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METaverse IN EDUCATION – TEACHERS’ PERSPECTIVES ON BENEFITS AND CHALLENGES⁵

Abstract: The metaverse, powered by artificial intelligence and integrating virtual, augmented, and mixed reality, represents an emerging technology with the potential to transform education by creating immersive learning environments. As confirmed by previous research worldwide, teachers at different educational levels recognize its possibilities in education. Alongside numerous benefits, concerns exist that the implementation of the metaverse could lead to certain negative consequences, some of which relate to teachers' insufficient competence for its purposeful use in teaching. For this reason, there is a need to investigate the attitudes of Serbian teachers regarding this concept. This study aimed to examine the attitudes of 108 pre-service and in-service primary school teachers toward the role of the metaverse in education, with a particular focus on the use of a metaverse-based educational platform model. The collected data were analyzed using descriptive statistics. The results suggest that respondents generally view the metaverse in education positively, valuing its role in exploring abstract and distant content and enhancing teaching efficiency. However, material-technical limitations pose a significant challenge, alongside concerns about the potential dehumanization of education. Teachers' resistance to new teaching models is partly rooted in insufficient training for artificial intelligence-based concepts applications in education. The results highlight the need for systematic professional development, advocating for its integration into initial teacher education curricula to ensure the effective and pedagogically purposeful use of technology.

Keywords: artificial intelligence, education, metaverse, primary school teachers

Introduction

Technological development is continuously transforming how we learn, communicate, and function in everyday life. One of the emerging concepts that stands out as an innovative factor in the educational process is the metaverse – a digital environment empowered by generative artificial intelligence (AI) algorithms that integrates virtual (VR), augmented (AR), and mixed reality (MR), offering users immersive and interactive experiences (Fitria, Simbolon, & Afdaleni, 2022). While the

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concept of the metaverse was initially mentioned in literary work (Stephenson, 1992), contemporary technological advancements are enabling its concrete application in various fields, including education. In this context, particularly at the K-12 level, the metaverse is seen as a tool for creating dynamic and interactive learning environments that transcend the traditional spatial and temporal constraints of the classroom (Koochang et al., 2023). Its potential lies in enhancing the educational environment through interaction that leads to collaboration and increased motivation (Flores-Castaneda, Olaya-Cotera, & Iparraguirre-Villanueva, 2024).

The numerous benefits of integrating the metaverse into the educational system do not exclude the potential challenges, such as material-technical limitations, insufficient ethical regulations, and the need for additional teacher training due to a lack of digital competencies required to apply AI in education. These conditions may lead to misconceptions among teachers, potentially resulting in resistance to technologies and the application of methods that are not purposeful. By analyzing relevant empirical and theoretical research, teachers' perceptions of the benefits and risks of applying the metaverse in education were examined. Considering these aspects, it is crucial to explore the perceptions of teaching staff regarding the use of the metaverse in education. Thus, this paper analyzes the attitudes of pre-service and in-service primary school teachers (hereinafter referred to as pre-service and in-service teachers) in Serbia about the possibilities of the metaverse in education, with a particular focus on evaluating the model of an educational platform based on this concept. The research aims to identify the dominant attitudes of pre-service and in-service teachers regarding the benefits, challenges, or limitations of implementing the metaverse in education, through the analysis of a metaverse-based platform model. The obtained results form the basis for defining guidelines for teacher training within the K-12 system, which will contribute to the development of digital competencies for applying AI-supported technologies in education. It is essential to adhere to legislative frameworks and current strategies to ensure that each innovation is introduced by legal and ethical regulations (Mandic, 2023; Ristic, 2017).

Theoretical background

Metaverse: definition and concept

The metaverse represents a modern concept that merges the physical and digital worlds, enabling the creation of an immersive virtual environment accessed by users through their avatars. This AI-powered technology integrates virtual reality (VR), augmented reality (AR), and mixed reality (MR), allowing for interactions from various perspectives and experiences of real-time events and spaces (Koochang et al., 2023). Although the idea of the metaverse appears in science fiction and was first introduced in the novel *Snow Crash* (Stephenson, 1992), its contemporary understanding far surpasses that initial concept. This modern interpretation extends beyond the original idea, as even the novel's author has emphasized that his work was fictional and conceived before the emergence of the internet (Ball, 2024). The metaverse is envisioned as a dynamic digital universe that connects users in real time and allows interaction through a network of interconnected virtual worlds. Key characteristics of the metaverse include social interaction, immersion, a credible simulation of real-world environments, and the potential for continuous expansion (Huang, Li, & Cai, 2023). These features facilitate seamless communication and interactions with digital objects and environments (Ritterbusch & Teichmann, 2023). A significant aspect of metaverse development is its potential to enhance social connectivity through innovative forms of communication, increased accessibility, and personalized avatars, all while respecting user privacy (Benaben, Conges, & Fertier, 2025). Beyond entertainment and business applications, the metaverse could significantly impact education, which recognizes its capacity for innovative teaching and learning methods. Metaverse technology fosters more profound and interactive educational experiences, serving as a tool to improve instruction, particularly in K-12 education (Alfaisal, Hashim, & Azizan, 2024). Although the metaverse is still experimental, existing research indicates its potential to influence the future of

education, providing a holistic approach to knowledge while fostering global connectivity between students and educators (Rachmadtullah, Setiawan, Wasesa, & Wicaksono, 2023b).

Literature review: Metaverse in K-12 education

Integration of the Metaverse in the Educational Process: Benefits and Teachers' Perception

Teachers' perception of the implementation of AI tools and technologies, such as the metaverse, is a key factor in their integration into education. Research indicates that teachers' knowledge and skills related to metaverse technology are still at a relatively low level (Han & Hong, 2022). However, they recognize its potential in online teaching, particularly regarding interactivity and student engagement, which can contribute to increased motivation, active participation, and a sense of presence in the learning process (Guo & Gao, 2022; Rospigliosi, 2022). Unlike traditional e-learning models, the metaverse enables dynamic student activities, which teachers identify as a significant advantage (Han & Hong, 2022).

According to research by Semerci, Sag, & Ozcelik (2024), teachers perceive the metaverse as an advanced form of VR that can enhance the quality, efficiency, and retention of knowledge, especially through interactive learning methods and practical instruction (Cui, Zhu, Hare, & Tang, 2023; Shu & Gu, 2023). Its integration is seen as a means of modernizing the education system, focusing on simplifying the understanding of abstract concepts and increasing student engagement (Semerci et al., 2024). Additionally, the metaverse is recognized as a tool that contributes to inclusivity in education, allowing students with disabilities to access educational content more adaptively and participate more actively in the learning process (Mukhtarkyzy, Abildinova, Serik, Kariyeva, & Sayakov, 2023). Furthermore, teachers emphasize its significance in the context of emergencies and societal challenges, such as pandemics, where it can ensure continuity of education and adaptation to new working conditions (Flores-Castaneda et al., 2024; Semerci et al., 2024;).

Although some teachers express reservations about adopting new technologies, research results indicate that the majority recognize the metaverse as a means to enhance students' competencies without necessarily abandoning traditional teaching methods (Rachmadtullah et al., 2023a). Its use is particularly notable in STEM education, where it can improve all aspects of the learning process. In this context, teachers see it as an inevitable innovation that aligns with the development of modern technological media and the digitalization of education (Rachmadtullah et al., 2023a). Studies on STEAM projects in the metaverse highlight the importance of connecting educational activities with real-world problems and the need for research-based, practical approaches (Rachmadtullah et al., 2023a). As a contemporary trend in digital technologies, the metaverse demonstrates significant potential for improving the educational process by enabling interactive and experiential learning (Han & Hong, 2022; Lin et al., 2022, Rachmadtullah et al., 2023a;). Its implementation in teaching depends on understanding its functionalities, designing activities, and focusing on students' active participation. According to Han & Hong (2022), there are three key approaches to student engagement in the metaverse: 1) role-playing and social interaction, 2) teacher-led simulations and practical activities, and 3) problem-solving with defined educational objectives.

The integration of VR, AR, and MR technologies facilitates the understanding of complex concepts and encourages the development of critical thinking, problem-solving, and communication skills while providing flexibility in learning without spatial and temporal constraints. Analyzed research suggests that this approach can contribute to the dynamism of education, strengthen collaboration, and ensure continuous student engagement, ultimately transforming the educational process through digital and personalized environments that enable simulations, collaborative tasks, and customized learning content (Chen, Zou, Xie, & Wang, 2023; Lin et al., 2022).

Integration of the Metaverse in the Educational Process: Limitations and Challenges from Teachers' Perspective

Despite the numerous advantages that teachers recognize regarding the implementation of the metaverse in education, research highlights a range of risks, limitations, and challenges that may hinder its successful integration (Gurkan & Bayer, 2023; Han & Hong, 2022; Semerci et al., 2024). Based on a literature review, certain limitations can be considered realistic, particularly those related to material and technical conditions. On the other hand, the negative impact of the metaverse, which is often mentioned, is frequently associated with misconceptions that teachers have about this technology. A key concern relates to the possibility that students may use the metaverse for non-educational activities, leading to reduced focus and distractions during lessons (Han & Hong, 2022). Additionally, research indicates that many teachers still predominantly associate the metaverse with gaming, while fewer recognize its potential in educational contexts (Gurkan & Bayer, 2023). The metaverse is perceived as less useful in theoretical and discussion-based teaching approaches, while its potential is more evident in practical and research-based learning (Gurkan & Bayer, 2023). This perspective is encouraging, considering that metaverse-supported teaching favors experiential learning modalities (Zhang, Chen, Hu, & Wang, 2022).

Although challenges exist, the majority of teachers still express interest in further education on the metaverse and its potential integration into teaching, recognizing the need for adequate training and regulatory frameworks that would ensure its effective application (MacCallum & Parsons, 2019; Semerci et al., 2024). Many believe that protective measures will develop in parallel with technological advancements, similar to the evolution of internet security (Semerci et al., 2024), reflecting optimism regarding its potential. However, a significant challenge to the effective implementation of the metaverse remains the limited practical training of teachers in this field (Demirel & Koroglu, 2024). Additional concerns include privacy, data security, access to education for marginalized groups, the risk of addiction, cognitive overload, and the necessity for clear regulations (Chen et al., 2023; Lin et al., 2022).

Proposal for an innovative metaverse-based educational platform

After analyzing the advantages and challenges of the metaverse in education from the perspective of K-12 teachers, as well as the opportunities provided by the metaverse, we propose an innovative avatar-based educational platform that integrates modern technologies and offers a dual function: 1) education in an immersive environment (classroom), where users are not limited by time constraints in accessing educational materials; 2) social interaction and networking with physically distant users. Considering the analyses related to the limitations and insufficient regulations regarding the application of AI in general, the foundation for developing the model of this platform is based on currently available and relevant strategic documents: *Strategy for the Development of Artificial Intelligence in the Republic of Serbia for the Period 2025–2030*, which is of national significance and emphasizes the importance of AI in education; *Strategy for the Development of Education in the Republic of Serbia until 2030*, with a focus on teachers' digital competencies; *UNESCO Strategy on Technological Innovation in Education (2021–2025)*, which highlights the importance of innovative education methods; *UNESCO report Reimagining Our Futures Together: A new social contract for education*, which advocates for digital educational ecosystems.

This platform model, whose specifications and performance are presented in Table 1, represents an innovative solution for educational systems both globally and locally. It is suitable for developing new educational models that effectively integrate technology into the teaching process. The concept of the platform is based on the integration of the metaverse and generative AI algorithms,

while its dual functionality, educational and social support, provides various opportunities for students, teachers, educational experts, and parents.

Table 1. Specifications and performance of metaverse-based educational platform model.

	CATEGORY	DESCRIPTION
Key Functions	Education in an Immersive Environment	1) Users attend classes through avatars; 2) Virtual classroom lessons without time constraints; 3) Generative artificial intelligence enables the creation of interactive lessons (immersive, semi-immersive, and non-immersive); 4) Teachers can generate and customize teaching materials.
	Social Interaction	1) Connecting students, teachers, parents, and experts (psychologists, pedagogues, special educators) in virtual spaces; 2) Consultation rooms for students with learning difficulties, virtual rooms for social interaction and support (experts assist students and parents).
	Technical Features	1) Avatar generation for all users; 2) Personalized spaces for learning and interaction during lessons; 3) The ability to track student progress through quizzes and activities.
	Target User Groups	1) Students; 2) Teachers; 3) Educational experts (pedagogues, psychologists, special educators); 4) Parents of students.
	Platform Benefits	1) Increased interactivity through mixed reality; 2) Continuity of education without spatial or temporal limitations; 3) Providing social support among physically distant users; 4) Increased accessibility and flexibility of teaching; 5) Development of digital competencies in teachers and students.

This platform model has the potential to improve the education system and be applied in various educational settings. The metaverse, as an emerging technology, has the potential to significantly transform educational systems in the coming years, both globally and in our country. To fully understand its potential in the context of national education, it is important to explore the attitudes of pre-service and in-service teachers towards the metaverse, using the example of the proposed educational platform. Teachers' attitudes and their readiness to integrate these technologies into the educational process provide key insights into the implementation opportunities, as well as the challenges that arise when adopting the metaverse. Additionally, the research was crucial to identify potential misconceptions among teachers and organize timely training, which would enable the effective application of the metaverse and its integration with other technologies in education.

Methodology

This research aims to examine the attitudes of pre-service and in-service primary school teachers (hereafter referred to as pre-service and in-service teachers) regarding the role of the metaverse in education, with a particular focus on the application of an educational platform model based on this concept, which has been described in the paper with its proposed functionalities. In this context, the research tasks included: (1) determining the pre-service and in-service teachers' attitudes towards the use of the metaverse on educational platform example; (2) examining the existence of statistically significant differences in attitudes between these two groups of respondents; (3) identifying the benefits that pre-service and in-service teachers recognize about metaverse grounded on application example of a metaverse-based platform and (4) identifying challenges and limitations of metaverse implementation grounded on application example of a metaverse-based platform. A **mixed-methods** research approach was applied (Creswell & Clark, 2011), allowing for an integrated quantitative and qualitative data analysis, thereby providing a deeper insight into the research problem. Quantitative data were processed using **descriptive statistics**, while qualitative data were analyzed through thematic coding methods. Statistical data processing was conducted

using IBM SPSS Statistics 2022. The data collection **instrument** consisted of two segments. The first part of the instrument was a five-point Likert scale consisting of ten statements that examined teachers' attitudes toward the benefits and challenges of using the metaverse in education. The second part of the instrument contained two open-ended questions, allowing respondents to share additional perceptions regarding the potential and limitations of this technology. Given that the metaverse is still in an experimental stage of development, it was assumed that a specific part of respondents might lack prior knowledge of its application in education. Therefore, the introductory section of the instrument included a theoretical explanation of the metaverse concept, along with a presentation of a possible scenario for its application in an educational context.

The **reliability of the instrument** was assessed using Cronbach's Alpha coefficient, which gave a value of 0.919, indicating an extremely high level of internal consistency of the measuring instrument (Siswaningsih, Firman, & Khoirunnisa, 2017). The research **sample** consisted of 108 participants, of whom 51 belonged to the category of pre-service teachers (students of the Faculty of Education, University of Belgrade), while 57 were in-service teachers, i.e., graduates and master's level teachers currently employed in primary schools across the Republic of Serbia. For the analysis of quantitative data, mean values (arithmetic mean) and standard deviations were calculated. These measures enabled the interpretation of respondents' attitudes towards the use of the metaverse in education, as well as the assessment of the variability of the obtained results within the sample.

Results and discussion

Research Task 1: This part of the research aimed to examine the attitudes of pre-service and in-service teachers toward the use of the metaverse in education based on educational platform example. The statements in the instrument were divided into four subcategories: (1) the efficiency of the metaverse-based platform (**SUB1**), (2) the enhancement of the educational process through the platform (**SUB2**), (3) social interaction and collaboration in the metaverse educational environment (**SUB3**), and (4) challenges/limitations in using the platform (**SUB4**). The results presented in Table 2 indicate a predominantly positive attitude among teachers toward using the metaverse-based platform. The highest level of agreement was recorded for the statement: *The metaverse-based platform allows teachers to create purposeful teaching materials about abstract concepts (such as the rotation and revolution of the Earth).* ($M = 4.30$). On the other hand, the statement with the highest level of disagreement was: *I believe that this platform could improve the social interaction between teachers and students.* ($M = 2.94$). This result suggests potential concerns among participants regarding the social dimension of teaching in a metaverse environment, possibly indicating a misconception about the lack of direct communication in immersive spaces. Regarding challenges, the mean value for this subcategory was ($M = 3.91$), with a high level of agreement expressed for the statements: *This platform requires additional training for teachers to ensure its effective use.* ($M = 4.31$) and *The use of the platform may cause uncertainty when navigating a new (virtual) environment.* ($M = 3.51$). This finding highlights the recognized need for additional training and support for teachers when implementing the metaverse in education. The subcategory related to the efficiency of the metaverse-based platform showed consistently positive attitudes among respondents, with mean values ranging from ($M = 3.76$ to $M = 4.11$), further confirming the perception of the metaverse environment as beneficial for improving the teaching process.

Table 2. Descriptive statistics results of attitudes towards a metaverse-based platform.

		STATEMENT (S)	N	M	SD
S1	SUB1	I believe that this platform would be effective for conducting classes in the event of crises (such as war, pandemic, earthquake, natural disasters...)	108	4,11	1,307
S2	SUB1	Teaching supported by technologies like metaverse can help in preparing materials for classes.	108	4,04	1,199

S3	SUB2	The metaverse-based platform allows teachers to create purposeful teaching materials about abstract concepts (like the rotation and revolution of the Earth).	108	4,30	1,079
S4	SUB3	I believe that this platform could improve the social interaction between teachers and students.	108	2,94	1,222
S5	SUB1	The existence of such a platform would enable continuity in education since, due to certain circumstances, teaching in schools can be temporarily interrupted, which is not the case in the metaverse.	108	3,76	1,274
S6	SUB3	The existence of such a platform can facilitate cooperation in the form of the exchange of experiences and educational materials between teachers from different schools that are physically distant.	108	4,06	1,191
S7	SUB4	The use of the platform may cause uncertainty when navigating a new (virtual) environment.	108	3,51	1,140
S8	SUB4	This platform requires additional training for teachers to ensure its effective use.	108	4,31	1,045
S9	SUB2	I believe that this platform could facilitate student achievement monitoring.	108	3,45	1,248
S10	SUB2	I believe that this platform could help teachers develop new teaching models (e.g., hybrid learning).	108	4,02	1,230

Research Task 2: This part of the study aimed to determine whether there was a statistically significant difference in attitudes between the two respondent groups. To examine whether there is a statistically significant difference in the attitudes between pre-service and in-service teachers, an independent t-test was conducted. The results of Levene's test for equality of variances indicated that there was **no statistically significant difference** in variances between the groups ($F = 0.440, p = 0.508$), allowing the use of the t-test assuming equal variances. The t-test results ($t(106) = 1.059, p = 0.292$) revealed that there was no statistically significant difference in the attitudes between pre-service and in-service teachers. The mean for pre-service teachers was $M = 3.95 (SD = 0.865)$, while the mean for in-service teachers was $M = 3.76 (SD = 0.947)$. Although pre-service teachers had a slightly higher mean, the difference was not statistically significant, suggesting that the attitudes of the two groups towards the metaverse-based educational platform are not significantly different (Table 3).

Table 3. Results of the t-test for pre-service and in-service teachers' attitudes.

GROUP	t	df	Sig. (2-tailed)	Mean Difference (MD)
pre-service vs. in-service teachers	1.059	106	0.292	0.186

Research Task 3: To identify the benefits that pre-service and in-service teachers recognize regarding the application of an educational platform based on the metaverse, responses were collected through open-ended questions asking participants to list one or more advantages they observe in the case of using such a platform. A total of 121 responses were recorded from 108 participants, as each participant had the opportunity to mention more than one benefit. However, a portion of the responses was not considered because the corresponding fields were left blank ($N = 10, 8.26\%$). The final sample included 111 responses, which were grouped according to similarity and then coded for more efficient analysis. Table 4 presents the distribution of responses according to the identified categories ($N = 6$). Respondents most frequently indicated that the primary advantage of learning in a metaverse environment is the ability to explore abstract content, as well as content that is temporally and spatially distant ($N = 42, 37.84\%$). To a somewhat lesser extent, responses categorized as advantages related to teaching efficiency were reported ($N = 23, 20.72\%$). This category includes responses in which participants recognized the metaverse educational environment's benefits in creating higher-quality teaching materials, preparing the teaching process, and monitoring, measuring, and evaluating student achievements. In comparison with the statements from Research Task 1, there is a corresponding overlap, as respondents had previously

expressed a positive attitude toward statements regarding the efficiency of a platform based on the metaverse concept. Moreover, one of the identified advantages is the development of new teaching models enabled by the use of the metaverse in education ($N = 16, 14.41\%$). Responses in this category included those in which respondents recognized that a metaverse-based platform would be suitable for implementing hybrid learning where part of the instruction takes place in the classroom and part in a metaverse environment. Next, responses related to the advantages the platform can offer under extraordinary circumstances ($N = 12, 10.81\%$) were noted, with particular emphasis on delivering instruction during pandemic conditions. The identification of this advantage is not coincidental, as both domestically (Kuzmanovic, 2022) and internationally (Sanchez et al., 2023), it has been shown that educational systems require a more adequate response to teaching during crises following the COVID-19 pandemic. An equally represented group of responses indicated that respondents could not identify any specific advantages ($N = 12, 10.81\%$). The least frequent category of responses pertained to the view that the use of this platform could contribute to the development of collaboration, communication, empathy, and a willingness to help others. These responses were categorized as advantages related to the development of pro-social skills ($N = 6, 5.41\%$), which encompass the aforementioned aspects (Sylva, Sammons, Melhuish, Siraj, & Taggart, 2020). The relatively low frequency of responses in this category was anticipated, given that the initial research task revealed that respondents did not exhibit a notably positive attitude toward the proposition that the platform could foster enhanced social interaction in student-teacher relations.

Table 4. Categories of perceived benefits of a metaverse-based educational platform.

CATEGORIES OF PERCEIVED BENEFITS	Frequency	Percent %
1 – efficiency of conducting the teaching process	23	20,72
2 – research of abstract, temporally, and spatially distant contents	42	37,84
3 – pro-social skills	6	5,41
4 – development of new teaching models	16	14,41
5 – extraordinary circumstances	12	10,81
6 – benefits are not recognized	12	10,81
Total number of responses⁶	111	100,00 %

Research Task 4: An analysis was conducted to identify the perceived challenges and limitations associated with the application of the metaverse in education based on educational platform example. Although 108 participants responded to the question, a total of 139 responses were recorded, as each participant was allowed to indicate more than one shortcoming. However, responses that were left blank ($N = 11, 5.04\%$) were excluded, resulting in 128 valid responses that were categorized into six groups, as presented in Table 5. The category with the most responses related to the respondents' opinion that the primary disadvantage of using a metaverse-based platform is related to reduced socialization and interaction in teacher-student and student-student relationships, as well as the inability to implement cooperative and collaborative learning, which would contribute to reduced motivation and development of social skills. The common thread underlying these responses is the concern that the integration of this technology might lead to a diminished human presence in the educational process, an issue perceived as dehumanization (Shyroka, Bilchuk, & Pivenet, 2023). This pattern of responses ($N = 38, 29.69\%$) was somewhat anticipated, considering that the least frequently recognized advantage in previous research tasks was related precisely to the positive impact on the development of pro-social skills in a metaverse educational environment. On the other hand, it is noteworthy that despite this identified shortcoming, respondents simultaneously exhibited a predominantly positive attitude toward the potential for collaboration on the platform and networking with teachers and students from other schools, as evidenced in Research Task 1. Furthermore, it was shown that respondents largely

⁶ The total number of responses does not correspond to the number of participants ($N = 108$) in the study, as the open-ended question format allowed each respondent to provide one or more perceived benefits.

recognize that the obstacle in using the platform is not directly related to it, but to the lack of digital competencies of teachers ($N=30$, 23.43%). This group of responses confirms what was shown in Research Task 1, where respondents largely agreed with the statement that using the platform requires additional training for teachers, which can be an obstacle in its implementation. Next, there are answers grouped under material-technical conditions that may be one of the shortcomings of the platform's implementation, where respondents cited answers such as lack of digital equipment in schools, lack of funds, poor internet connection, and the like ($N=28$, 21.88%). There is an interesting group of responses categorized as resistance to new teaching models, where it is noted that the mentioned deficiency is not directly related to the platform in the metaverse environment, but rather to the respondents' resistance to a hybrid learning model that differs from established models. On the other hand, within Research Task 3, the development of new teaching models was recognized as one of the advantages ($N = 16$, 14.41%). On the other hand, within Research Task 3, the development of new teaching models was recognized as one of the advantages ($N = 16$, 14.41%). However, it is encouraging that there was not a large number of responses in the mentioned category ($N = 14$, 10.94%), which indicates a relatively high degree of openness of respondents towards innovations in the educational process and excessive technology usage. This attitude, similar to the attitude of dehumanization, may reflect insufficient teacher competence for the purposeful application of incoming technology and a misunderstanding of the concept that technology is not a goal in itself, but a means to improve educational outcomes (Mandic, Miscević, & Bujisic, 2024; Matovic, 2024). The least represented response category referred to respondents who did not identify specific shortcomings or challenges related to using a metaverse-based educational platform ($N = 3$, 2.34%).

Table 5. Perceived challenges and limitations of a metaverse-based educational platform.

CATEGORIES OF PERCEIVED CHALLENGES AND LIMITATIONS	Frequency	Percent %
1 – material-technical conditions	28	21,88
2 – dehumanization	38	29,69
3 – lack of digital competencies of teachers	30	23,43
4 – resistance to new teaching models	14	10,94
5 – excessive technology usage	15	11,72
6 – without identified specific shortcomings or challenges	3	2,34
Total number of responses⁷	128	100,00 %

Conclusion

Based on global research focused on the application of the metaverse in education and teachers' perceptions, numerous benefits of this technology have been identified, including: promoting interactive, experiential, and personalized learning, increasing student engagement and motivation, developing critical thinking, encouraging research and collaboration among students, and facilitating the understanding of abstract concepts. The metaverse will offer innovative approaches to education, but its application will face challenges such as technological accessibility, data privacy, and the lack of teacher training. The key to successful integration lies in balancing the digital benefits with pedagogical needs and educational outcomes in the best interest of students, as well as in continuous teacher development. These findings served as the basis for proposing a model of an educational metaverse-based platform empowered by generative AI, which was used as a framework for examining attitudes toward the implementation of new technologies in the Serbian

⁷ The total number of responses does not correspond to the number of participants ($N = 108$) in the study, as the open-ended question format allowed each respondent to provide one or more perceived challenges and limitations.

education system. The study of attitudes among pre-service and in-service primary school teachers in the Republic of Serbia was conducted by evaluating the proposed model.

The research results showed that both pre-service and in-service teachers in the Republic of Serbia recognize the potential of metaverse technology in enhancing the educational process, but at the same time, they highlight the challenges associated with its future implementation. The predominantly positive attitude toward the metaverse platform includes the efficiency of teaching and the ability to explore abstract content. However, on the other hand, respondents expressed doubt about the platform's ability to improve social interaction between teachers and students, emphasizing the risk of dehumanizing the educational process and reducing cooperative learning. Nevertheless, global research suggests that the metaverse in education can encourage social interaction among users, which implies that this attitude might result from the lack of teacher competencies for the effective application of new technology and a misunderstanding of the concept that technology is not the ultimate goal, but rather a means to enhance educational outcomes (Mandic, Miscevic, & Bujisic, 2024; Matovic, 2024; Ristic, 2022).

Other challenges and limitations were mainly related to material-technical deficiencies, as well as resistance to new teaching models. Respondents pointed out the need for additional training and technical support, given the challenges associated with navigating the metaverse environment and the lack of digital skills to apply AI. The research results are encouraging when it comes to assessing the potential of the metaverse in education. It is somewhat expected that there are concerns among respondents about the limitations and challenges posed by this innovative concept. Teachers should be encouraged and motivated to use metaverse technology, with appropriate training. Therefore, it is crucial to provide support for their active involvement in new teaching models (Demirel & Koroglu, 2024; Chen et al., 2023; Rachmadtullah et al., 2023b).

The successful implementation of the metaverse in education depends on systematic teacher education, continuous support, technical conditions, and a clear legal and ethical framework (Suvakovic, 2024), which would enable its effective application in modern education.

Implications

Based on the obtained and interpreted research results, the key implications highlight the need for additional teacher training in the application of artificial intelligence in education, including the innovative concept of the metaverse. To ensure the effective and purposeful integration of this technology into the teaching process, it is necessary for such training to become an integral part of the curriculum at faculties that educate teaching staff in the K-12 system (Mandic, Miscevic, Babic, & Matovic, 2024). This would lead to the improvement of future teachers' competencies and ensure the effective implementation of the metaverse in the educational context in a way that optimally contributes to achieving educational outcomes. In organizing and creating such training, it is essential to involve educational experts, relevant institutions, as well as other competent educational and research centers, to provide professional support and standardization for the introduction of the metaverse into the teaching process. The application of the metaverse in education may be limited without appropriate legal frameworks. It is necessary to develop guidelines for selecting appropriate platforms and improving digital educational and social policies, as the lack of legal frameworks can restrict its institutional application (Han & Hong, 2022). Further technological advancement and scientific research will be key to overcoming challenges and ensuring the effective and sustainable use of the metaverse in the education system (Lin et al., 2022).

Future research should focus on developing standardized approaches to teacher training, evaluating the effectiveness of metaverse technologies in education, and creating legal and ethical frameworks that will enable its long-term and sustainable application in educational institutions.

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