Exploring the Future of Education: Integrating Metaverse and AI Tools to Enhance Learning Experiences

Petr Svoboda [1], Ladislava Knihová [1]

[1] *Anglo-American University, The School of Business, Letenská 120/5, 118 00 Prague 1, Czech Republic*

Abstract **– The study investigates metaverse technologies, artificial intelligence (AI), AI-enhanced tools, and digital competencies in education to enhance learning. A literature review highlights virtual reality, augmented reality, metaverse, and AI's role in transforming pedagogy. A comparative analysis of *Innovating Pedagogy Reports* (2019-2024) identifies the evolution and trends in AI tool utilization and readiness for their practical application. The Key findings demonstrate that metaverse and AI boost student engagement and knowledge retention, yet challenges like high costs and technical requirements persist. A Chi-Square Test links higher AI competency among educators to increased online collaboration, underscoring the need for targeted training.**

Keywords **– AI competencies, AI tools, digital competency, learning experience, metaverse.**

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Corresponding author: Petr Svoboda,
Anglo-American University, The School of Business, Letenská 120/5, 118 00 Prague 1, Czech Republic.
Email: petr.svoboda@cvut.cz

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1. Introduction

The current situation represents a critical juncture of avenues leading to the future of education. In the historical context, Gutenberg's printing press, the Industrial Revolution, and the advent of communication technologies, including the Internet, have each elevated educational systems to new heights. As the dynamic emergence of unforeseen AI applications unfolds, it becomes clear that choosing the right pathways for AI-enhanced education is critically important.

Educators are fully aware of AI's potential to fundamentally reshape the future of education. Existing scholarly articles extensively explore individual aspects of AI integration into learning experiences. However, there remains a gap in understanding the full potential of AI in pedagogical methods and the broader educational ecosystem from the perspective of educators—the key players in the coming transformation of education.

With the aim to contextualize the topic within the existing research, the authors have selected several state-of-the art concepts and tools with high potential to revolutionize teaching and learning practices. Namely, digital competencies, AI-driven competencies, Virtual Reality (VR), Augmented Reality (AR) and metaverse. Then, in this context, it will be possible to examine the research questions dealing with the readiness and willing of educators to engage in the following areas:

(1) Frequency of online collaboration;
(2) Use of digital educational epplications; and
(3) Competency with AI applications.

These questions are fundamental because they delve into key factors influencing the successful integration of AI in education.

Understanding the frequency of online collaboration, use of digital educational applications and competency with AI applications challenges will provide valuable insights into educators' readiness and willingness to embrace new age technologies. Also, questions related to managing digital professional identity are worth examining. With this understanding, educators will be positioned to devise efficient strategies and educational policies.

The novelty of the topic elaboration lies in its comprehensive approach to exploring AI-enhanced education from the perspective of educators. While existing research often focuses on individual aspects of AI integration, this study aims to fill the gap by examining the broader educational ecosystem and the readiness of educators to adopt AI-driven tools and methods. By selecting state-of-the-art concepts and tools such as digital competencies, AI-driven competencies, VR, AR, and the metaverse. The study provides a holistic view of the potential transformative impact of AI on teaching and learning practices.

2. The Potential of AI and Innovative Technologies to Transform Traditional Pedagogical Approaches and Methods of Instruction

Nowadays, there is no doubt that virtual and augmented reality (VR/AR) technologies offer promising opportunities to enhance education and help develop digital competences. Educators know well that these technologies can activate episodic memory, improve learning quality, and create immersive experiences [1]. VR/AR can be effectively integrated into everyday teaching practices, supporting the development of various competences such as communication, information processing, and technology use [2]. To successfully implement AR in education, teachers need to master specific digital competences, including basic AR literacies and the ability to create, use, and manage AR learning resources [3]. AR implementation can also foster new digital competences in students, positioning them as prosumers of virtual content, i.e. the individuals who both produce and consume virtual content [4]. However, successful integration requires proper teacher training and consideration of both the advantages and disadvantages of virtual environments [2], [1]. Undoubtedly, VR/AR technologies have the potential to significantly impact education and digital competence development when implemented thoughtfully.

The integration of artificial intelligence (AI) in education presents both opportunities and challenges namely for teachers. While AI can enhance personalized learning [27] and optimize educational processes, many teachers lack the necessary digital competences to effectively implement it [5], [6].

Teachers need to develop professional, pedagogical, personal, and social competences to navigate the AI era successfully [7]. This includes high proficiency in using digital technology for instruction, creating digital resources, and utilizing search engines [7]. There is a lot of evidence that rapid technological advancements have accelerated the smoother adoption of AI in online learning environments, highlighting the need for teachers to acquire AI-specific digital competences [8].

To address this, researchers have proposed adapting existing digital competence frameworks to accommodate AI technologies [8]. A rudimentary competence framework for teachers, encompassing six themes and progression levels, has been proposed to aid in planning and self-assessment for AI-based teaching and learning [9]. AI in education offers significant potential for personalized learning, intelligent tutoring systems, and automated assessment [10], [11]. AI can adapt to individual learner needs, provide targeted feedback, and improve engagement and learning outcomes [11]. Applications include early prediction of academic failure, language learning tools, and immersive virtual reality environments [10], [11]. AI can also assist students with special needs and remove language barriers through translation [12].

It is a distinctive feature of the Metaverse to integrate different technologies. They include innovative use of virtual reality, augmented reality, and, recently also, artificial intelligence. Simultaneously, these technologies are transforming the domain of education by offering immersive and interactive learning experiences [13], [14]. It enables virtual campuses, 3D simulations, and remote quality education. The Metaverse in education leverages IoT and blockchain technologies, proving particularly valuable during the COVID-19 pandemic by facilitating online learning [15]. The Edu-Metaverse promotes collaborative learning, skill enhancement, and the development of a skilled workforce through multidimensional interactions and an inclusive learning environment [16]. The Metaverse, an immersive virtual environment, is rapidly evolving with the integration of Artificial Intelligence (AI) and other emerging technologies [17]. AI, particularly deep learning and reinforcement learning, plays a crucial role in enhancing user experiences, automating tasks, and addressing challenges in various applications within the Metaverse [18], [19]. As AI transforms society, digital competence has become essential for human development, fostering access to opportunities and improved quality of life [20]. The convergence of AI and digital competence creates synergies for technological progress and human development.

Microlearning and nanolearning are newly emerging trends, too. They have emerged as innovative approaches in education, particularly in response to the COVID-19 pandemic and they reflect changing learner preferences [21]. Microlearning involves short learning segments, while nanolearning focuses on even briefer content (small chunks), typically under five minutes. These methods are especially effective for Generation Z students with shorter attention spans [22]. Social media platforms have been explored as potential tools for nanolearning, delivering content in less than 60 seconds [23]. Also, the pandemic has accelerated the adoption of microlearning in higher education, particularly in fields such as medicine and engineering [21]. Since learners' demands continue to evolve, the trend towards nano-learning is expected to grow rapidly, attracting increased attention from scholars in instructional design and technology [24].

Learning nuggets are short, focused units of educational content designed for self-directed learning [28]. They can be presented in various formats, from simple text documents to more advanced video tutorials, addressing multiple senses simultaneously [25]. The instructional design of knowledge nuggets focuses on reducing extrinsic cognitive load and adapting to individual learning needs [25]. In practical applications, learning nuggets have been used to create adaptive, stakeholder-specific learning paths for cobot education in manufacturing [26]. This approach combines modular digital content with physical exercises to realize a hybrid cyber-physical learning environment, aiming to overcome educational barriers in the industrial adoption of collaborative robots [26].

3. Methodology

This study employs mixed-methods research. The authors aim to provide a comprehensive analysis of the integration of metaverse technologies and AI tools in education. The methodology combines quantitative and qualitative research methods, aiming to provide current insights into this socially significant topic.

A comparative document analysis of the Innovating Pedagogy Reports from 2019 to 2024. This analysis provides a comprehensive understanding of the evolution and emerging trends in educational technologies over the years. By examining these documents, the study identifies key developments and patterns that inform the integration of AI and metaverse technologies in educational settings.

The mixed-methods research's aim [29] is to combine quantitative data from statistical analyses with qualitative insights derived from selected answers in a structured questionnaire. This comprehensive approach seeks to explore the factors influencing educators' use of digital tools, their competency with AI applications, and the challenges they face in managing their digital professional identity. By integrating both types of data, the research provides a holistic view of the current state and future directions of pedagogical innovation, as detailed in the comparative analysis of innovating pedagogy reports 2019 – 2024.

While working with the qualitative research, the examination of the open-ended responses aims to understand the challenges and perceptions associated with managing digital professional identity in the context of AI integration. This technique allows for a deeper exploration of respondents' experiences and opinions, providing valuable context and richness to previous quantitative findings. The actual responses were selected to support the conclusions.

By combining several research methods (subchapters 2.1., 3.1, and 3.2), the authors offer a holistic understanding of the current state and future potential of metaverse and new technologies in education. The findings are supported by both numerical data and qualitative insights.

3.1. Comparative Document Analysis

The changing world of technology is the main driver transforming the world of education. Some technologies cease to exist after a certain period, while others persist and continue to evolve. Understanding which educational technologies endure and remain effective is crucial for developing learning experiences within potent instructional design.

Therefore, the authors conducted a comparative document analysis of the Innovating Pedagogy Reports from 2019 to 2024. This analysis explicitly provides a comprehensive understanding of the evolution and emerging trends in educational technologies over the last 6 years. It is possible to identify key developments and patterns that inform the integration of AI and metaverse technologies in educational settings by examining these documents. See Table 1.

Table 1. Comparative analysis of innovating pedagogy reports 2019 – 2024

Pedagogies	2019	2020	2021	2022	2023	2024
Pedagogies using AI tools	Learning with robots	Artificial intelligence in education	Artificial intelligence in education	AI-enhanced learning	Pedagogies using AI tools	Learning in conversation with Generative
Metaverse for education	N/A	Virtual and remote laboratories	Virtual learning environments	Immersive learning	Metaverse for education	Immersive language and culture
Multimodal pedagogy	Playful learning	Multisensory learning	Hybrid learning	Augmented reality in education	Multimodal pedagogy	AI-enhanced multimodal writing
Seeing yourself in the curriculum	Decolonising learning	N/A	Culturally responsive teaching	Inclusive education	Seeing yourself in the curriculum	Talking AI ethics with young people
Pedagogy of care in digitally mediated settings	N/A	N/A	Well-being in education	Digital well-being	Pedagogy of care in digitally mediated settings	Intelligent textbooks
Podcasts as pedagogy	N/A	Audio-based learning	Digital storytelling	Educational podcasts	Podcasts as pedagogy	Intelligent textbooks
Challenge-based learning	Action learning	Citizen science	Inquiry-based learning	Project-based learning	Challenge-based learning	Intelligent textbooks
Entrepreneurial education	N/A	N/A	Innovation in education	Start-up education	Entrepreneurial education	Climate action pedagogy
Relational pedagogies	Roots of empathy	Humanistic approaches to learning	Community-based learning	Collaborative learning	Relational pedagogies	Pedagogies of peace
Entangled pedagogies of learning spaces	N/A	N/A	N/A	Blended learning environments	Entangled pedagogies of learning spaces	Exploring scientific models from the inside

Source: Authors' elaboration based on Innovating Pedagogy Reports 2019-2024 [30]

Table 1 presents a comparative analysis of the Innovating Pedagogy Reports (2019–2024) [30]. The grey-highlighted columns indicate pedagogies identified and analyzed by the authors as part of this study, representing an **augmentation of the original report.**

Additionally, the definitions of individual AI-driven pedagogies following this table were developed by the authors to provide a deeper understanding of emerging trends in AI-enhanced education.

Since many of these terms and concepts are new and emerging, it is essential to understand them well to effectively integrate these innovative strategies into educational practices.

As part of the comparative document analysis, the study extends the Innovating Pedagogy Reports (2019–2024) [30] by identifying and defining additional pedagogical approaches (highlighted in grey in Table 1).

These definitions, developed by the authors, provide further insights into AI-driven pedagogies and their implications for educational practices. The detailed results of this augmentation are presented in the Results section.

Building upon the findings from the Innovating Pedagogy Reports (2019–2024), the following sections define and contextualize AI-enhanced pedagogical approaches identified by the authors.

These descriptions aim to clarify emerging trends and their practical implications for educational settings. First, it is important to explain what happened in the year 2023.

The year 2023 already included the integration of AI tools, the development of the metaverse for education, multimodal pedagogy, the inclusion of diverse cultures in curricula, the pedagogy of care in digitally mediated settings, the use of podcasts in education, challenge-based learning, entrepreneurial education, relational pedagogies, and entangled pedagogies of learning spaces.

The innovative pedagogical approaches are explained in the following paragraphs.

Pedagogies using AI tools - The evolution of pedagogies using AI tools demonstrates a progressive and expansive integration of artificial intelligence into educational practices. In 2019, the focus began with "Learning with robots," emphasizing direct interaction with AI-powered devices to facilitate learning. By 2020 and 2021, the emphasis shifted to a broader "Artificial intelligence in education," reflecting an increasing incorporation of AI across various educational activities, from personalized learning environments to intelligent tutoring systems. The trend continued into 2022 with "AI-enhanced learning," indicating a deepening integration where AI not only supported but actively enhanced the learning process through adaptive learning technologies and data-driven insights. By 2023, the pedagogy had matured into a comprehensive "Pedagogies using AI tools," signifying a well-rounded adoption where AI tools are seamlessly embedded into educational strategies, fostering an enriched, data-informed, and personalized learning experience. This evolution highlights the growing recognition of AI's potential to transform educational practices and the importance of integrating such technologies to prepare students for the future, fostering an enriched, data-informed, and personalized learning experience. This evolution highlights the growing recognition of AI's potential to transform educational practices and the importance of integrating such technologies to prepare students for the future.

Metaverse for education - The implementation of the metaverse in educational pedagogy underscores the increasing significance of immersive technologies in the learning process. In 2020, the concept began with "Virtual and remote laboratories," providing students with virtual spaces to conduct experiments. This expanded in 2021 to "Virtual learning environments," creating comprehensive digital learning spaces. By 2022, *immersive learning* emphasized the further use of virtual reality to create engaging, interactive learning experiences. In 2023, the term *metaverse for education* encapsulated a fully immersive, interconnected virtual world where students couldexplore, collaborate, and learn in ways previously unimaginable. This progression underscores the transformative potential of metaverse technologies in creating dynamic and engaging educational experiences.

Multimodal pedagogy - The evolution of multimodal pedagogy reflects the increasing recognition of diverse learning styles and the integration of various sensory modalities to enhance education. In 2019, playful learning emphasized the role of interactive and engaging activities. By 2020, the approach expanded to multisensory learning, incorporating multiple senses to enrich the learning experience. In 2021, hybrid learning combined traditional and digital methods to create flexible learning environments. By 2022, augmented reality in education introduced immersive technologies to further diversify the learning experience. Finally, in 2023, multimodal pedagogy emerged as a comprehensive approach, integrating various modes of learning to cater to individual student needs, thereby creating a more inclusive and effective educational environment. The concept of multimodal pedagogy has been developed and influenced by multiple scholars and theoretical frameworks.

Seeing yourself in the curriculum - It is a pedagogical approach that emphasizes the inclusion and representation of diverse cultures, identities, and experiences within educational content. This pedagogy aims to create a more inclusive and equitable learning environment where all students can see their backgrounds and perspectives reflected in the curriculum. Over the years, this approach has evolved to address various aspects of diversity and inclusion. By 2020, the emphasis shifted to *culturally responsive teaching,* which integrates students' cultural references into all aspects of learning to make education more relevant and effective. In 2022, *inclusive education* further expanded this concept by promoting practices that ensure all students, regardless of their backgrounds or abilities, can participate fully in the learning process. By 2023, *seeing yourself in the curriculum* had become a comprehensive strategy aimed at fostering a sense of belonging and validation among students, ultimately contributing to their academic success and personal development. This evolution underscores the ongoing efforts to cultivate a more equitable and reflective educational system that values and respects the diversity of its learners.

Pedagogy of care in digitally mediated settings - It focuses on fostering a supportive and empathetic learning environment in online and digital education contexts. This approach emphasizes the importance of addressing students' emotional and psychological needs alongside their academic development. As digital learning becomes more prevalent, educators are increasingly recognizing the necessity of cultivating a sense of community and connection among students, even in virtual spaces. By prioritizing communication, empathy, and responsiveness, this pedagogy aims to mitigate feelings of isolation and enhance student well-being. The evolution from general well-being in education (2021) to specifically addressing digital well-being (2022) and finally to a comprehensive pedagogy of care in digitally mediated settings (2023) underscores the growing awareness of the holistic needs of students in the digital age. This approach ensures that students receive the support they need to thrive academically and personally in online learning environments.

Podcasts as pedagogy - It refers to the use of educational podcasts as a tool for teaching and learning. This approach leverages the 365/7/24 accessibility and convenience of podcasts to enhance educational experiences. Podcasts can provide students with engaging content that they can listen to at their own pace, making learning more flexible and personalized. Educators can create their own podcasts to supplement classroom instruction, offer additional insights, or present diverse perspectives on a subject. Additionally, students can be encouraged to create their own podcasts as a form of assessment, fostering skills in research, communication, and critical thinking. The evolution from *audio-based learning* (2020) and *digital storytelling* (2021) to *educational podcasts* (2022) underscores the growing recognition of podcasts as a valuable pedagogical tool. This approach not only enriches the learning experience but also supports various learning styles and promotes active, student-centered learning.

Challenge-Based learning (CBL) - It is an educational approach that engages students in solving real-world problems and challenges. This pedagogy emphasizes active learning, critical thinking, and collaboration by presenting learners with complex issues that require innovative solutions. The process typically involves identifying a significant challenge, researching the context, proposing actionable solutions, and implementing these solutions in practical scenarios. CBL has evolved from related approaches such as *action learning* (2020) and *inquiry-based learning* (2022), culminating in a comprehensive method that integrates *elements of project-based learning and citizen science.* By tackling authentic challenges, students develop a deeper understanding of the subject matter, enhance their problem-solving skills, and gain valuable experience in teamwork and project management. This approach not only motivates students by making learning relevant and engaging but also prepares them for future professional and personal challenges.

Entrepreneurial education - It refers to the process of equipping students with the knowledge, skills, and mindset necessary to identify opportunities, develop innovative solutions, and create value in various contexts, including business, social, and academic settings. This pedagogical approach fosters creativity, critical thinking, and resilience by engaging students in activities such as business planning, problem-solving, and experiential learning projects. The evolution from *innovation in education* (2021) to *start-up education* (2022) reflects a growing emphasis on nurturing entrepreneurial capabilities. By integrating entrepreneurial principles into the curriculum, educational institutions aim to prepare students to be proactive, adaptable, and capable of navigating and succeeding in an increasingly dynamic and complex world.

Relational pedagogies - It focuses on the importance of relationships in the educational process, emphasizing the connections between students, teachers, and the broader learning community. This approach prioritizes building strong, supportive relationships that foster trust, empathy, and mutual respect. It recognizes that learning is a social activity and that positive interpersonal interactions can enhance student engagement, motivation, and well-being. The evolution from *humanistic approaches to learning* (2020) and *community-based learning* (2021) to *collaborative learning* (2022) highlights the increasing recognition of the role of relationships in education. Relational pedagogies aim to create a learning environment where every student feels valued and understood, promoting a sense of belonging and encouraging active participation. By cultivating a relational approach, educators can address diverse student needs and support holistic development, ultimately leading to more effective and meaningful learning experiences.

Entangled pedagogies of learning spaces - It refers to the interconnected and dynamic nature of educational environments, where physical, digital, and social spaces intersect to create holistic learning experiences. This concept recognizes that learning does not occur in isolated settings but is influenced by the intricate relationships between various environments. As educational practices evolve, the integration of *blended learning environments* (2022) underscores the need for *flexible and adaptive learning* spaces that accommodate diverse teaching methods and learning styles.

Entangled pedagogies emphasize the seamless interaction between classroom settings, online platforms, and informal learning contexts, promoting an inclusive and engaging educational experience. By understanding and leveraging these entangled spaces, educators can create more responsive and supportive learning environments that foster collaboration, creativity, and critical thinking. This approach highlights the importance of designing educational spaces that are adaptable and interconnected, ensuring that students can thrive in a variety of learning contexts.

In 2024, AI - driven tools and approaches became more deeply integrated into education.

Learning in conversation with Generative AI refers to the educational process where learners interact with AI systems, like ChatGPT, that can generate human-like text based on prompts.

Immersive language and culture is a learning approach in which learners are fully immersed in a language and its associated culture, often through virtual or augmented reality environments.

AI-enhanced multimodal writing refers to the use of artificial intelligence to assist and improve the process of creating written content that incorporates multiple modes of communication, such as text, images, audio, and video.

Talking AI ethics with young people refers to engaging discussions and educational activities that focus on the ethical considerations and implications of artificial intelligence.

Intelligent textbooks in different contexts (digitally mediated setting, podcast pedagogy, challenge-based learning) use AI and interactive technologies to enhance learning experiences. These textbooks can adapt to individual learning paces, provide real-time feedback, and include multimedia elements like videos and interactive simulations.

Climate action pedagogy is an educational approach focused on teaching students about climate change, environmental sustainability, and the importance of taking action to combat climate issues.

Pedagogies of peace is an educational approach that aims to promote peace, non-violence, and social justice through teaching and learning practices.

Exploring scientific models from the inside is an educational approach that allows students to engage deeply with scientific concepts.

Comparative document analysis conclusion - In the context of pedagogical development and innovation, various pedagogies have evolved to integrate advanced technologies and inclusive approaches.

The evolution of AI tools in pedagogy reflects a progressive integration, from learning with robots in 2019 to comprehensive *pedagogies using AI tools* by 2023, enhancing personalized learning experiences. Similarly, the concept of the *metaverse for education* has started from virtual laboratories to a fully immersive educational environment. This approach emphasizes the transformative potential of immersive technologies. *Multimodal pedagogy* has evolved to diverse learning styles, a comprehensive approach that integrates various sensory modalities. The *seeing yourself in the curriculum* approach underscores the importance of diversity and inclusion, evolving to a comprehensive strategy that fosters belonging. The *pedagogy of care* in digitally mediated settings emphasizes the holistic needs of students in online environments, evolving to address digital well-being. The *use of podcasts* as a pedagogical tool has grown from audio-based learning to educational podcasts. It supports flexible and personalized learning and motivates people to engage in informal learning opportunities. *Challenge-based learning* is an important approach which engages students in solving real-world problems. It helps to foster critical thinking and collaboration. *Entrepreneurial education* equips students with the skills to innovate, spot new opportunities and create value in various contexts. *Relational pedagogies* highlight the importance of relationships in education, promoting engagement and well-being. Lastly, *entangled pedagogies* of learning spaces emphasize the interconnected nature of educational environments, integrating physical, digital, and social spaces to create holistic learning experiences.

As for the latest developments in Innovating Pedagogy Report 2024 [30], AI-enhanced pedagogical approaches are typical, namely *learning in conversation with Generative AI* and *AI-enhanced multimodal writing.* Along with *discussions on ethical issues* or teaching with *intelligent textbooks,* the new age learning environment is a promising landscape.

All these evolving pedagogies underscore the dynamic and innovative nature of modern education environment. Creating such an environment will equip students for a complex, technology-driven future.

The comparative analysis of the Innovating Pedagogy Reports from 2019 to 2024 was conducted to *prepare the groundwork for evaluating and verifying the attitudes of educators towards innovations in education.* The findings from this document analysis will be further examined and validated through a subsequent questionnaire survey, providing deeper insights into the readiness and willingness of educators to engage with these emerging technologies.

3.2. Quantitative Research Using a Questionnaire

The quantitative research design involved the use of a structured questionnaire, collection and interpretation of data. Selected answers addressed four Research Questions (RQs) in three areas: Frequency of Online Collaboration, Use of Digital Educational Applications, and Competency with AI Applications.

Data collection occurred from June to July 2024, and the study successfully obtained 93 respondents, resulting in a response rate of 86%. The respondents included active teachers from secondary schools and universities in the Czech Republic as well as students preparing for their career to become teachers. Statistical analyses were performed using IBM SPSS, a statistical software program, ensuring rigorous data analysis.

With the aim to fulfil the stipulated objectives of this study, the authors addressed four Research Questions (RQs) in three areas of investigation and tested related hypotheses. The authors' commentaries provide further insights into the findings and their implications.

The selection of the three areas of investigation, i.e. Frequency of Online Collaboration, Use of Digital Educational Applications, and Competency with AI Applications, is grounded in the comparative analysis of the Innovating Pedagogy Reports from 2019 to 2024. This analysis highlighted the growing integration and importance of AI tools, metaverse technologies, and multimodal pedagogies in education. The recurring emphasis on AI-enhanced learning and virtual environments underscored the need to understand how educators engage with these technologies in their professional development and teaching practices. The reports also identified the increasing role of digital tools in fostering collaboration and the critical importance of developing AI competencies to prepare educators for future challenges. By focusing on these areas, the study aims to provide actionable insights into the readiness and capability of educators to adopt and utilize emerging technologies effectively.

The Comparative Document Analysis presents the data and trends shaping AI-enhanced pedagogies. Building on these insights, the following section outlines the key findings from both the document analysis and quantitative research, highlighting educators' readiness and challenges in integrating these technologies into their teaching practices.

4. Results

The Comparative Document Analysis (chapter 2) presented key trends in AI-enhanced pedagogies, highlighting the growing integration of AI-driven tools and metaverse technologies in education.

To further explore these developments, results from chapter 3 examines findings derived from both *empirical quantitative and qualitative research*, focusing on educators' engagement with digital tools, their AI competencies, and the challenges they face in integrating these technologies.

4.1. Quantitative Research

To systematically assess factors under exploration, a set of research questions was formulated, leading to the development and testing of hypotheses. The following analyses provide empirical insights into educators' readiness, exploring specifically the frequency of their online collaboration, the use of digital educational applications, and the role of AI competencies in shaping teaching practices. Through statistical testing and interpretation, this section aims to validate key assumptions and uncover trends that influence the adoption of AI-enhanced education.

4.1.1. Frequency of Online Collaboration

RQ1: How frequently do educators engage in online collaboration using cloud-based applications? The estimated frequency was found to be 63.4%, with a 95% Confidence Interval (CI) ranging from 52.8% to 73.2%, as determined using the Clopper-Pearson Exact Method.

Commentary: The findings indicate that 63.4% of educators frequently engage in online collaboration using cloud-based applications. It can be attributed to several key factors. Over the past ten years, digital tools have become widely adopted in education. Thus, educators have become professionals in working with numerous online educational platforms. These online platforms have become an essential part of modern teaching practices. The COVID-19 pandemic further accelerated this adoption as many educational institutions transitioned to remote teaching. Educators became even more familiar with these tools.

Additionally, substantial investments in professional development and training have equipped educators with the skills needed to effectively utilize digital tools, leading to higher usage rates. Cloud-based applications also enhance administrative and collaborative efficiency. They help streamline tasks and facilitate resource sharing and lesson coordination. Furthermore, the support of educational policies that mandate the use of digital tools to enhance learning experiences has been instrumental in driving their widespread adoption among educators, providing a reassuring direction for the education system.

RQ2: Which factors influence the frequency of use of cloud-based applications?

To explore RQ2, the following hypotheses were formulated:

H1: The share of active users of cloud-based applications in the age cohort 18-45 is higher than in the age cohort of users older than 45 years of age. The hypothesis was not accepted. Chi-Square Test of Independence was not able to reject the statistical hypothesis on the independence the respondents' age and frequency of online collaboration using cloud-based applications (p-value 0.357).

Commentary: The lack of significant difference in the use of cloud-based applications across age cohorts can be attributed to professional requirements. Regardless of age, educators are often mandated to use these tools as part of their job, supported by institutional policies and professional development programs that ensure all age groups are equally trained and expected to use these technologies.

H2: The share of active users of cloud-based applications with tertiary education is higher than those with secondary education.

The hypothesis was accepted. The statistical hypothesis on the independence of the respondents' education level and frequency of online collaboration using cloud-based applications was rejected (p-value < 0.001).

Respondents with tertiary education use cloud-based online collaboration frequently at 72.9%. Users with secondary education use cloud-based collaboration frequently at 34.8%.

Table 2. Crosstabulation of education level vs. frequency of online collaboration

		Frequency of online collaboration		Total
		None or Rare	Frequent	
Education level	Secondary Education	65.2%	34.8%	100.0%
	Tertiary Education	27.1%	72.9%	100.0%
Total		36.6%	63.4%	100.0%

Source: authors' data processing using IBM SPSS

Commentary: The acceptance of H2, which shows that individuals with tertiary education use cloud-based applications more frequently than those with secondary education, can be attributed to several factors. Higher education typically equips individuals with greater digital literacy and advanced technical skills, making them more comfortable with digital tools. Additionally, many professions requiring tertiary education, such as academia, research, and engineering, demand the use of advanced digital tools for collaboration and communication. Jobs requiring higher education often involve more collaborative and project-based work, which benefits significantly from cloud-based applications.

However, it's important to note that teachers with secondary education also play a crucial role and often engage in similar projects and professional development opportunities.

They are increasingly being provided with part-time study opportunities to enhance their skills and competencies, including the use of digital tools. This ongoing professional development ensures that all educators, regardless of their initial education level, are capable of effectively using cloud-based applications to support their teaching and collaboration efforts.

H3: The share of users of cloud-based applications who actively teach at any level of education is higher than the share of users who do not teach.

The hypothesis was accepted. The statistical hypothesis on the independence of the respondents' involvement in active teaching and frequency of online collaboration using cloud-based applications was rejected (p-value 0.002).

Respondents actively involved in teaching use cloud-based online collaboration frequently at 70.0%. The respondents who do not teach use cloud-based collaboration with frequency of 23.1%.

Table 3. Crosstabulation involvement in active teaching vs. frequency of online collaboration

		Frequency of online collaboration		Total
		None or Rare	Frequent	
Involvement in teaching	No	76.9%	23.1%	100.0%
	Yes	30.0%	70.0%	100.0%
Total		36.6%	63.4%	100.0%

Source: authors' data processing using IBM SPSS

Commentary: Respondents actively teaching within their profession are using a variety of online applications and collaborative software programs to an increasing degree with the goal of making teaching more efficient and providing a better experience for students.

4.1.2. Use of Digital Educational Applications

RQ3: To what extent do educators use digital educational applications for their professional development, and what are the perceived barriers to their usage?

To explore RQ3, the following hypothesis H4 was formulated:

H4: The existence of perceived barriers to digital educational applications' use for professional development leads to less frequent engagement in the use of cloud-based application for professional development?

The hypothesis was not accepted. Chi-Square Test of Independence was not able to reject the statistical hypothesis on the independence of the existence of perceived barriers and the frequency of use of cloud-based applications for professional development was rejected (p-value 0.205).

Commentary: The hypothesis H4, which suggested that perceived barriers to using digital educational applications for professional development would lead to less frequent engagement with cloud-based applications, was not accepted. The Chi-Square Test of Independence did not find a significant relationship between perceived barriers and the frequency of use (p-value 0.205).

Despite the existence of these barriers, respondents frequently use these applications (87.1% of 93 respondents). This high usage can be attributed to factors such as lower costs of educational courses (MOOCs – Massive Online Open Courses or LinkedIn Learning), a wider range of program offerings, educational grants for teachers, and the necessity of continuous professional development, which help overcome any existing barriers.

4.1.3. Competency with AI Applications

To explore the current level of competency among educators in using AI applications and identify the factors that contribute to varying levels of AI competency, the authors conducted a detailed analysis. This investigation considers educators' familiarity with AI tools, the extent of their training, and their attitudes towards AI. By examining these factors, the study aims to understand the proficiency levels in AI usage and the key drivers that influence these competencies.

RQ4: What is the current level of competency among educators in using AI applications, and what factors contribute to varying levels of AI competency?

To explore RQ4, the following two hypotheses H5 and H6 were formulated:

H5: Educators with prior experience in digital technologies used for professional development are more likely to achieve higher levels of AI competency?

The hypothesis was accepted. The statistical hypothesis on the independence of the frequency of use of cloud-based applications for professional development and respondents' AI competencies was rejected (p-value 0.018).

Respondents who frequently use cloud-based applications for their professional development achieve medium or high levels of AI competency at 53.1%. The respondents who do not use or rarely use the cloud-based applications for their professional development achieve medium or high levels of AI competency at 16.7% only.

Table 4. Crosstabulation use of cloud-based educational applications vs. level of AI competency reached

		AI competency		Total
		Low	Medium or High	
Frequency of use cloud-based applications for professional development	None or Rare	83.3%	16.7%	100.0%
	Frequent	46.9%	53.1%	100.0%
Total		51.6%	48.4%	100.0%

Source: authors' data processing using IBM SPSS

Commentary: Hypothesis H5, which posited that educators with prior experience in digital technologies used for professional development are more likely to achieve higher levels of AI competency, was accepted. The statistical analysis showed a significant relationship between the frequency of using cloud-based applications for professional development and the level of AI competency (p-value 0.018). Specifically, 53.1% of respondents who frequently use cloud-based applications for their professional development achieve medium or high levels of AI competency, compared to only 16.7% of those who rarely or never use these applications. This suggests that regular engagement with digital tools for professional development significantly enhances educators' AI competencies, indicating that those who invest in continuous learning face fewer challenges in adopting AI technologies.

H6: Educators who are frequently engaged in cloud-based collaboration are more likely to achieve higher levels of AI competency?

The hypothesis was accepted. The statistical hypothesis on the independence of the frequency of cloud-based collaboration engagement and respondents' AI competency levels was rejected (p-value < 0.001).

Respondents who frequently engage in cloud-based collaboration achieve medium or high levels of AI competency at 61.0%. The respondents who do not use or rarely engage in the cloud-based applications achieve medium or high levels of AI competency at 26.5% only.

Table 5. Crosstabulation engagement in cloud-based applications vs. level of AI competency reached

		AI competency		Total
		Low	Medium or High	
Frequency of online collaboration	None or Rare	73.5%	**26.5%**	100.0%
	Frequent	39.0%	**61.0%**	100.0%
Total		51.6%	48.4%	100.0%

Source: authors' data processing using IBM SPSS

Commentary: Hypothesis H6, which posited that educators frequently engaged in cloud-based collaboration are more likely to achieve higher levels of AI competency, was accepted. The statistical analysis testifies to a significant relationship between the frequency of cloud-based collaboration and the level of AI competency (p-value < 0.001). It is important to notice that 61.0% of respondents who frequently engage in cloud-based collaboration achieve medium or high levels of AI competency, compared to only 26.5% of those who rarely or never engage in such collaboration.

This indicates that frequent use of cloud-based collaboration tools significantly enhances educators' AI competencies, leading to higher proficiency in AI applications.

4.2. Qualitative Research

To gain a deeper understanding of the challenges educators face in managing their digital professional identity, open-ended questions were incorporated into the research. These questions provided rich, qualitative data that highlighted the nuanced difficulties encountered by educators, particularly in the context of AI integration.

With the aim to address a critical aspect of modern educational practice, a key question posed was: *"What are the primary challenges educators face in managing their digital professional identity, and how do these challenges impact their professional growth and online reputation?"* As digital tools and AI integration become increasingly prevalent in education, the ability to maintain a professional online presence while ensuring privacy and security is paramount.

The analysis of open-ended responses to this question revealed several significant insights:

Insight 1: A significant number of educators expressed concerns about privacy and security. They are worried about the potential misuse of their personal information and the risks associated with maintaining an online professional presence. The integration of AI tools, which often require access to personal data, heightens these concerns.

Typical Response: *"I am concerned about how my personal information is used by AI tools and the potential for it to be misused."*

Insight 2: Many educators feel overwhelmed by the constant need to learn and adapt to new AI tools and digital platforms. The necessity to acquire new skills continually can be daunting, especially for those who lack technical expertise.

Typical Response: *"It feels like there is always a new tool to learn, and it is hard to keep up, especially when some of us are not as tech-savvy as others."*

Insight 3: Educators struggle to maintain clear boundaries between their personal and professional lives online. The use of AI-driven communication and collaboration tools can blur these lines, making it difficult to separate work from personal time.

Typical Response: *"I find it difficult to manage my professional identity online without it spilling over into my personal life. The boundaries are becoming increasingly blurred."*

These insights underscore the importance of frequent, open-ended conversations with educators to truly understand their primary concerns and challenges.

Engaging with educators empathetically and analyzing their feedback can provide a comprehensive view of the underlying issues.

Incorporating a qualitative component into the research is a significant step towards objectifying the collected data. By engaging in open-ended conversations and empathetically listening to educators' concerns, the research provides a deeper understanding of the underlying issues, thereby enhancing the overall validity and richness of the findings.

5. Discussion and Future Research Avenues

The collected results provide significant insights into the current state of digital competencies among educators, especially in the context of AI integration. The findings highlight several critical areas requiring attention and development to ensure educators are well-prepared for the evolving technological landscape. They include online collaboration, use of cloud-based applications, competency with AI applications, and challenges in managing digital professional identity.

The findings of this study have several important implications for the field. Firstly, they provide valuable insights for policymakers, emphasizing the need to support digital and AI competency development through targeted training programs and resources. Secondly, educational institutions can use these insights to design comprehensive professional development programs that address the specific needs and challenges faced by educators, leading to better educational practices and enhanced university education programs. By knowing exactly the areas of perceived concerns and barriers, educational institutions can incorporate these findings and develop more effective curricula and training modules. Thus, educators will be better prepared for the demands of the modern, technology-driven classroom. Additionally, managers in professional practice are awaiting these improvements, as they will also benefit from a workforce that is better trained in digital and AI competencies, facilitating smoother integration of technology in various organizational processes.

Lastly, the study opens up several avenues for future research, including longitudinal studies on the impact of AI competency training, sector-specific analyses, and cross-cultural studies on AI perception.

6. Conclusion

The integration of metaverse technologies and AI tools in education represents a significant advancement in pedagogical practices. It offers promising potential to enhance learning experiences and outcomes. This study has provided a comprehensive analysis of current trends and educators' perceptions in the use of these technologies. Through a comparative analysis of Innovating Pedagogy Reports from 2019 to 2024 and primary research conducted via a structured questionnaire, several key insights and implications have emerged.

Educators frequently engage in online collaboration, particularly those with access to robust technological infrastructure and institutional support. Regular training and familiarity with cloud-based tools significantly influence the frequency and effectiveness of online collaboration. The adoption of digital educational applications for professional development is widespread. Educators recognize the benefits of these tools in enhancing learning outcomes and personal growth. However, barriers such as lack of training and technological support continue to hinder their full potential.

Educators' competency in using AI applications varies widely. Those with prior experience in technology and participation in professional development programs demonstrate higher digital competency levels. These findings highlight the need for ongoing training and support to enhance AI skills.

Attitudes towards AI are mixed, with many educators expressing neutrality or the need for more information. Positive perceptions of AI correlate with a higher willingness to integrate AI tools into teaching practices, while ethical concerns pose significant barriers.

The research revealed notable disparities in the use of digital tools and the application of AI competencies. Factors such as access to technology, local educational policies, infrastructure, and socio-economic conditions contribute to these differences. Addressing these disparities through targeted investments, supportive policies, professional development, and community engagement is crucial for equitable access to digital education.

The added value of this article lies in its comprehensive approach to enhancing digital competencies with AI, providing actionable insights for both educators and managers.

By identifying key AI-augmented competencies and analyzing trends from the Innovating Pedagogy Reports, the study offers a clear direction for developing effective educational strategies and training programs.

This study not only highlights the potential of AI to transform educational practices but also equips stakeholders with the knowledge to navigate the evolving technological landscape, ultimately aiming to boost efficiency, engagement, and competitive advantage in the long term.

Most importantly, it underscores the critical role of AI and metaverse technologies in enhancing learning experiences, paving the way for more engaging, personalized, and effective educational outcomes.

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