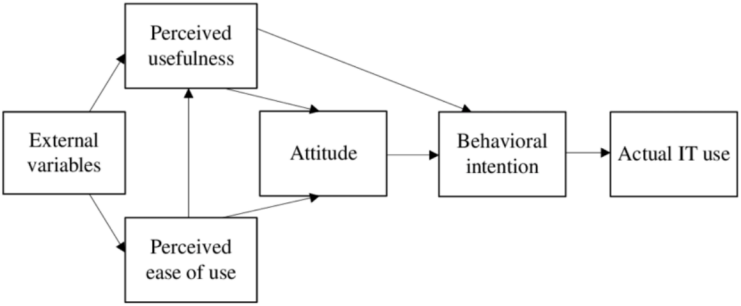
The Technology Acceptance Model

This study is grounded in the TAM theoretical framework, which is widely recognised in the field of technology adoption and use (Davis, 1989; Venkatesh & Bala, 2008). The TAM offers a robust framework for understanding the factors that influence the adoption of emergent technologies such as AI. TAM posits that Perceived Usefulness (PU) and Perceived Ease of Use (PEoU) are primary determinants of users' attitudes towards a technology, which in turn affect their behavioural intention to use it (Davis, 1989; Venkatesh & Bala, 2008). Behavioural intention is a key factor that leads people to actually use the technology (Alharbi & Drew, 2014). TAM is used to study the adoption of digital technologies in educational settings (Granić & Marangunić, 2019; Lin & Yu, 2023), to predict students' and educators' behavioural intention to use and actual use of digital technologies (Marikyan & Papagiannidis, 2024), and to identify areas for improvement and better understand the conditions for successful technology adoption (Granić, 2022; Al-Adwan et al., 2023).

The TAM comprises several variables explaining behavioural intentions and the use of technology directly or indirectly (i.e., PU, PEoU, attitudes toward technology). It has been extended by external variables, such as self-efficacy, subjective norms, and facilitating conditions of technology use (Schepers & Wetzels, 2007). The TAM has gained considerable prominence, mainly due to its transferability to various contexts and samples, its potential to explain variance in the intention to use or the use of technology, and its simplicity of specification (e.g. Marangunić & Granić, 2015).

Figure 1

Technology Acceptance Model (Davies, 1989)



While TAM has been widely applied to various educational contexts, its application to AI in school evaluations remains largely unexplored (Granić & Marangunić, 2019; Zawacki-Richter et al., 2019; Venkatesh & Davis, 2000). Most studies focus on mainstream educational technologies or internal school processes, leaving the external evaluation aspect underexplored (Scherer et al., 2019; Vate-U-Lan, 2020). The limited application of AI in school evaluations can be attributed to the general uncertainty surrounding AI's practical benefits and implications in this context (Holmes et al., 2019; Chen et al., 2020). Additionally, existing literature often overlooks the potential ethical concerns associated with AI adoption, such as data privacy and algorithmic bias, which are crucial for understanding evaluators' hesitancy or resistance to AI (Morley et al., 2020; Araujo et al., 2020; Selwyn, 2021). Given the nascent stage of AI in school evaluations, this study seeks to apply TAM to explore evaluators' attitudes, beliefs, and perceptions about the relevance of technology in their role. The model provides valuable insights into how well AI is accepted and utilised by evaluators and potential barriers to AI adoption. These factors are particularly relevant in school evaluations, where the stakes are high, and the accuracy of assessments is paramount (Alharbi & Drew, 2014).

There is a noticeable gap in applying TAM to study AI adoption in the context of external school evaluations. This study aims to fill this gap by leveraging TAM to investigate how school evaluators perceive AI-powered tools in external evaluations. By focusing on PU, PEoU, and awareness, the research seeks to identify the key factors influencing AI adoption among school evaluators.

In summary, existing research demonstrates a growing recognition of AI's potential in educational contexts, but external school evaluation remains underexplored. Building on the TAM, this study examines how AI readiness, perceived usefulness, and ease of use shape evaluator attitudes and intentions.

Methods

This study employed a mixed-methods approach, combining quantitative and qualitative methods to explore European school evaluators' awareness and adoption of AI in external school evaluations. Mixed-methods research is well-suited for studying emerging technologies where user perceptions are still developing and the practical applications are not yet fully realised (Sprenger & Schwaninger, 2021).

An online survey was distributed to European inspectorates, targeting members of the Standing International Conference of Inspectorates, which comprises national and regional inspectorates and organisations dedicated to the external evaluation of education. The survey, conducted between March and April 2024, received responses from 56 individuals, with countries with the highest representation being: Portugal (n=20), Malta (n=10), the United Kingdom (n=10), and Bulgaria (n=6). The survey included multiple-choice, Likert scale, and open-ended questions to assess participants' familiarity with AI, PU, and PEoU regarding AI tools in school evaluations (Vomberg & Klarmann, 2022).

Following the survey, respondents had the option to volunteer for an online interview. Six evaluators from Belgium, France, the United Kingdom, the Netherlands, and Malta were chosen at random, ensuring only that they are from different countries, and interviewed in July 2024. The semi-structured interviews aimed to gain deeper insights into the participants' experiences, perceptions, and challenges related to AI adoption in school evaluations. Each interview lasted approximately 45 minutes and was conducted online to accommodate geographical distances.

Survey data was analysed using descriptive statistics to summarise demographic information and key variables related to AI awareness, PU, and PEoU. The quantitative analysis provided an overview of the general trends and patterns among the participants. Qualitative data from open-ended survey responses and interview transcripts were analysed using thematic analysis (Braun & Clarke, 2006). The qualitative data was coded to identify themes and any connections that characterised them (Rogers, 2018). The process involved reading and re-reading the data to become immersed and familiar with its content, generating initial codes to identify significant features of the data relevant to the research questions, collating codes into potential themes and gathering all data relevant to each theme. This was followed by refining themes to ensure they accurately represented the data. This allowed the researcher to identify, analyse and interpret patterns of meanings within the qualitative dataset so as to draw meaningful conclusions (Terry et al., 2017).

MAXQDA software was used to organise and code the qualitative data. To ensure confidentiality, participants were assigned pseudonyms (Evaluator_1 to Evaluator_6).

Participants were informed about the study's purpose, procedures, and their rights, including the voluntary nature of participation and the assurance of confidentiality. Informed consent was obtained from all participants prior to data collection. Data was securely stored and anonymised to protect participants' identities.

The data-gathering tools were guided by the principles of transparency and accountability, ensuring that the questions were clear, unbiased, and relevant to the research objectives (Guthrie et al., 2013). The survey was pilot-tested with an evaluator to ensure the clarity and relevance of the questions. Combining quantitative and qualitative data allowed for cross-validation of findings. The survey also focused on user-friendliness, with clear instructions and a logical flow to encourage participation and honest responses (Vomberg & Klarmann, 2022). The rigorous and systematic process ensured that the data-gathering tools were valid and reliable.

Findings

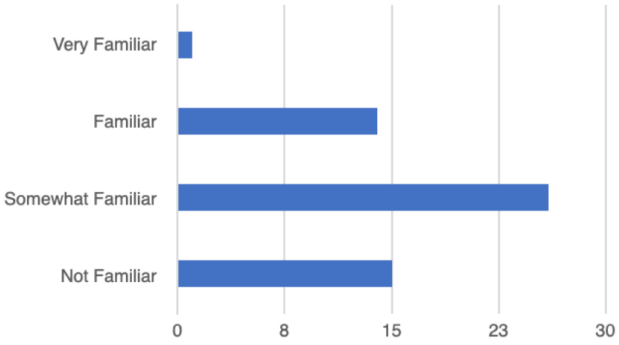
This section presents the findings of the study, integrating quantitative and qualitative data to address the research questions. The results are organised around key themes derived from the TAM and the research questions: awareness and familiarity with AI, perceived ease of use, perceived usefulness, barriers and ethical concerns. The most common role represented was that of an evaluator (including inspector and education officer; n=49), but there were other roles, primarily senior positions in inspectorates. Participants' experience in educational evaluation varied significantly, with an average of 14.7 years, a median of 13.1 years, and the most frequent experience level being 16 years. The varied experience levels across participants suggest a broad base of expertise in educational evaluation, which could influence the openness to and challenges of AI adoption.

Awareness and Familiarity with AI

The study explored the extent to which European school evaluators are aware of AI's capabilities and potential applications in school evaluation. Among the fifty-six survey participants, twenty-six reported being somewhat familiar with emerging technologies, including AI, machine learning, data analytics, and augmented reality. Fifteen participants indicated they were unfamiliar with these technologies, while the remaining 15 claimed varying degrees of familiarity. Moreover, in the survey's open-ended questions, 24 respondents indicated insufficient knowledge about the use of AI in external evaluations of schools.

Figure 2

Familiarity with Emerging Technologies



The interviews revealed significant variations in familiarity with AI among evaluators. Evaluators 5 and 6 demonstrated strong understanding and practical experience with AI tools. For instance, Evaluator_5 stated, "I am working on AI-related projects, particularly in data analysis and training simulations." Similarly, Evaluator_6 mentioned using AI tools to streamline report writing. In contrast, Evaluator_4 acknowledged awareness of AI's potential in education but expressed caution, noting, "AI can enhance adaptive testing and provide valuable insights, but we need to be cautious about ethical implications." Evaluators 1, 2, and 3 exhibited limited familiarity. Evaluator_1 admitted, "I know about AI only through mentions of tools like ChatGPT, but I have not engaged with it professionally."

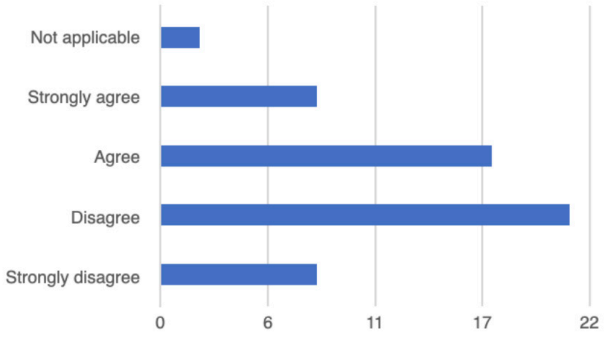
These findings indicate a moderate awareness of AI among school evaluators, with a significant portion unfamiliar or only somewhat familiar. Those with higher familiarity are more likely to have engaged with AI tools and recognise their potential applications in evaluation processes.

Perceived Ease of Use of AI Tools

This section examines how evaluators perceive the ease of use of AI-powered tools in school evaluations. When asked about their perceptions of the effort required to use AI tools, 25 participants agreed or strongly agreed that AI tools are easy to use. Twenty-nine believed that using AI tools would require significant effort.

Figure 3

Confident in Using AI for External School Evaluation Processes



Evaluators familiar with AI find it relatively easy to integrate it into their workflows. For example, Evaluator_6 acknowledged the ease of using specific AI tools but also emphasised the importance of training and the potential difficulty in ensuring accurate implementation. Those with low familiarity perceived AI as irrelevant to their work or potentially difficult to use. Evaluator_1, who claimed to have no experience with AI, did not see the need for its use in their current practices and expressed concerns about adopting new technologies without adequate understanding.

Perceived ease of use varies among evaluators, influenced mainly by their familiarity with AI. The need for comprehensive training emerges as a crucial factor in enhancing perceived ease of use.

Perceived Usefulness of AI in Evaluations

This section explores evaluators' perceptions of the usefulness of AI-powered tools in enhancing school evaluation processes.

Despite their limited familiarity, a majority of participants recognised AI's potential positive impact. Thirty-nine participants agreed that AI could improve the efficiency and accuracy of school evaluations. Ten participants were unsure about AI's usefulness, and seven participants disagreed that AI would be beneficial.

Figure 4

AI Can Enhance the Efficiency and Accuracy of External School Evaluation Processes

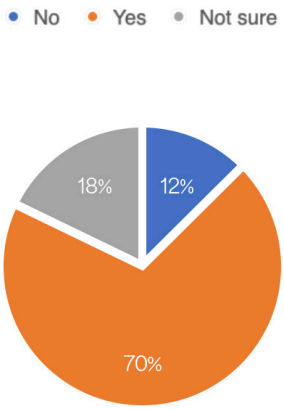
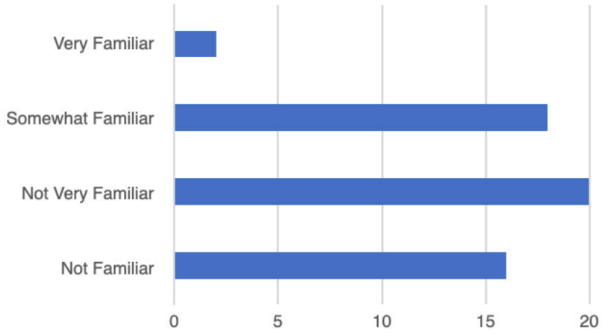


Figure 5

Understanding of the Potential Applications of AI in External School Evaluation Processes



Several respondents highlighted how AI could enhance efficiency and consistency in evaluations. In the open-ended survey response, seventeen participants saw value in AI for analysing large datasets, 8 participants recognised AI's potential in automating report writing and editing, and seven believed AI could assist in predicting future school performance and provide personalised recommendations. In interviews, evaluators with higher familiarity viewed AI as a valuable tool for improving efficiency and consistency in tasks such as report writing and data analysis. Evaluator_6 highlighted how AI could streamline report generation and ensure consistency across evaluations. However, evaluators with low familiarity were uncertain about its usefulness. Evaluator_1 mentioned, "My analysis skills are really good … maybe I do not know how better it [AI] is than me."

While there is a general recognition of AI's potential usefulness, actual appreciation of its benefits correlates with the evaluators' familiarity and experience with AI tools. Those with more exposure to AI are more likely to perceive it as beneficial.

Barriers and Ethical Challenges in AI Adoption

The study identified key barriers that hinder the adoption of AI technologies among school evaluators.

Figure 6

"In the past three years, have you taken training in using digital technology for school external evaluation?"

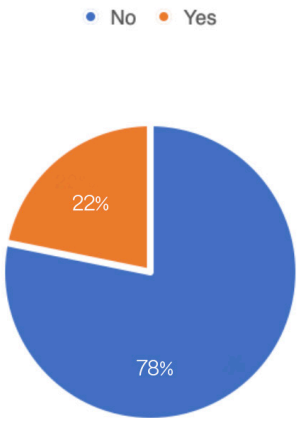
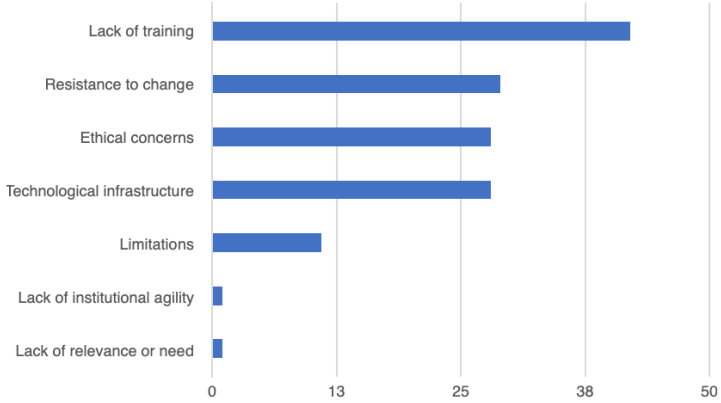


Figure 7

Barriers to AI Adoption in External School Evaluation



Participants reported significant barriers to adopting AI technologies in their evaluation processes. Lack of training was the most prominent barrier, with 43 participants identifying insufficient training as a significant obstacle. Thirty-five participants acknowledged resistance to change within organisations, indicating a cultural challenge in adopting new technologies. Thirty participants cited inadequate technological infrastructure, reflecting limitations in current systems to support AI integration. Thirty-five participants expressed ethical concerns regarding AI use.

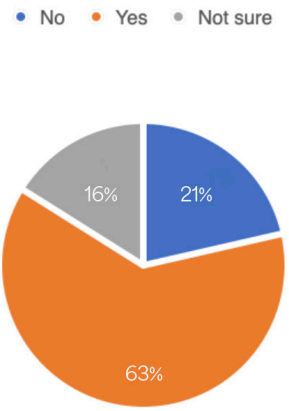
The need for professional development emerged as a critical theme. Evaluator_2 emphasised, "I would need training to understand better how it works, how it will help me carry out my work properly and how it might solve any challenges." Organisational culture also posed challenges. Evaluator_3 noted, "I always work manually before and during the review … I print everything, and even after, I write and type the report." Infrastructure limitations were highlighted by Evaluator_4, who pointed out the need for "appropriate and up-to-date technological devices to effectively meet the requirements." Data privacy concerns and ethical considerations were recurring themes in all interviews. Interviewees stressed the importance of human oversight to mitigate potential biases in AI-powered evaluations.

The predominant barriers to AI adoption are lack of training and resistance to change, compounded by infrastructural limitations and ethical concerns. Addressing these barriers is essential for facilitating AI integration in school evaluations.

When explicitly asked, 35 survey participants expressed significant ethical concerns about adopting AI in school evaluations.

Figure 8

Concern about Potential Ethical Issues or Fairness Implications Related to the Use of AI in School External Evaluation



Concerns about data privacy were significant, with 35 participants worried about risks related to handling sensitive student and school data using AI systems. The potential for AI algorithms to reinforce existing biases was a concern for 40 participants, reflecting apprehension about fairness and impartiality in AI-driven evaluations. A lack of transparency in AI decision-making processes made 30 participants feel uneasy and uncertain about how AI reaches conclusions.

Ethical considerations were also a significant theme in the interviews. Evaluator_5 warned, "If you do not train it correctly, you create stereotypes and bias, and you reinforce them." The need for transparency was highlighted by Evaluator_6, who commented, "openness and transparency around the use of data and how it is processed, I think would be the biggest concern". Evaluators, particularly those less familiar with AI, such as Evaluator_3 and Evaluator_4, mentioned a lack of trust in AI's ability to perform critical tasks accurately, which could hinder adoption. Data security was a concern for Evaluator_4, who expressed, "You are inputting very confidential and sensitive information. Who has access to that? How is that information being used?"

These findings indicate that evaluators are apprehensive about potential biases, data privacy, and the lack of transparency in AI systems. This highlights the need for robust ethical frameworks to address these issues. Addressing these concerns is crucial to building trust among evaluators and ensuring the fair and unbiased application of AI in school evaluation processes.

Integration of Technology in Current Evaluation Processes

This section assesses the current state of technology integration in school evaluations. The survey revealed that technology integration in evaluation processes is limited. Thirty-one participants reported no integration of digital technology in their evaluation practices. Twenty-four participants indicated partial integration, mainly using essential digital tools for administrative tasks. Only one participant reported full integration of digital technologies in their evaluation processes.

The limited use of technology was also evident in the interviews. Evaluator_2 mentioned, "We mainly use digital tools for scheduling and communication, not for evaluation tasks." However, there were signs of readiness for AI integration among those with higher technology use. Evaluator_5, who reported greater use of digital tools, stated, "We have all these indicators, and we have an algorithm every year, and we feed that algorithm all kinds of information on all the schools annually."

The limited integration of technology suggests that many evaluators are not currently positioned to adopt AI tools. This highlights the necessity for infrastructural improvements and organisational support for technology adoption in evaluation processes.

These findings address the research questions by highlighting the evaluators' awareness of AI, their perceptions of its ease of use and usefulness, and the barriers and ethical concerns that influence AI adoption in school evaluations. The insights gained set the stage for further discussion on how to facilitate the effective integration of AI in educational evaluation processes.

Discussion

The findings reveal moderate awareness and limited adoption of AI, with significant variations in perceived usefulness and ethical concerns. While there is optimism about AI's potential, substantial barriers remain. This section interprets these findings concerning the research questions, theoretical framework, and existing literature.

Awareness and Familiarity with AI

The moderate awareness and familiarity with AI among school evaluators, with only just under half (n=26) somewhat familiar and 15 participants unfamiliar, highlight a significant gap in exposure to AI. This aligns with Granić and Marangunić's (2019) observation that familiarity with AI in educational contexts is still developing, particularly in less common applications like external evaluation. While AI has been increasingly adopted in teaching and learning (Sprenger & Schwaninger, 2021), its role in external evaluations is far less explored. The gap in familiarity signals a critical need for targeted professional development, which aligns with Guan et al. (2020), who also found that a lack of understanding of AI's practical applications limits its broader use in education. As the TAM suggests, familiarity influences PEoU and PU, which are key components in whether evaluators will eventually adopt AI tools (Davis, 1989).

The analysis suggests that familiarity with AI is a key determinant of its perceived usefulness and ease of use for school evaluators. Those with more exposure to AI-powered tools tend to view it more favourably, recognising its potential to improve efficiency and consistency in educational evaluations. The low integration rates may reflect concerns about the complexity and effort required to use AI tools effectively. Addressing these concerns through user-friendly technology design and comprehensive training could facilitate higher adoption rates.

Perceived Usefulness and Integration of AI

Most participants (n=32) expressed that AI could improve the efficiency and accuracy of school evaluation processes, particularly in data analysis and report generation. This finding aligns with the TAM, which posits that PU is a core determinant of technology adoption (Venkatesh & Davis, 2000). Evaluators recognise the potential of AI to enhance data-driven decision-making and streamline processes, consistent with Holmes et al. (2019), who noted AI's ability to manage and process vast amounts of data in educational settings. These findings support the notion that AI can streamline various aspects of the evaluation process, reducing the workload on evaluators and enabling more data-driven decision-making. The ability of AI to handle large datasets and provide detailed analysis can significantly enhance the quality and reliability of evaluations.

Despite recognising its usefulness, the actual integration of AI into evaluations remains minimal, with more than half of the participants reporting no integration. This gap is similar to what Harford (2018) noted in Ofsted's initial efforts to digitise its evaluation processes. The limited integration suggests that even when evaluators understand AI's value, practical implementation is hindered by infrastructural constraints and a lack of tailored AI tools for external evaluations (Selwyn, 2019). This is compounded by institutional and staff resistance to change. Addressing these barriers is key for actual adoption.

Barriers to AI Adoption and Implications

Resistance to change was a significant barrier mentioned by the study's participants. This reflected the challenges outlined by Rogers's (2003) diffusion of innovations theory regarding how established norms can impede the adoption of new technologies. Moreover, the study found that lack of training, ethical concerns, and inadequate technological infrastructure are other main barriers to AI adoption in school evaluations. These findings are consistent with Alharbi and Drew (2014), who identified similar barriers to technology integration in educational settings.

Training

Lack of training emerged as the most significant barrier, with 43 participants indicating that in the past 3 years, they had not received formal training on digital technologies like AI. This aligns with findings by Granić & Marangunić (2019), who emphasised that insufficient training often slows technology adoption. Without proper training, evaluators may struggle to

understand the full potential of AI and feel uncertain about integrating it into their workflows, negatively affecting their PEoU and PU (Davis, 1989). As Marikyan & Papagiannidis (2024) suggest, targeted training focusing on both the technical aspects and practical applications can enhance evaluators' competence and confidence in using AI-powered tools.

Educational policymakers and leaders should prioritise the development of tailored training that focuses on increasing AI competence among evaluators. Such programmes should cover the technical aspects of AI tools and emphasise their practical applications in the context of school evaluations, as outlined by Guan et al. (2020), thereby enhancing PEoU and PU and fostering adoption.

Investment in Infrastructure

Inadequate technological infrastructure, including both hardware and software, underscores the practical limitations inspectorates face. Guan et al. (2020) mirrored this, pointing to the need for more investment in technological infrastructure to support AI adoption in educational contexts. Selwyn (2019) noted that technology adoption remains unlikely without adequate resources. Evaluators cannot effectively use AI tools without the necessary hardware, software, and support systems.

Policymakers, inspectorates, and technology developers should invest in upgrading technological infrastructure to support AI integration. Ensuring that evaluators have access to necessary technologies will enhance PU and facilitate adoption, aligning with TAM's assertion that external factors influence technology adoption.

Ethical Concerns

Ethical considerations were significant, with most participants concerned about data privacy, potential biases and lack of transparency in AI systems. Participants were concerned that AI systems could inadvertently reinforce existing inequalities, mainly if they rely on biased historical data (Morley et al., 2020). Additionally, the opacity of AI decision-making processes undermines trust (Araujo et al., 2020; Selwyn, 2021).

Robust ethical frameworks must be developed to address these concerns (Morley et al., 2020). Aligning AI implementation with policies like the EU AI Act (2024) can mitigate ethical issues. Transparency, accountability, and fairness must be integral to AI systems to build trust among evaluators. Addressing ethical concerns will be critical to the successful adoption of AI in school evaluations.

Limitations of the Study

Despite the valuable insights provided by this study, there are specific limitations. First, the relatively small and uneven sample size may limit the generalisability of the findings across inspectorates. Second, the cross-sectional design provides a snapshot in time, not accounting for evolving perceptions. Third, reliance on online translations and potential language barriers could have affected the accuracy of responses. Lastly, the fast-paced development of AI means new tools and policies may have emerged since data collection. Future research should consider larger, more diverse samples, employ longitudinal designs, and incorporate professional translation services to enhance the validity and applicability of these findings.

Implications

This study extends the TAM by highlighting the significant role of ethical concerns as external variables influencing technology adoption in the context of AI integration in education. Incorporating ethical considerations into the TAM framework may provide a more comprehensive understanding of adoption factors.

For policymakers and educational leaders, the findings underscore the necessity of investing in training programs, infrastructural improvements, and ethical guidelines to facilitate AI adoption. The potential benefits of AI in enhancing evaluation processes can be realised by addressing barriers such as lack of training and ethical concerns.

Addressing the identified barriers through strategic interventions can enhance evaluators' adoption of AI, leading to improved efficiency and effectiveness in external school evaluations. Stakeholders can fully leverage AI's potential by investing in training, infrastructure, and ethical considerations. These efforts will contribute to improving school evaluation practices and educational outcomes.

Conclusion

This study highlights both enthusiasm and trepidation toward AI among European school evaluators. The findings reveal moderate awareness and adoption of AI. Rooted in the TAM, the study shows how perceived usefulness, ease of use and ethical safeguards shape evaluators' readiness to adopt AI. The results underscore the importance of comprehensive training, infrastructural development, and robust ethical frameworks to address evaluators' concerns about data privacy and bias.

By embracing targeted professional development and mindful policy creation, inspectorates and educational authorities can unlock AI's potential for enhancing school evaluations. As technology advances rapidly, continued empirical investigation will be vital, enabling stakeholders to refine best practices, mitigate risks, and ultimately ensure that AI tools support fair, transparent, and effective educational outcomes across Europe.

Notes on Contributor

Keith Aquilina specializes in digital education and quality assurance with over two decades in education. He holds a Master's in Online and Distance Education from Open University, UK, and a diploma in computing in education. An expert in the European Commission's IFREG advisory group, he serves as a digital evaluator with MFHEA and a visiting lecturer with IfE.

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Whimsical Wonders or Digital Dangers: Exploring the Influence of Artificial Intelligence During Story Reading in an Early Years Classroom

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Abstract

This qualitative research explored the integration of Artificial Intelligence (AI) technology into story-reading sessions in an early years classroom. It focused on the strategies employed by a kindergarten educator in a Maltese state school to maintain a balance between technological innovation and traditional storytelling elements. Both the Early Childhood and Care National Policy Framework for Malta and Gozo (MEDE, 2021) and the Digital Education Strategy 2024-2030 (MEYR, 2024) emphasise integrating digital technology in early education to develop multi-literacy skills, foster creativity through digital storytelling and animation, and ensure a safe environment for communication and collaboration. The study aimed to identify innovative ways to use AI to enhance learning experiences and improve student outcomes while still preserving the essential aspects of human story reading. The goal of this research was to explore the thoughtful methods used by the kindergarten educator to blend AI into story reading, underlining how this integration benefits education by creating better learning environments for young students. Grounded in a qualitative framework, the research employed classroom observations and semi-structured interviews with the educator as primary data sources. This study not only enhanced theoretical understanding but also provided practical insights, offering useful perspectives for educators navigating the evolving realm of technology in early childhood education (ECE). Additionally, it aimed to assist policymakers in supporting educators with the effective integration of AI in their classrooms.

Keyword

AI technology, early years education, story reading, technological innovation, traditional story reading elements

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Introduction

The integration of AI into early childhood education (ECE) has garnered significant interest, as emerging technologies present new opportunities for enhancing learning experiences. AI in education refers to using intelligent systems to support and augment traditional educational practices, with researchers advocating for engagement with AI tools as early as possible, even from preschool (Williams et al., 2019). These systems can adapt to individual learning needs, provide real-time feedback, and facilitate a more interactive and engaging learning environment (Zawacki-Richter et al., 2019). The potential of AI to transform education is vast, encompassing applications such as intelligent tutoring systems, personalised learning environments, and automated assessment tools (Mousavinasab et al., 2021).

From a theoretical perspective, the integration of AI in ECE can be understood through the concepts of digital literacy and emergent literacy. Digital literacy refers to the ability to access, understand, and critically engage with digital technologies (Buckingham, 2015). It is increasingly recognised as a crucial skill for young learners in the 21st century (Hague & Payton, 2010). In ECE, AI-driven tools can serve as an effective way to help children develop these foundational digital literacy skills, allowing them to navigate and make sense of digital content in an age-appropriate manner.

Similarly, emergent literacy theory emphasises the gradual development of reading, writing, and communication skills from infancy, facilitated by rich, interactive experiences with language (Whitehurst & Lonigan, 1998). Recent advances in technology have led to the emergence of social robots as educational tools that have the potential to enhance early language and literacy skills in young children (Neumann, 2020). By incorporating AI tools into storytelling, ECE educators can promote both emergent literacy and digital literacy, creating meaningful, technology-mediated learning experiences that support cognitive and social development.

Story reading is a fundamental pedagogical tool in ECE. It fosters language development and initial literacy skills, allowing children to understand, produce, and make predictions about narratives. This practice also helps children incorporate formal aspects of written language in their approaches to reading and writing (Cárdenas-García et al., 2017). By integrating AI, educators can create dynamic story reading and storytelling sessions that captivate young learners' attention and provide personalised learning experiences. Research by Kewalramani et al. (2021) indicated that children's interactions with AI robots enhance creative, emotional, and collaborative inquiry skills. However, the introduction of AI in such a sensitive educational stage also raises concerns about maintaining the human touch and the traditional elements that are crucial in ECE. The integration of AI in education is a complex and debated issue, especially concerning the ethical principles that guide its design and development. While AI applications in schools continue to grow, it is crucial that we pay more attention to ethical considerations (Karagkouni & Sotiropoulou, 2023).

This study aimed to explore the use of AI during story-reading sessions in a kindergarten classroom in a Maltese state school, with a focus on balancing technological innovation and

the preservation of traditional story-reading elements. Through observations of classroom interactions and semi-structured interviews with an early years educator, the research sought to identify effective strategies for integrating AI in a manner that enhances engagement and learning outcomes, while preserving the essence of human storytelling interactions.

The study is based on the following research question:

What strategies can educators employ to integrate AI technology into storytelling sessions effectively, ensuring a balance between technological innovation and the preservation of traditional story-reading elements?

Conceptual and Research Foundations

Story Reading in ECE

Story reading, particularly in ECE, involves the active engagement of young children with written narratives through a shared, interactive experience (Piasta et al., 2012). It is a crucial pedagogical tool that fosters the development of early literacy, language comprehension, and socio-emotional skills (van der Wilt et al., 2022). In preschool settings such as kindergartens in Malta, story reading typically involves an adult reading aloud to children, creating an environment that encourages language exposure, vocabulary acquisition, and an understanding of narrative structures (Brodin & Renblad, 2020). This shared experience allows children to engage in discussions, ask questions, and relate the story to their personal experiences, further enhancing their cognitive and emotional development (van der Wilt et al., 2022). The practice of story reading at an early age is foundational for emergent literacy and future academic success (Sofri et al., 2023). Multiple studies confirm that early engagement with reading is key to developing critical literacy and communication skills (Brodin & Renblad, 2020; van der Wilt et al., 2022).

The positive effects of story reading on ECE have been well documented in the literature (Gallets, 2005; Cárdenas-García et al., 2017; Piasta et al., 2012; Sofri et al., 2023). Van der Wilt et al. (2022) examined two methods of shared book reading: traditional interactive reading and interactive reading with mind maps. Both approaches were found to significantly enhance children's language skills. The study highlighted dialogic scaffolding, where educators engage children in meaningful discussions around the story. This interactive method not only improved thematic vocabulary but also promoted narrative competence and critical listening skills. Importantly, both methods demonstrated effectiveness in enhancing children's language skills, suggesting that various forms of interactive reading, when structured properly, positively contribute to early literacy development (van der Wilt et al., 2022).

Similarly, Brodin and Renblad (2020) conducted a large-scale study in Swedish preschools, emphasising the importance of reading aloud in supporting preschool children's speech and language development. They found that regular reading sessions significantly enhanced children's communication abilities, concept development, and vocabulary. Furthermore, they stressed the compensatory role of preschools, particularly for children from linguistically

deprived backgrounds, in fostering early literacy skills. The authors argued that reading aloud helps children with speech and language difficulties to catch up with their peers, provi ded educators are well-trained and prioritise literacy activities in the classroom (Brodin & Renblad, 2020). This aligns with the broader consensus in ECE that literacy-rich environments significantly influence language outcomes for young children (Hargrave & Sénéchal, 2000; Piasta et al., 2012).

Traditional vs. Innovative Approaches to Story Reading

Traditional story reading, typically characterised by an adult reading aloud, remains one of the most popular and effective methods of fostering literacy in young children. Sofri et al. (2023) examined how children's emotional engagement during traditional story-reading sessions is linked to school readiness. Their findings indicated that emotional competencies, such as identifying with story characters, understanding the narrative lessons, and connecting personal experiences to the story, are closely linked to improved verbal abilities, social skills, and learning behaviours. Similarly, Mol and Bus (2011) found that frequent storybook reading is associated with accelerated vocabulary growth and improved comprehension skills. This emphasises the dual role of story reading in enhancing both literacy and emotional and social development, which are essential for school readiness (Sofri et al., 2023).

In contrast, more innovative approaches to story reading, such as those involving visual aids like mind maps, offer additional benefits, particularly for cognitive development. Van der Wilt et al. (2022) demonstrated that mind-mapping, a technique where information from the story is visually represented, helped reduce cognitive load and improve causal reasoning by allowing children to see connections between story elements. While no significant difference was found between traditional interactive reading and mind-mapping in terms of overall language competence, both methods positively impacted children's understanding of narrative structures and improved their critical thinking skills. In a similar study, Wulandari (2019) discovered that both story mapping and mind mapping are effective techniques for enhancing students' reading comprehension. This indicates that combining traditional story reading with innovative methods could provide a balanced approach, benefitting multiple developmental areas.

Brodin and Renblad (2020) emphasised the importance of a balanced approach to reading aloud and storytelling. They highlighted that while traditional methods are effective, educators should also use intentional strategies to enhance engagement and comprehension. The authors noted that the quality of interactions during reading sessions, such as asking questions, encouraging predictions, and making connections between the story and real-life experiences, significantly impacts the educational benefits of storytelling. These findings are consistent with previous research, which indicates that both the content of the reading material and its presentation influence children's literacy and cognitive development (Mol & Bus, 2011).

The literature strongly supports the notion that story reading is a critical component of ECE, with numerous studies stressing its role in fostering language, cognitive, and emotional development (Brodin & Renblad, 2020; Sofri et al., 2023; van der Wilt et al., 2022). Whether through traditional reading aloud or more interactive approaches such as mind-mapping, story reading offers significant benefits that contribute to children's readiness for school. Additionally, the emotional engagement elicited during story reading provides valuable insights into children's cognitive and social development, further supporting its role as a vital pedagogical tool. Integrating various story reading strategies in early childhood classrooms offers educators flexible methods for supporting diverse learners and enhancing literacy outcomes, particularly for those who may need additional language support (Brodin & Renblad, 2020; Sofri et al., 2023). Therefore, a combined approach that incorporates both traditional and innovative techniques may provide the most comprehensive benefits for young learners. Consequently, the integration of AI in reading stories is being explored.

AI in ECE

AI refers to the capacity of machines to perform tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and language translation. These technologies can be categorised into narrow AI, which is designed to perform a specific task such as facial recognition, and general AI, which would have the ability to understand and reason across a wide range of tasks (Zawacki-Richter et al., 2019). AI systems leverage techniques such as machine learning, where algorithms learn from and make predictions based on data, and natural language processing, enabling machines to comprehend and generate human language (Ng et al., 2021). As the prevalence of AI technologies grows in everyday life, understanding their implications and applications becomes essential, particularly in educational contexts. Jocius et al. (2021)emphasise the need for formal training programmes to prepare educators with the skills and knowledge necessary to teach computational thinking, particularly in environments where such training is not yet standardised.

The integration of AI in ECE has gained traction as researchers and educators recognise its potential to enhance learning experiences. AI tools are increasingly being employed to facilitate personalised learning, improve engagement, and support educational outcomes for young children. For instance, platforms like PopBots allow kindergarten children to interact with social robots, promoting understanding of foundational AI concepts such as knowledge-based systems and supervised machine learning (Williams et al., 2019). Such interactions have shown that they can not only improve children's comprehension of AI but also shape their perceptions of robots, with younger children viewing them as intelligent toys and older children recognising their limitations (Williams et al., 2019).

ChatGPT, a natural language processing model, represents another innovative application of AI in ECE. Its capabilities can be leveraged to enhance teaching activities. By providing rich, interactive resources tailored to children's learning needs, ChatGPT can facilitate personalised learning experiences that engage children and help them better understand abstract concepts (Zhang, 2024). Additionally, ChatGPT encourages autonomous and

collaborative learning, allowing children to explore content and communicate with peers in a supportive environment. This flexibility can significantly benefit early childhood educators by aiding them in activity design and facilitating more effective teaching strategies.

Several studies have demonstrated the effectiveness of AI applications in ECE. For example, AI-driven educational tools have been found to enhance skills such as creativity, emotional regulation, and collaborative inquiry among children (Su & Yang, 2022). Moreover, educational robots have proven to improve social interactions and engagement in learning activities, fostering a more participatory environment. Beran et al. (2011) found that children naturally exhibit curiosity and a willingness to explore and interact with new objects, including robots. They appear inherently inclined to engage positively with these technologies, as demonstrated by Beran et al.'s finding that 83.7% of children believed the robot could engage with them in various ways. This highlights the need for robots to be multifunctional and adaptable to different interactions. Druga et al. (2019) also conducted a study focusing on AI literacy among children, emphasising the importance of inclusive education in this domain. Their research highlights the need for accessible AI learning experiences tailored to diverse populations, aiming to democratise AI education for young learners. However, despite these advancements, there remains a significant gap in comprehensive research on AI's role in ECE, highlighting the need for further investigation into its applications and outcomes (Su & Yang, 2022).

As children increasingly interact with AI technologies in their everyday lives, the need for digital literacy becomes paramount. Digital literacy encompasses the skills required to effectively navigate, evaluate, and create information using digital technologies. The Early Childhood and Care National Policy Framework for Malta and Gozo emphasises the importance of creating "Meaningful opportunities for learning about, with and through digital technology to enhance the development of responsible multi-literacy communicative repertoires enabling children's successful participation in a digital society" (MEDE, 2021, p. 15). Similarly, the Digital Education Strategy 2024-2030 states that "Early Years education should foster creativity in children by allowing them to create their own digital stories, drawings or animations using age-appropriate tools. Further to this early childhood education shall create a safe digital environment where children can share and discuss their creations to enhance communication skills" (MEYR, 2024, p. 32). Therefore, in the context of ECE, this may include understanding the principles of AI, recognising its applications, and developing critical thinking skills to assess the information presented by AI systems (Ng et al., 2021).

Research indicates that while young children are adept at using digital devices, they often lack a foundational understanding of how these technologies operate (Marsh, 2016). This gap can lead to misconceptions about AI and its capabilities. For that reason, fostering AI literacy in ECE is essential for equipping children with the skills they need to thrive in a technology-driven society. Incorporating AI literacy into early childhood curricula prepares children for future technology interactions and fosters a critical understanding of the ethical considerations and limitations of AI tools (Su et al., 2023). The integration of AI in ECE offers significant opportunities to enhance learning and development. As educators increasingly utilise AI technologies, it is crucial to prioritise the development of digital literacy among

young learners, ensuring they possess the necessary skills to engage with these advanced tools responsibly and effectively.

The use of AI in ECE is a burgeoning field, particularly in enhancing children's learning experiences during story reading (Maureen et al., 2020; Wang et al., 2024). However, the specific role of AI in story reading and storytelling for kindergarten students remains underexplored, with existing research providing glimpses into both its potential and limitations (Rahiem, 2021; Tolksdorf et al., 2021). Several studies, nonetheless, illustrate the innovative applications of AI in storytelling, including digital storytelling platforms (Maureen et al., 2020; Rahiem, 2021), storytelling robots (Tolksdorf et al., 2021), and augmented reality books (Wang et al., 2024), each offering distinct opportunities for improving educational outcomes.

Maureen et al. (2020) demonstrated that structured digital storytelling significantly improved both literacy and digital literacy among kindergarten students, even more so than traditional storytelling methods. The use of digital elements, such as audio and visual aids, engaged children more deeply and fostered emergent literacy skills through interactive and play-based learning experiences. This finding aligns with Rahiem (2021), who studied the use of digital storytelling in a storytelling club in Jakarta. The study reported that digital tools made storytelling sessions more captivating and engaging, thereby enriching the learning experience and enhancing children's comprehension. This increase in engagement through digital storytelling is further supported by the integration of multimedia and interactivity, allowing children to explore stories in new ways. For example, Wang et al. (2024) introduced an AI-driven augmented reality platform, which offered immersive story experiences and fostered greater interest in reading and comprehension.

The integration of AI into story-reading sessions for young children offers a transformative approach to ECE. AI tools such as digital storytelling platforms, storytelling robots, and augmented reality books provide opportunities to enhance literacy and engagement in innovative ways. Research demonstrates that these tools not only make learning more interactive but also foster critical cognitive and emotional skills. For instance, augmented reality systems like 'Metabook' enhance engagement through immersive experiences, combining visual and conversational AI for deeper story comprehension (Wang et al., 2024). The need for balanced integration with traditional story reading practices to ensure the human elements vital for young learners' socio-emotional development requires more exploration (Rahiem, 2021; Tolksdorf et al., 2021).

Methodology

This study employed a qualitative case study approach to explore the integration of AI into story-reading sessions in a state kindergarten classroom. Qualitative methodologies are particularly effective in capturing the nuances of educational practices and the contextual factors that influence their implementation (Creswell & Poth, 2013). The research design included five classroom observations and two semi-structured interviews with the kindergarten educator to gain comprehensive insights into the application of AI tools in ECE.

"The value of observation is that it permits researchers to study people in their native environment in order to understand 'things' from their perspective" (Baker, 2006, p. 171). In this study, classroom observations were important as they provided hands-on data about real-time interactions, teaching strategies, and student engagement. The number of observations was based on the sessions needed to read the entire book with the students. Observations allowed the researcher to capture the dynamics of shared book reading, dialogic scaffolding, and interactive activities using AI tools such as ChatterPix Kids, OZOBOT, and other applications. These observations were essential for identifying how AI tools influenced student behaviour, engagement, and learning outcomes during story-reading sessions. By situating the research in an authentic classroom setting, the study provided a nuanced understanding of the practical benefits and challenges of AI integration.

Two semi-structured interviews were conducted with the kindergarten educator, one before the classroom observations and one afterwards. The first meeting established the context, goals, and strategies for integrating AI into story reading. The participant had the freedom to select the strategies and methods for implementation. The post-observation interview was crucial for gathering the educator's insights on the observed sessions, the perceived impact of AI tools, and the challenges encountered. This interview served as a reflection which is vital in educational research as it provides opportunities for educators to articulate their experiences, enabling a deeper understanding of the practical implications of pedagogical innovations (Broeder & Stokmans, 2012). The discussions during the interviews also helped validate the observational data by comparing it with the educator's perspectives, ensuring a holistic analysis of the findings.

The researcher's positionality is essential for ensuring objectivity and minimising bias during data collection (Darwin Holmes, 2020). With extensive experience in primary and kindergarten education, the researcher was well-acquainted with the classroom environment, which facilitated a comfortable and natural observation process. This immersion proved to be an enriching experience. While some minimal interaction with kindergarten students was maintained to ensure their sense of safety, participation was intentionally limited to prevent any undue influence on their engagement during activities (Flewitt, 2005). Data collection involved detailed note-taking, along with photographic documentation to capture key moments throughout the sessions. Ethical guidelines were strictly adhered to, with informed consent obtained from the parents and the educator before the study commenced, aligning with established research ethics in ECE (Spriggs et al., 2010).

By combining classroom observations and reflective meetings, this study captured the observable outcomes and the underlying thought processes involved in integrating AI tools into story reading. This methodological approach ensured a comprehensive understanding of the research problem, aligning with established practices in qualitative educational research (Creswell & Poth, 2013).

Findings and Analysis

The Choice of AI Tools and their Integration

The educator used five different AI tools, which were introduced to the children either on an interactive panel or on the kindergarten educator's mobile device. The selected book was "The Paper Dolls", which aligned well with the class project. This project-based approach is seamlessly integrated into the emergent curriculum pedagogy, allowing children's interests and real-world experiences to guide their learning. It fosters inquiry, collaboration, and critical thinking. Educators observe children's curiosity, co-construct learning experiences, and facilitate in-depth exploration through hands-on projects that evolve over time. This child-centred methodology encourages active participation and is adaptable to individual developmental needs, making learning more meaningful and engaging (Sampson & McLean, 2021). In Malta, the emergent curriculum approach was implemented in kindergartens in 2018, marking a shift from prescriptive education to a more inquiry-based model (Bonello et al., 2022). The kindergarten educator follows an emergent curriculum approach to teaching, and one project that emerged from the students' interests was Rock, Paper, Scissors.

Each reading session followed a consistent format: it began with the children singing a song about their love for reading. The educator would then ask questions to gather information about the book's cover, author, and illustrator. After that, the kindergarten educator would read the story, encouraging the children to join in by repeating rhyming phrases, singing, dancing, or predicting what might happen next. Each new part of the story was followed by two activities: one involving AI and the other being a hands-on activity.

The AI tools and activities were the following:

1. An AI sketch-to-image generator called Scribble to Art was used on simplified.com. The children drew paper dolls on an interactive panel, which was then uploaded to the site. In response to the prompt "paper doll" each child could see a new paper doll being generated. During this hands-on activity, they drew and cut out paper dolls.

2. An AI text-to-image generator was used on simplified.com. This time, the educator asked the students what they knew about dinosaurs: Where did they live? What did they eat? The various answers were used as prompts to create a picture of the dinosaurs' habitat. Following this, the children participated in an activity where they crafted the dinosaurs' habitat using play dough, stones, and other materials.

3. After the part of the story where the paper dolls arrive on a farm, the children started building their own farm. Each child selected an animal to place behind the fence, in the barn, or under the trees. They then used an app on the KGE's mobile phone called ChatterPIX. This time, they took a photo of their chosen animal, recorded its sound, and added emojis.

4. The next AI tool introduced to the children was Animated Drawing on sketch. metademolab.com/canvas. The children listened to the KGE reading about paper dolls holding hands as they hopped and danced. Inspired by the story, the children then drew their own paper dolls on the interactive panel, making sure the dolls joined hands. Soon, they could see their drawings animated, as the paper dolls began to dance.

5. The final AI tool used was the Ozobot. After listening to the story multiple times, each child was asked to draw their favourite part. Together with the KGE they created a story map featuring all the different sections, with each part connected by a line from beginning to end. The children had a fantastic time watching the Ozobot follow the storyline.

Student Engagement and Learning Outcomes

Integrating AI tools into story-reading sessions significantly enhanced students' engagement and learning outcomes, aligning with existing literature on interactive and technology-enhanced storytelling. Observations revealed that children were highly engaged during the sessions, demonstrated by their active participation and enjoyment of the story being read aloud. They exhibited strong recall skills, remembering story details, including character names such as the paper dolls' names, and maintaining continuity across sessions. This mirrors the findings by Isbell et al. (2004), who highlighted that interactive story reading promotes children's comprehension and narrative retention. The children eagerly joined in during repeated phrases, reflecting their enthusiasm for the story and their growing familiarity with its structure, a key factor in developing early literacy skills (van der Wilt et al., 2022). The sessions also encouraged social interaction and collaboration, as the children accepted turn-taking and were encouraged to engage in discussions while the educator was reading the story and during the hands-on activities. Such behaviours align with the principles of dialogic reading, which emphasise active participation to foster language and communication skills (Grolig, 2020).

Creativity was another notable outcome, as the children expressed their understanding of the story through hands-on tasks and described their work in detail. This supports Maureen et al.'s (2020) findings that digital and interactive storytelling platforms enhance children's ability to engage imaginatively while reinforcing their comprehension. In this case study, the combination of traditional story-reading elements with AI tools not only sustained high levels of student engagement but also facilitated learning outcomes such as recall, narrative comprehension, and collaborative interaction, essential components of early childhood development.

Integrating AI into Story-Reading Sessions

The findings from this study reveal a deliberate and balanced approach to integrating AI into story-reading sessions, reflecting key themes of preparation, maintaining balance, enhancing student engagement, and fostering motivation. Data collected during the semi-structured interviews show that preparation involved selecting an appropriate storybook that

aligns with the project they were working on, and researching AI tools that could effectively complement traditional methods. This aligns with the literature, which emphasises the importance of selecting context-appropriate resources to support educational innovation (Maureen et al., 2020; Rahiem, 2021).

The findings from the educator interviews provide valuable insights into the integration of AI into early years education, particularly in enhancing story-reading experiences. The educator highlighted the practical challenges and benefits of adopting AI tools, emphasising the transformative potential of technology. "I used AI to help me use AI," the educator explained, reflecting on the proactive approach to identifying suitable resources and strategies for working with young learners. This iterative use of AI resources underscores their accessibility and capacity to empower educators by streamlining tasks and enhancing teaching strategies. For instance, AI can assist in lesson planning, generate educational content, and provide personalised student feedback, thereby reducing administrative burdens and allowing teachers to focus more on student engagement (Shikhrakar, 2024). The educator also emphasised the necessity of embracing AI in modern education by stating, "We are no longer in a situation where we can ignore AI and its developments. We need to show our children the pros and cons. We need to use it responsibly." This perspective aligns with the growing consensus in educational literature, which advocates for fostering AI literacy among young learners to prepare them for a technology-driven society (Su et al., 2023).

Reflecting on the experience, the educator noted that AI tools did not replace traditional storytelling but instead enriched the process: "Storytelling was always engaging and interactive; AI just enhanced the experience … holistic development, creativity, oracy, digital competence." This statement encapsulates the complementary role of AI in supporting fundamental development goals. By enabling children to explore stories through interactive and digital platforms, educators can nurture creativity and critical thinking while maintaining the essential human elements of story reading (Rahiem, 2021; Wang et al., 2024). The educator's enthusiasm for integrating AI tools was also evident in the comment "Once you involve yourself in one activity, you always want more." This sentiment highlights the iterative and evolving nature of integrating technology into teaching practices, fostering continual professional growth and innovation. The educator encouraged others to embrace AI's potential, stating, "Everything is so connected; all we have to do is to give it a go." This optimistic view reinforces the importance of building educators' confidence and capabilities to explore new technologies, ensuring that AI integration is both effective and sustainable in early years classrooms. These reflections underscore the transformative potential of AI in education when implemented thoughtfully and responsibly.

The study's findings align with digital literacy frameworks, which emphasise the need for educators and students to develop AI literacy skills to navigate a technology-driven world. The iterative use of AI tools in story-reading sessions reflects the principles of digital literacy, where engagement with digital tools fosters comprehension, creativity, and communication (Ng et al., 2021). According to Su and Yang (2022), AI literacy in early childhood education supports children's cognitive, creative, and collaborative inquiry skills, reinforcing the argument that AI enhances rather than replaces traditional storytelling practices.

From the perspective of emergent literacy, the integration of AI into story-reading sessions can be viewed as an extension of interactive reading strategies that support early literacy development. AI-facilitated reading aligns with Vygotsky's sociocultural theory, which highlights the role of interactive and scaffolded learning experiences in early childhood development (Williams et al., 2019). Research also suggests that AI-enhanced storytelling fosters oracy, digital competence, and multimodal literacy, supporting children's ability to engage with narratives in dynamic and interactive ways (Kewalramani et al., 2021). However, the findings also highlight the need for ethical considerations and balanced integration of AI in early childhood education. Educators' concerns about preserving the human touch align with existing debates on AI ethics in education, where scholars caution against over-reliance on digital tools that may compromise traditional literacy development and social-emotional learning (Su et al., 2022). The educator's emphasis on responsible AI use reflects the principles of critical digital literacy, where children must be guided in recognising both the affordances and limitations of AI (Druga et al., 2022).

Challenges in Integration

Despite the benefits, several challenges were identified. Limited access to resources, such as having to use the educator's mobile phone, and having only one computer in class, combined with difficulties encountered due to internet bandwidth and lack of classroom space, posed logistical hurdles. Technical issues, including firewalls and tool compatibility could also pose difficulties in proceeding with the planned activities, highlighting the need for robust infrastructure to support digital tools effectively. The continuous disruptions throughout the day and the addition of children from other classes also presented a challenge. Additionally, the educator noted the need for professional development to enhance confidence and proficiency in using AI tools, a concern echoed in broader research on the use of digital technology in classrooms (Su et al., 2023).

Research shows that educators face several challenges in implementing AI in ECE, primarily due to limited AI literacy, lack of professional development, and ethical concerns. Many educators struggle with insufficient knowledge and confidence in using AI tools, which hinders effective integration into the classroom (Su & Yang, 2022). Additionally, the lack of structured curricula and pedagogical guidelines for AI in early learning settings creates uncertainty about best practices for implementation (Ng et al., 2021). Ethical considerations, including concerns about data privacy, screen time, and the balance between technology and human interaction, further complicate AI adoption in early childhood settings (Druga et al., 2022). Moreover, inequities in access to AI resources contribute to a digital divide, where some educators and schools have limited technological infrastructure, affecting the equitable implementation of AI-enhanced learning experiences (Kewalramani et al., 2021). Addressing these challenges requires targeted teacher training, ethical AI frameworks, and the development of age-appropriate AI literacy curricula to support early childhood educators in navigating AI integration effectively.

Recommendations

Based on these findings, recommendations emerge for practitioners and policymakers. First, investing in reliable infrastructure, such as high-speed internet and secure digital platforms, is essential to support seamless integration of AI tools in classrooms. Second, professional development programmes should be prioritised to equip educators with the skills and confidence to navigate and utilise AI tools effectively. These programmes could include hands-on workshops, collaborative webinars, and peer-learning opportunities to build a culture of innovation among educators.

A vital recommendation is to incorporate AI literacy into early childhood curricula. As children increasingly interact with AI tools, it is essential to prepare them to use these technologies responsibly and critically. Activities should aim to help children understand basic AI concepts, evaluate AI outputs analytically, and recognise the ethical considerations associated with its use. This method encourages digital literacy and prepares children for a technology-driven society (Su et al., 2023).

Finally, additional research is needed to examine the long-term effects of AI integration in ECE. Future studies should investigate various educational environments to understand how AI tools impact learning outcomes across different sociocultural contexts. Furthermore, research should focus on the potential of AI to support socio-emotional development and creativity, which are essential components of holistic childhood development.

Conclusion

The findings of this study call attention to the transformative potential of integrating AI into story-reading sessions in ECE while highlighting the importance of maintaining a balanced approach that respects traditional storytelling methods. Through the deliberate use of AI tools alongside traditional story-reading practices, this research has demonstrated that AI can enhance engagement, foster creativity, and contribute to holistic development in young learners. However, successful integration requires careful planning, adequate training, and robust infrastructure to address challenges and maximise the benefits of this innovative approach.

Integrating AI tools such as interactive image generators, animation platforms, and robots like Ozobot enriched the story-reading experience and supported essential developmental outcomes, including narrative comprehension, social collaboration, and creativity. These findings are consistent with existing literature that emphasises the role of technology in enhancing interactive learning and fostering cognitive and emotional development in young children. For example, Wang et al. (2024) highlighted how AI tools such as augmented reality storytelling platforms can create immersive learning environments that captivate children's attention and encourage active participation.

One of the key insights from this study is the complementary relationship between AI and traditional methods. The insights of the educator indicate that while storytelling has always

been a compelling approach, AI tools serve to enhance rather than replace these traditional techniques. This is an important point, as literature emphasises the necessity of preserving human elements in ECE to foster social-emotional learning and interpersonal connections (Rahiem, 2021). By integrating the interactive and engaging aspects of traditional storytelling with the innovative capabilities of AI, educators can create a balanced and enriching learning environment.

The study also revealed several challenges that must be addressed to ensure the effective integration of AI into classrooms. These include technical issues such as limited resources, internet bandwidth constraints, compatibility problems, and logistical difficulties like limited classroom space and frequent interruptions. The educator also mentioned the need for professional development opportunities to build confidence and proficiency in using AI tools. These challenges mirror broader concerns in educational technology literature, which often emphasises the need for investments in infrastructure and continuous teacher training (Su et al., 2023).

This study shows that, while integrating AI into story-reading sessions offers significant opportunities for enhancing ECE, careful planning, adequate resources, and ongoing professional development are essential for successful implementation. By addressing these challenges and leveraging the strengths of both traditional and AI-enhanced storytelling, educators can foster a dynamic and inclusive learning environment. As the educator aptly noted, we can no longer disregard AI and its developments. It is important to explain to children both the advantages and disadvantages of using AI. This sentiment captures the essence of the research: embracing innovation responsibly to empower the next generation.

Notes on Contributor

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Using Artificial Intelligence for Personal, Social and Career Development: Possibilities and Challenges

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Abstract

In today's context, the use of innovative technology is helpful for student engagement, collaborative learning, personalised learning, inclusion and preparation for the future. The paper explores the use of artificial intelligence (AI) for the facilitation of personal and social competences during a curricular subject named PSCD (Personal, Social and Career Development). For our research, we invited PSCD course participants who are doing their PSCD pedagogy course at the Institute for Education (IfE). Participants attended a training on how to integrate AI during PSCD lessons. After the training, they had to create a resource that can be used in class. Following this phase, participants participated in a focus group to present the resource and to share possibilities and challenges of the use of AI during a PSCD lesson. Results from the research shed light on the possibilities, the feelings related to the use of AI, as well as the importance and the challenges of including AI in education for PSCD lessons.

Keyword

Artificial intelligence, PSCD, holistic education, competences, values, teaching and learning

Introduction

In today's reality, artificial intelligence (AI) is being used in all contexts. The European Parliament (2020) has defined AI as the "ability of a machine to display human-like capabilities such as reasoning, learning, planning and creativity" (para. 1). The use of AI is central in the digital transformation of citizens and is considered one of the EU priorities. AI is rapidly evolving, impacting various aspects of students' lives, including education. Such rapid advancements in AI technology have opened new avenues for transforming education, empowering educators to personalise learning experiences, enhancing student engagement, and streamlining administrative processes (Altrabsheh et al., 2018). The subject of Personal, Social, and Career Development (PSCD) is particularly well-suited for AI integration, offering

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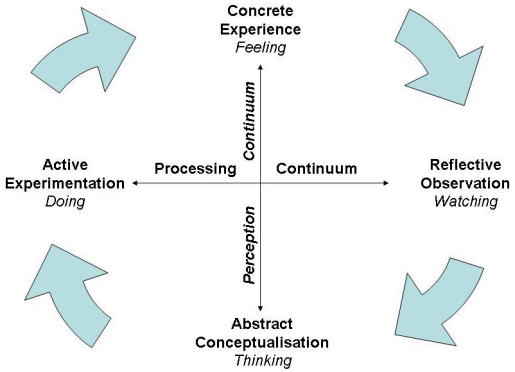
ample opportunities for enhanced and engaging learning experiences. By integrating AI into PSCD education, we can create a more effective and equitable learning environment that addresses the unique needs and aspirations of each student. AI tools can provide personalised support, tailoring educational resources to individual student needs and learning styles. This can help students develop self-awareness, understand their strengths and weaknesses, and explore career paths aligned with their interests and abilities (Baños et al., 2009). AI-powered assessments and feedback mechanisms can also provide valuable insights into student progress, enabling teachers to tailor their instruction effectively (Baños et al., 2009). In global education, the use of AI is already widespread; however, its local importance as well as the possibilities and the challenges in the statutory curricular Personal, Social and Career Development (PSCD) have not yet been explored. PSCD is a subject that is taught to all students in the Maltese Islands. It aims to develop the personal, social and career dimension of the individual, hence aiming to provide holistic education for the wellbeing and employability of children and young people (Bezzina, 2018a, 2018b; Camilleri & Bezzina, 2021, 2022; Camilleri et al., 2012; Falzon & Muscat, 2009; Muscat, 2006). The current research paper explores this research area in depth and tackles an existing dearth in research.

Personal, Social and Career Development: Theoretical Framework and Methodology

PSCD is a curricular subject that follows a set of learning outcomes that specifically aim to develop the person as a whole (Government of Malta, 2025). The subject enables the students to work on their skills, attitudes, values, competencies, and knowledge (Bezzina 2018a, 2018b). The subject is based on seven theoretical frameworks: the constructivist, the progressive, the contextual, the humanistic, the critical, the developmental and the positive. Through the constructivist approach, PSCD teachers elicit the knowledge, the values and the skills from the students and facilitate the lesson based on what the students know, what the students would have experienced and what the students need to know. In this way, PSCD is also based on humanistic and contextual theory since education in PSCD is student-centred, based on the needs of the students, and linked to the context and realities of the students. It is also based on progressive theory since it elicits the experiences of the students. Linking to positive psychological theory and critical theory, students work on their character strengths and critically evaluate the realities that are presented to them (Falzon et al., 2019; Waters & Johnstone, 2022; White et al., 2019; Wilson, 2022; Wilson et al., 2023). During the PSCD subject, students follow Kolb's Experiential Learning Cycle (Farrow, 2011), whereby the PSCD teacher presents an activity in class, which is then processed. Processing includes reflection on the activity, summary of the outcomes and the link to their real-life experience (Figure 1). Processing is aimed at group growth and learning, and it is borrowed from counselling and psychology (Camilleri et al., 2012; Falzon et al., 2019; Muscat, 2006).

Figure 1

Kolb's Experiential Learning Model (Farrow, 2011, p. 1)



Background and Rationale

This research delves into the potential of AI to enhance PSCD education. This exploration arises from a growing recognition of AI's transformative influence across diverse sectors, including education. The rapid advancements in AI technologies, particularly in natural language processing (NLP) and machine learning, have spurred interest in harnessing their capabilities to improve learning outcomes and student experiences (Ayala-Pazmiño, 2023). However, the integration of AI in PSCD education remains relatively unexplored, leaving a gap in understanding its potential impact on this critical aspect of schooling. This research aims to address this gap by investigating the perceptions, potential applications, and implications of AI for PSCD educators and their students.

The rationale for this research lies in the evolving landscape of education and the urgent need to equip students with the skills, knowledge, and values necessary to thrive in a rapidly changing world. PSCD education, encompassing personal development, social responsibility, civic engagement, and economic literacy, plays a crucial role in preparing students for life beyond the classroom (Kelleher & Tierney, 2018). With AI increasingly shaping the future of work and society, understanding its potential impact on PSCD is paramount. By exploring how AI can enhance this educational domain, this research seeks to contribute to a more effective and relevant learning experience for students, empowering them to navigate the complex challenges and opportunities presented by the digital age (Baños et al., 2009).

The Challenges of Traditional PSCD Delivery

Traditional approaches to PSCD have faced multiple challenges that have hindered their effectiveness. The most significant issue has been the lack of personalised learning experiences (Ayala-Pazmiño, 2023; Russell & Norvig, 2022). PSCD often relies on generic

programmes, failing to cater to individual student needs, strengths, and interests. This leads to disengagement and a lack of motivation among students (Ayala-Pazmiño, 2023; Russell & Norvig, 2022).

Another long-standing challenge is the limited resources and support available for PSCD teachers who often lack the necessary training and expertise to effectively implement and deliver personalised PSCD programmes (Russell & Norvig, 2022). Such a lack of professional development can limit their ability to create meaningful and engaging learning experiences (Russell & Norvig, 2022).

Furthermore, traditional PSCD programmes have often struggled to address the growing mental health concerns among students. The fast-paced and demanding nature of modern education puts significant pressure on students, leading to increased anxiety, stress, and depression (Ayala-Pazmiño, 2023). Addressing these issues requires a more comprehensive approach that integrates mental health support into PSCD programmes.

Moreover, traditional PSCD approaches have not always adequately prepared students for the rapidly changing job market. Exponential technological advancements and automation are transforming industries, demanding rapidly adaptable and future-ready graduates. This strongly implies the need for PSCD programmes to evolve to be able to integrate emerging technologies and skills required for the 21st-century workforce (Kelleher & Tierney, 2018).

AI-Powered Tools, Applications and Gamification in Learning

Artificial intelligence (AI) has infiltrated various aspects of our lives, and education is no exception. In the realm of PSCD, AI-powered tools offer a transformative potential to enhance learning experiences and empower students for the 21st century (Hattie, 2012). These tools are not meant to replace teachers but to act as valuable companions, providing tailored support and personalised guidance (Roorda et al., 2011). AI-powered platforms can analyse student data, including their strengths, weaknesses, and learning styles, to create individualised learning paths. For example, AI can identify students struggling with specific social skills and provide them with targeted interventions, like interactive simulations or personalised feedback (Durlak et al., 2011). Adaptive learning platforms can adjust the difficulty level of exercises in real-time based on a student's performance, ensuring they are challenged but not overwhelmed. AI can also deliver personalised career guidance by analysing a student's skills, interests, and potential career paths based on their performance in specific areas (Diaz et al., 2021). This can help them explore different career options and make informed decisions about their future. AI-powered virtual tutors can provide one-on-one support, answering questions, offering feedback, and motivating students to achieve their goals. This personalised approach can significantly improve student engagement, motivation, and overall academic achievement (Russell & Norvig, 2022).

These platforms offer adaptive learning content, provide real-time feedback, and offer targeted interventions to address specific needs. AI-driven chatbots and virtual assistants can provide students with immediate assistance with PSCD-related queries, such as

career exploration, resource recommendations, and emotional support (Sethi & Jain, 2024). Personalised learning platforms can leverage AI algorithms to analyse student responses, interactions, and learning patterns, identifying strengths, weaknesses, and areas for growth (López-Pérez et al., 2020). This data-driven approach allows students to gain deeper insights into their cognitive styles, learning preferences, and emotional responses, fostering greater self-understanding. AI-powered emotional intelligence assessments can measure and track students' emotional states, helping them identify and understand their feelings, build emotional regulation skills, and develop empathy for others (Liao et al., 2021). These assessments can be used to create personalised feedback, providing students with tailored strategies for managing stress, navigating challenging situations, and improving interpersonal relationships. Moreover, AI-powered simulations and role-playing scenarios can provide students with safe and controlled environments to practice and develop their emotional intelligence skills. These virtual experiences can help them navigate real-world situations such as conflict resolution, teamwork, and communication, developing crucial social skills and emotional competence (Sethi & Jain, 2024). By providing opportunities for practice and reflection, AI tools can empower students to become more self-aware, emotionally intelligent individuals, better prepared for the challenges and opportunities of the 21st century (Diaz et al., 2021).

AI can play a crucial role in addressing mental health and wellbeing challenges within educational settings. By leveraging AI-powered tools, schools can provide students with personalised support and interventions that are tailored to their individual needs (Ayala-Pazmiño, 2023). One of the significant advantages of AI-powered PSCD solutions is their inherent scalability. Unlike traditional methods, which often struggle to reach large student populations, AI can effectively cater to diverse learning needs across diverse educational settings (López-Pérez et al., 2020). This scalability is attributed to AI's ability to personalise learning experiences, providing tailored support to each student, regardless of their location or learning pace (Liao et al., 2021).

AI-driven chatbots and virtual assistants can offer confidential and accessible mental health support, providing students with a safe space to discuss their concerns and access resources (Pardo-Ballester et al., 2021). AI algorithms can analyse student data, such as academic performance, attendance, and online interactions to identify early signs of distress or potential mental health issues. AI-powered apps can provide personalised mindfulness exercises, stress-reducing techniques, and mental health tracking tools, promoting positive mental wellbeing among students (Pardo-Ballester et al., 2021). By incorporating AI into mental health initiatives, schools can create a more supportive and proactive environment that fosters student wellbeing and reduces the stigma associated with mental health. AI can also be used to develop interactive games and simulations that teach students about mental health concepts, coping mechanisms, and healthy relationships (Sethi & Jain, 2024).

Another related theme is that of gamification in learning. Gamification, the process of integrating game-like elements into non-game contexts, holds immense potential for enhancing PSCD. AI can play a crucial role in creating, engaging and personalising gamified learning experiences (Ayala-Pazmiño, 2023; Deterding et al., 2011). Through such potential,

students could possibly navigate a virtual city, where they make choices about their career paths, manage finances, and interact with virtual mentors, all while accumulating points, unlocking achievements, and receiving feedback based on their decisions (Pardo-Ballester et al., 2021). AI can tailor these experiences based on individual needs and learning styles, fostering a sense of motivation, competition, and achievement (Pellegrino & Hilton, 2013). AI can also facilitate interactive learning through simulations and virtual reality (VR) environments (Pardo-Ballester et al., 2021). Students can participate in interactive scenarios, like public speaking exercises, conflict resolution simulations, or team-building challenges (Deterding et al., 2011; Sethi & Jain, 2024). These immersive experiences allow students to practice social skills, develop empathy, and gain valuable insights into different situations in a safe and controlled environment. This interactive approach makes learning more engaging and memorable, promoting active participation and deeper understanding (Liao et al., 2021).

Ethical Considerations in AI-Driven PSCD

The use of AI in PSCD can possibly raise serious concerns about data privacy and security. Since students' personal data, including their academic performance, social interactions, and even their emotional states, could be collected and processed by AI systems, it is crucial to ensure that this data is handled responsibly. Such responsible data processing requires adhering to clear ethical guidelines (Dwivedi et al., 2023; Gašević et al., 2023; European Parliament, 2020), including:

- Transparency and accountability: Students, parents, and educators should be informed about how student data is being used and who is responsible for its processing.
- Purpose limitation: Student data should only be used for the purposes for which it was collected, and not for other unrelated purposes.
- Data accuracy: It should be ensured that the collected data is accurate, complete, and up to date. Procedures should be implemented for correcting errors and updating information.
- Data integrity: The integrity of the data should be maintained, protecting it from alteration or unauthorised changes.
- Limited data sharing: Sharing student data with third parties should be done with caution, only with explicit consent, and under strict data protection agreements.

Following these guidelines can ensure that student data is processed ethically and responsibly, respecting individual privacy and promoting trust.

Moreover, appropriate safeguards must be in place to protect students' privacy and prevent misuse (Barab et al., 2012; Gašević et al., 2023). Safeguarding student privacy requires a multifaceted approach, encompassing:

- Data minimization: Only the data that is absolutely necessary for the intended purpose should be collected, avoiding excessive or irrelevant information.
- Data anonymization: Where possible, data should be anonymised to remove personally identifiable information, making it difficult to link the data back to individual students.
- Data encryption: Encryption should be used to protect data in transit and at rest, making it unreadable to unauthorised parties.
- Access control: Robust access control mechanisms should be implemented to limit who can access student data, allowing only authorised personnel with a legitimate need for the information.
- Data retention policies: Clear policies should be developed for how long data is stored and how it is disposed of after it is no longer needed.

These measures can help ensure that student data is collected and processed responsibly, minimising risks to privacy and security (Barab et al., 2012; Dwivedi et al., 2023; Gašević et al., 2023).

AI algorithms are trained on data, and if that data reflects existing societal biases, the algorithms themselves can perpetuate those biases. This can lead to unfair outcomes for certain students, for example, by recommending different career paths based on their gender or ethnicity. It is essential to develop and deploy AI systems that are fair and equitable, minimising the impact of inherent bias (Ayala-Pazmiño, 2023).

AI systems can be complex and opaque, making it difficult to understand how they arrive at their decisions (Hutto & Gilbert, 2014). This lack of transparency can raise concerns about accountability. Efforts should be made to develop AI systems that are transparent and explainable, so that students and educators can understand how they work and why they make the decisions they do (Pellegrino & Hilton, 2013).

AI systems should not replace human teachers or diminish students' autonomy. AI should be seen as a tool to support and enhance teaching and learning, not as a replacement for human interaction. Students should have the freedom to make their own choices and develop their own skills, with AI tools providing guidance and support (Pellegrino & Hilton, 2013).

Methodology and Ethical Procedures

In addressing the present dearth in literature in this research area, we employed a qualitative research methodology inspired by interpretivist theory to explore the views of PSCD course participants who are undertaking their pedagogy course at the Institute for Education. This research aimed to contribute to academia knowledge about the application and perception of AI in PSCD education. The research questions that were addressed were:

a. What are the perspectives of Maltese PSCD teachers regarding the use of AI in their classroom pedagogies?

b. How can AI be integrated into PSCD education to enhance teaching and learning outcomes through student-centred experiential pedagogies?

c. How can various AI tools cultivate creativity in addressing the personal, social, and career dimensions of PSCD, as well as emotional literacy, mental health, and holistic wellbeing within these dimensions?

To gain an in-depth understanding of the participants' views, we invited them to a two-hour training session on the use of AI in PSCD, facilitated by Prof. Alexiei Dingli from the University of Malta (UM). This training aimed to provide a foundational understanding of AI applications in educational settings. All participants except one attended the training. The session was recorded for the absent participant to ensure they could access the information.

Participants were then invited to take part in the research study. They were provided with an information sheet and a consent form, detailing the study's purpose, and ensuring ethical transparency. Out of the target group, six participants consented to join the study. They were subsequently tasked with preparing and presenting a resource for a PSCD lesson. Following the resource presentations, participants took part in a one-hour focus group discussion that was held online using Microsoft Teams to facilitate participants' availability and allow them to share their reflections and outcomes. The discussion aimed to process their experiences, exploring the possibilities, benefits, and challenges of using AI in PSCD. Focus groups, as highlighted by Breen (2006) and Vaughn et al. (1996) are effective in generating in-depth data about real-life situations if participants listen to each other and avoid bias. The informal nature of the focus groups facilitated an exchange of ideas, providing rich qualitative data that revealed the complexity of integrating AI into educational settings.

A purposive sampling method was employed to select participants, focusing on individuals enrolled in the PSCD pedagogy course at the Institute for Education to ensure alignment with the research objectives. Both researchers, being PSCD teachers by profession, acted as insider researchers, which necessitated maintaining a reflexive process throughout the study to address potential biases and enhance credibility. Ethical standards were rigorously upheld, with ethical approval obtained from the Institute for Education. Participants were fully informed about the study's purpose and their rights, assured of confidentiality, and given the freedom to withdraw at any time without consequences.

Data Analysis

In addressing the present dearth in literature in this research area, we employed a qualitative research methodology inspired by interpretivist theory to explore the views of PSCD course

The focus group generated deep insights, which were analysed using Braun and Clarke's (2006) steps of thematic analysis. First, we familiarised ourselves with the data by immersing ourselves in the perspectives of course participants. This involved reading the transcripts multiple times and making notes to help understand the experiences conveyed. Subsequently, we began sorting and manually creating codes. As Schmidt (2004) defined, coding involves "relating particular passages in the text of an interview to one category" (p. 255). Using colouring and highlighting techniques, we identified different codes, continuing this process until a saturation point was reached. This ensured comprehensive representation of all the obtained data under appropriate codes. Subsequently, these codes were organised into the following themes.

Theme 1: Feelings attributed to the use of AI
Theme 2: Benefits and limitations of using AI for planning and facilitation of the lesson

The data analysis below is supported by excerpts from the data. Fictitious names are used to protect the identity of the participants.

Feelings Attributed to the Use of AI

> In its development, artificial intelligence has also penetrated the world of education ... The development of the times requires the world of education to adapt to technological developments to improve the quality of education, especially the adjustment of information and communication technology. Digital learning content that is developing today can be presented thanks to the application of AI. (Fitria, 2021, p. 134)

Artificial Intelligence (AI) is widely used in the field of education (Altrabsheh et al., 2018). A major theme that emerged from our research study was the range of feelings experienced during the use of AI for planning and implementation of the activity or resource. These feelings could be broadly categorised into positive, negative, and ambivalent. The positive feelings of excitement, curiosity, and optimism emerged explicitly and constantly throughout this research. It seems that excitement and anticipation were sparked by the potential of AI to augment personal and professional development. Curiosity to learn more about AI and its applications, as well as a sense of eagerness to explore its potential, also emerged from the participants' attitudes and reflections. Optimism transpired from the fact that AI is viewed as a tool for positive change and improvement, instilling optimism for a brighter future. One of the participants, Mandy, said:

Ma kontx naf li ħa jagħtini dik l-informazzjoni kollha. Bqajt iċċassata. Komda ħassejtni. Ħassejtni tajba għax meta inti tipprepara lezzjoni ara kemm iddum taħseb x'ser tagħmel u tfittex liema huma l-aħjar attivitajiet. Dan diġa' pass għalijja. Tkun taf li l-mistoqsijiet jista' jiktibhom hu mhux joqgħod jaħseb fil-mistoqsijiet, helpful ħafna.

I didn't know that it would give me all that information. I was shocked. I felt comfortable. I felt good because when you prepare a lesson, you take long to think about what you are going to do and look for the best activities. This is already a step forward for me. When you know that questions can be written by it and not have to think of questions, that is very helpful.

Mandy felt very positive, amazed and surprised about the use of AI because it facilitated her planning and it helped her to brainstorm ideas.

Conversely, participants also expressed a certain level of apprehension, scepticism, and distrust. Teachers felt at times apprehensive about the use of AI, particularly in personal development. They also explained that this apprehension could stem from uncertainty about the reliability and accuracy of AI tools. In addition, they expressed scepticism about the potential of AI to effectively guide personal growth. This scepticism might arise from concerns about AI's ability to understand complex human emotions and individual needs. In line with the literature (e.g., Ayala-Pazmiño, 2023), a lack of transparency in how AI algorithms function can lead to distrust. Participants felt uncomfortable relinquishing control of their personal development to an opaque system. John, one of the research participants, said that he felt very cautious when using it because he did not want to lose control, and he wanted to plan lessons himself whilst thinking in depth about the type of activities and processing questions, while keeping in mind the students he will be teaching.

Jien min-naħa tiegħi ma rridx li nħalli dak l-aspett tal-lesson planning jieħu over hu. I mean that type of control. Nibża' li ħa jneħħilna the thinking process. Jiena just ngħidlu activities that relate to the learning outcomes. Anything else is in my control għax inkella nħossni li qed inħalli wisq fuq xi ħadd ieħor and … ma tkunx tiegħi.

From my view, I don't want to let that aspect of lesson planning take over. I mean that type of control. I am afraid that the thinking process will be taken away. I just ask for activities that relate to the learning outcomes. Anything else is in my control because otherwise I feel like I'm leaving too much on some other side and … would not be my own.

Similar to these experiences, Shank et al. (2019) combined two studies and explored the qualitative descriptions of participants' personal experiences with an AI. The majority reported feelings of surprise, happiness, amusement, uneasiness, confusion, and amazement.

The authors reported that:

> In this data, we contend that human emotions are linked with mind perception … in this data AIs often produce outcomes that respondents perceive as extraordinary. … what constitutes an extraordinary feat for an AI depends on the current level of technology and its diffusion and enculturation into people's expectations … When the AIs exceed these expectations, some people are amazed by the outcomes… (p. 264)

In our research, the feeling of amazement was coupled with the feeling of control, which was also mentioned by Sue, who added that the use of AI made her feel in doubt about the generation of text presented. As a result, she mentioned that one needs to trust AI-generated tools.

> *Biex inkompli ma li kienet qed tgħid, trid tkun specific għax inkella ġieli …. Anki jekk għandek age group. L-ewwel kontu qed tiddiskutu jekk għandekx tafda. Li qed iddejjaqni li jien ma nafx where the source is coming from. Dan mhux dħalt ġo website-tgħid din scientific website. Min hemm behind it? It-tfal ngħidilhom toqgħodux fuq Wikipedia għax mhux dejjem ikun reliable. U jien x'garanzija għandi?*
>
> To continue with what she was saying, you must be specific because otherwise sometimes…. Even if you have an age group. You were discussing first whether you should trust. What is bothering me is that I don't know where the source is coming from. This is not accessing a website. Who is behind it? I ask children not to use Wikipedia because it's not always reliable. And what guarantee do I have?

Trust was then discussed with the participants in the focus group. Mia mentioned that she has to adapt to the needs of the group. As a result, even though she trusts the AI tools, she feels that she knows the group and their interests, hence she consults with the tools, but then feels more at ease to develop her own lesson.

> *Lili tani lesson plans, ħarist lejhom. Kien hemm activities li jogħġbuni pero jien knowing me, insibha vera difficli li nħalli chatgpt jagħmilli l-lesson. Waħda mir-raġunijiet hi jien naf l-istudenti tiegħi u naf what they feel comfortable doing. Tinsiex jien ġejja minn primarja għallura t-tfal jippreferu hands on.*
>
> It presented the lesson plans, and I looked at them. There were activities which I liked, however knowing me, I find it difficult to allow chatGPT to do my lesson. One of the reasons is that I know my students and know what they feel comfortable doing. Do not forget that I come from the primary where children prefer hands-on.

Different participants were in agreement that the AI tools they used generated positive feelings in relation to ease of lesson preparation, brainstorming of ideas and efficiency in the planning of work. On the other hand, they also were in agreement that AI tools also created the feelings of lack of control, lack of trust, and insecurity. In addition, different participants expressed their doubt of the effectiveness of AI in character formation.

Similarly, Fitria (2021) said that:

> The existence of artificial intelligence may be able to provide knowledge to students, but developing character cannot be done. That is an educator's job. How to inspire, motivate, make students become good students. So the role of the teacher in providing motivation, inspiration, and developing character are what AI cannot replace because AI is not given feelings and emotions like humans in general. In the end, if we look at technological developments, we must be able to adapt as technology advances. If we do not adjust, we as educators (teacher/lecturer) may be replaced by technology. (p. 146)

In the light of these different feelings, Fitria (2021) emphasised the fact that when AI is present within the education sector, it raises concerns by educators. This is because some educators believe that they cannot be replaced by AI. This might explain the feelings of lack of trust, insecurity and lack of control that the participants in our research experienced. This sheds light on the importance of addressing these different emotions and providing adequate training to educators (Fitria, 2021; Kopp & Stjerne Thomsen, 2023). Maskey (2020) stated that "we must also ensure that teachers are prepared and empowered to leverage artificial intelligence. Assuming these elements are addressed, the possibilities of AI-powered learning are infinite" (para 4.).

Benefits and Limitations of Using AI for Planning and Facilitation of the Lesson

"Education institutions now have the opportunity to explore the potential of learning supported by artificial intelligence" (Maskey, 2020, para. 1). The focus group participants recognised the varied possibilities of AI when planning their lessons and when facilitating lessons. This change and positive attitude towards new technologies is essential because:

> While the debate on how AI will change business is at the top of the present-day agenda, education is already being challenged to reconceptualise existing teaching and learning methods by putting AI techniques and tools into service (Owoc et al., 2019., p. 38).

Amongst the benefits, Kopp and Stjerne Thomsen (2023) listed more inclusive learning, stimulation of critical thinking and problem-solving and streamlining of teachers' workflows, allowing them to have more time to invest in relationships (Durlak et al., 2011). All participants in our research agreed that AI enhances learning by efficiently processing large amounts of data, identifying patterns, and providing tailored, interactive, and personalised learning experiences. This is in line with the research carried out by Deterding et al. (2011). Our participants further said that AI-powered tools offer scalable, 24/7 access, enabling users to learn at their own pace and from any location. Most of the benefits that they shared with us were related to the planning of the lesson, rather than the facilitation of the lesson. They agreed about the benefit of enhancing critical thinking and problem-solving through the specific, contextualised case studies presented by AI tools. Claudia, one of the participants, said that AI helped her to develop her idea and come up with an experiential activity:

Il-klassi tiegħi tal-Year 5 diga għandhom social media most of them- they are gamers u social media children. Ridt nittakilja l-outcome how media affects gender and body image. U f'moħħi pjanajt lezzjoni u f'moħħi kelli li nsib stampi differenti u nibdew d-diskussjoni hekk. Pero mbagħad meta kellna t-training mal-Profs fuq l-AI, ridt inħabbel moħħi u bdejt ngħid din ma rridhiex discussion biss. Irridha iktar interactive għax huma tfal li joqgħodu bil-qiegħda. U ktibtlu l-AI- different games related to media messages and body image and gender. U tani ħafna games differenti. Waħda minnhom kienet media messages charades games fejn tagħni ħafna eżempji ta' media messages u stereotypes li nsibu u ridna nilgħabu charades bihom.... Kieku ma kienx l-AI ma kinitx ser tiġini f'moħħi kif nikkumbina charades ma' dil-learning outcome. Jiena ġieli ghamiltha charades imma mhux ma' din l-learning outcome. So for me kienet activity vera tajba.

My Year 5 class already have social media most of them - they are gamers and social media children. I wanted to recapture the outcome how media affects gender and body image. And in my mind, I planned the lesson and in my mind I had to find different pictures and start the discussion like that. But then when we had the training with the Profs on AI, I wanted to make up my mind and started saying that I didn't just want discussion. I wanted it more interactive because they are kids who sit down. And I wrote in the AI - different games related to media messages and body image and gender. And it gave me a lot of different games. One of them was media messages charades games, where it gave me a lot of examples of media messages and stereotypes that we find and we wanted to play charades with. If it wasn't for AI, it wouldn't have come to my mind how to combine charades with this learning outcome. I have sometimes done charades but not with this learning outcome. So for me it was a really good activity.

Different participants further said that AI tools generated different options for activities and resources. For example, John stated:

Rigward il-hands on approach, ġieli jagħtini prompts minn dawk l-activities- biex nikkrea board game. So id-diversita' tal-attivitajiet dejjem bellħitni. So jekk ma jkollokx idejat, nista' mmur lura għal dak li tlabtu u ngħid dissena flok sitwazzjonijiet ħa nagħmel board game. Dak huwa s-sabiħ.

As for the hands-on approach, sometimes it gives me prompts from those activities - to create a board game. So the diversity of activities has always surprised me. So if you don't have any ideas, I can go back to what I asked for and say this year instead of situations I'm going to do a board game. That's the nice.

To increase the effectiveness, participants agreed that AI tools need to have specific prompts. Mia mentioned time as a specification, whereas others mentioned the age of the group.

All participants in our research also shared their view about the limitations of the use of AI. They mostly focused on the lack of emotional intelligence. They argued that AI systems are designed to process information and respond rationally, but they struggle with emotional nuance. Furthermore, they expressed their concern with regards to the difficulty in nuanced communication. This is because AI communication can sometimes appear robotic or insensitive, lacking the subtle cues that humans rely on. In line with what Barab et al. (2012) discovered, another limitation which our participants mentioned was data privacy. Our participants expressed their concern about the potential for misuse of personal data collected by AI systems. This was also outlined in the research carried out by Hutto and Gilbert in 2014. This can lead to individuals who may be hesitant to use AI tools as they are worried about their data being used for unintended purposes. Related to this, participants said that there are also security issues because AI systems are vulnerable to security breaches and attacks. Data breaches can result in the theft of sensitive information and compromise the integrity of AI systems (Barab et al., 2012).

In conclusion, in line with the research by Russell and Norvig (2022), when discussing benefits and limitations, participants agreed that to maximise the benefits of AI effectively and to restrict the possible limitations, individuals should embrace new technology with curiosity and a willingness to explore, remaining adaptable to ambiguity and continuous learning as AI evolves. Essential personal attributes include emotional intelligence, collaboration, and open dialogue, allowing for shared learning and resilience in navigating AI's challenges and opportunities (D'Mello & Graesser, 2012).

Recommendations

Our research provided valuable data about the use of AI in PSCD. It helped us to reflect on the following recommendations: the integration of AI within the PSCD curriculum, more teacher training and development, monitoring AI impact on PSCD, overcoming technological barriers and infrastructure, collaboration between educators and AI developers, and data privacy and security. Integrating AI into the PSCD curriculum requires rethinking how PSCD is taught, incorporating AI-powered learning experiences, interactive lessons, and providing teacher training to effectively use AI tools. Teacher training and development should emphasise hands-on workshops, understanding AI concepts, and addressing ethical concerns, with ongoing support for educators. Parental engagement should focus on fostering communication between schools and parents about AI's benefits and ethical considerations, allowing parents to contribute to AI tool selection and integration. Monitoring AI impact involves collecting data, conducting interviews, and running focus groups to evaluate the effectiveness of AI on learning and development. Overcoming technological barriers requires addressing infrastructure issues, ensuring equitable access, and managing cybersecurity to support AI in schools. Collaboration between educators and developers is key for designing effective AI tools aligned with educational needs, encouraging continuous improvement through feedback and dialogue. Data privacy and security stresses the need for strict data handling practices like anonymisation, consent, and robust security measures to protect student information. Adaptability of AI-driven PSCD highlights AI's ability to tailor

learning, adapt to job market trends, and ensure that PSCD programmes remain flexible, relevant, and future-proof.

Limitations

The research presented in this paper was limited in different ways. First, the relatively small sample size restricted the ability to generalise the findings to broader populations. This limitation highlights the need for future research to include larger and more diverse participant groups, ensuring that conclusions are more representative of varying contexts and demographics. Additionally, the dual role of the researchers as PSCD teachers by profession created the possibility of bias. While our professional experience provided valuable insights into the realities faced by PSCD teachers, it may also have influenced the interpretation of data. To mitigate this in future studies, integrating a triangulation process could enhance objectivity and strengthen the validity of the findings.

The online nature of the training and focus group session presented another limitation, particularly in observing non-verbal cues. As noted by Hutto and Gilbert (2014), non-verbal communication plays a critical role in understanding participants' emotions, engagement, and unspoken perspectives. Conducting in-person sessions or utilising advanced technologies capable of analysing non-verbal communication could address this limitation in future studies.

Conclusion

The study provides a valuable and timely exploration of the challenges faced by PSCD teachers in navigating the widespread adoption of artificial intelligence (AI). The findings shed light on the critical need for equipping educators and parents with adequate training to effectively integrate AI into educational and developmental contexts. This recommendation aligns with the broader call for lifelong learning in an era of rapid technological advancement. Moreover, the study emphasises the importance of ongoing monitoring and evaluation of AI's benefits and limitations. By systematically examining its impact on pedagogy, student outcomes, and teacher wellbeing, educators and policymakers can develop informed strategies that maximise AI's potential while mitigating its risks. This approach ensures that educators are not only supported but also empowered to adapt to this evolving reality with confidence and competence.

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