IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 13, Issue 8, August 2025

DOI: 10.17148/IJIREEICE.2025.13811

A Multi-dimensional Metaverse Approach in Educational Environments

Dimitrios Magetos[1], Prof. Sarandis Mitropoulos[2]

IT Teacher, Ph.D., (C), Department of Informatics, University of Piraeus, Greece[1]

School of Science & Technology, Hellenic Open University, Greece[2]

Abstract: Metaverse, as an emerging, interactive and immersive 3D virtual space technology of Web 3.0, is expected to lead to a profound transformation of the educational process. Its ability to combine digital presence, direct interaction and experiential learning offers new perspectives for active student participation and personalized learning in virtual environments. Within this context, the present study focuses on examining the integration of Metaverse into education, exploring its potential and advantages, as well as the issues and challenges that may arise from its use. To support the research process, a mixed methodology was used, which included a literature review, a qualitative study, and a quantitative study. In addition, pilot virtual worlds were created on the Spatial.io platform, using the ADDIE method, offering teachers the opportunity to test and gain experience. The results show that Metaverse contributes substantially to the improvement of learning experience, offering realistic and interactive learning environments, while enhancing social interaction and promoting experiential learning. However, potential risks must be taken into account, such as digital inequality, malicious use of educational data, prevention of cyberbullying, and unnecessary and excessive use of the metaverse by students, such as isolation from the natural environment and obsession with virtual worlds and our digital persona. In conclusion, the empirical research reveals a positive response of Greek teachers to the proposed Metaverse model, predicting improvements in the learning experience and student interest.

Keywords: Web 3.0, Metaverse, Avatar, Spatial.io, ADDIE, Virtual Worlds**.**

I. INTRODUCTION

The modern educational reality requires continuous adaptation and integration of innovative technologies, in order to respond to the changing needs of students and the challenges of the digital age. In this context, the introduction of the metaverse in education emerges as an innovative solution for the creation of enriched and personalized learning experiences [17]. The metaverse, as a constantly evolving technological environment, attracts the interest of researchers and professionals in the educational field, offering a new dimension in the connection of the physical and digital worlds. The use of the metaverse in education can lead to significant improvements, offering immersive and interactive learning experiences, tailored to the needs of students.

This study highlights the significant impact of Metaverse's new and emerging technology in education. It utilizes a mixed methodology approach that combines literature review, qualitative and quantitative study. The bibliographic review highlights the current knowledge of Metaverse and its possibilities to apply to the educational space. Qualitative research allows exploration of deeper implications and understanding of the application of Metaverse in the educational process, through group discussion with educators and researchers. The quantitative study provides objective data, such as statistics from the use of Metaverse in educational contexts. The combined approach of these methodologies allows for a complete and multidimensional understanding of how this technology affects and enhances the educational space. First and foremost, it offers the literature a thorough empirical investigation focused on the use of Metaverse in the educational field. It examines the added value of educational experiences in the Metaverse through the views and attitudes expressed by professional primary and secondary teachers. Our study is an important contribution, given that, according to [37] existing research on the Metaverse often focuses on higher education, with little research remaining on early childhood, primary and secondary education. This particular study provides an overview of metaverse systems, which can be exploited either in education or more broadly in other fields.

The research also highlights the process of building virtual worlds in the Metaverse and leverages the ADDIE method in building specific pilot educational worlds. These are particularly important to educators, as well as educational content creators and other stakeholders, and are useful tools and sources of guidance for those seeking to create virtual worlds in the Metaverse. Finally, the conclusions of this research extend to the real world, offering educational organizations valuable information on how and why they should leverage the Metaverse in the educational process.

DOI: 10.17148/IJIREEICE.2025.13811

Overall, our research highlights the significant contribution of Metaverse to the educational field and offers important approaches for its future application in the field of education.

While the domain of Web 2.0 has been extensively researched, there is a large gap in research activities related to Web 3.0. Web 2.0 has played an important role in the evolution of education and technological interaction, Web 3.0 seems to offer new possibilities that have not yet been extensively explored [51]. However, despite the increasing interest in these possibilities, the available research on Metaverse remains limited, and is even more limited in terms of its application in the educational sector [27]. Among other technologies, it is necessary to conduct in -depth research on whether and how Metaverse can be used specifically in school education. The success of any new technology presupposes its acceptance by the community of its users. In the case of education, teachers, students and all stakeholders will play a decisive role in whether Metaverse will be integrated and adopted in the educational space in the coming years. However, existing research on the educational value and capabilities of emerging web 3.0 remains limited, while investigating the use of Metaverse in school education is even more limited. In -depth understanding of the opportunities and potential dangers of Metaverse for learning processes, evaluation and cooperation in distributed environments is a major challenge that requires further research and development.

This document focuses on Metaverse's potential in education, analyzing its usefulness, issues that arise and the processes of creating educational virtual worlds. Teachers' views on the acceptance of this technology, the potential risks to students and teachers, as well as the open issues related to safety and the potential negative impact on students, are presented. At present, empirical research focusing solely on the use of metaverse in education remains limited. Although there are some studies and examples showing how virtual reality and other immersive technologies can enhance learning experience, Metaverse as a concept remains a new and emerging field. The present study was based on a bibliographic review of Metaverse studies in education, which were published after 2023 in valid scientific journals. The purpose of the bibliographic research is to highlight the modern trends and effects of Metaverse on the educational field. Furthermore, by using both qualitative and quantitative research methods, we aim to investigate the degree of willingness of Greek teachers to integrate the metaverse into their teaching and learning processes in the future.

In the context of this study:

1. The field of metaverse was investigated, and specifically the use of its virtual worlds in education.
2. Technology acceptance theories were investigated: Mapping relevant theories and scales for the acceptance and adoption of metaverse technologies by teachers and students.
3. A new TAM+ model was proposed: In addition to ease of use and usefulness, the TAM+ model we created also takes into account other variables that influence teachers' intention to adopt metaverse technology in education.
4. Empirical research was conducted: The research determined the level of acceptance of metaverse in education, from the perspective of Greek teachers. The statistical analysis was not limited to descriptive measurements, but was extended to inductive analysis with hypothesis testing and interpretation of results for the general population.

The organization of this paper is as follows: section I is the Introduction, in section II the Theoretical Background and Related Work. In section III we describe Our Methodological Approach. In section IV we report the Evaluation Results and in section V we present the Discussion on Results. In section VI we report the Future Work and Open Issues. In section VII we present the conclusions.

II. THEORETICAL BACKGROUND & RELATED WORK

2.1 Metaverse in education

The Metaverse is the future 3D Internet, characterized by immersion, interactivity, and persistence of the digital environment [53]. It is an evolving digital experience space where users actively participate, interact with each other and with objects in the virtual world, and enjoy a sense of presence through virtual and augmented reality (VR/AR) technologies, 3D imaging, and spatial audio [54]. The persistence of the Metaverse states that virtual worlds evolve and remain available regardless of the user’s connection.

The Metaverse is considered a component of Web 3.0, as it is associated with decentralization, interoperability, and ownership of digital assets through blockchain and smart contract technologies, facilitating an interconnected and sustainable digital presence ecosystem [55].

According to current literature, the Metaverse can be analyzed into multiple layers of functionality [56], which compose the complete user experience:

DOI: 10.17148/IJIREEICE.2025.13811

1. **Infrastructure Layer:** It includes next-generation networks (5G/6G), cloud computing, edge computing systems and blockchain technologies that ensure interoperability and transaction security.
2. **Interface Layer:** It concerns access devices such as VR/AR headsets, haptic interfaces, spatial speakers and mobile devices, which allow immersion and interaction with the environment.
3. **Virtual World Layer:** It includes 3D and interactive worlds, which are persistent, adaptive and support the presence of many users at the same time (multi-user persistent environments).
4. **Economy & Content Layer:** Regards the production, exchange and ownership of digital content, such as NFTs, virtual goods, avatar skins, as well as economic activity within the virtual world.
5. **Experience Layer:** Focuses on the use and consumption of experiences, including educational applications, entertainment, social networking, collaborative work and cultural events.

This hierarchy makes it clear that the Metaverse is a multi-layered ecosystem, where technological infrastructure, user interfaces, 3D worlds, financial transactions and social experience combine to form an interactive, immersive and persistent environment, which is expected to drastically transform education, social interaction and the digital economy in the context of Web 3.0.

The literature on the application of the metaverse in education highlights the potential and challenges associated with this technology. The metaverse allows the creation of virtual learning environments that mimic real classrooms, enhancing collaboration and interaction between students and teachers [34]. The use of virtual worlds and 3D models can help students understand complex concepts and develop practical skills in a safe and controlled environment [45]. In addition, the metaverse offers the possibility of creating personalized learning paths, tailored to the needs and preferences of each student. The development of blockchain technology has brought about significant changes, allowing the creation of immersive and multi-sensory 3D environments. However, the adoption of the metaverse in the educational process is not without obstacles, as issues of accessibility, digital illiteracy and the need for specialized training of teachers arise.

Furthermore, the creation of an educational metaverse requires the development of appropriate educational content and the integration of pedagogical principles that promote active learning and student participation [46]. The integration of artificial intelligence into the metaverse can further enhance educational capabilities, offering personalized feedback and support to students. At the same time, the development and integration of the metaverse in education requires collaboration between educators, technologists and content creators, in order to ensure the quality and effectiveness of learning experiences.

Virtual reality has emerged as a powerful tool for enhancing distance learning, offering capabilities that go beyond the limitations of traditional methods. Many studies have shown that the use of the metaverse in education can improve student engagement, increase conceptual understanding, and promote skill development. Integrating the metaverse in education allows users to interact and work remotely in 3D environments.

The metaverse integrates different cutting-edge technologies into contemporary internet applications and social structures, creating a persistent virtual space that blends with augmented physical reality. Metaverse's ability to create immersive, interactive, and collaborative educational experiences has the potential to revolutionize online education by eliminating the limitations of traditional online learning platforms [46]. The use of the metaverse in education has been shown to enhance student engagement, motivation, and learning outcomes by creating a more vibrant and immersive educational environment [42]. The use of virtual and augmented reality technologies in the metaverse to create dynamic and interactive educational materials can make complex ideas more accessible and understandable.

The metaverse promotes decentralized, visualized learning resources that allow students to engage with the material [45]. The metaverse's interactive nature encourages active learning by enabling students to participate in simulations, virtual field trips, and collaborative problem-solving activities, which encourages critical thinking and practical skill development. These immersive experiences promote deeper learning and knowledge retention by enabling students to engage with the material in ways that are both significant and memorable. The metaverse offers a unique opportunity to support and improve e-learning [42]. The metaverse has the potential to revolutionize education by creating engaging, immersive, and personalized learning experiences for students of all ages and backgrounds [28].

2.2 Theories of innovation technology acceptance

Various theories have been proposed from time to time that show how an organization, business, or group is influenced by various elements such as its environment and its internal structure. Some of these theories have prevailed, and for this reason, they are repeated and found in more recent studies that deal with the factors that influence teachers to

DOI: 10.17148/IJIREEICE.2025.13811

accept or adopt technology in the educational process. Most are based on the Theory of Reasoned Action [33]. This theory predicts human behavior using a set of attitudes and intentions. The Technology Acceptance Model (TAM) attempts to explain why and how various groups (including educators) embrace (or reject) the use of technology [8]. The TAM model suggests that when a new technology or software package is introduced, a set of factors influences our decision about when and how to use it. The innovation diffusion theory (Rogers, 2003) [32] relates to how, why, and to what extent new ideas and technology diffuse. Innovation, according to Rogers, is an idea or practice that is perceived as new by the individual user or by a group of users. This theory finds application, for example, in the acceptance of new technological products (e.g., computers), musical styles, ideas, etc. The Success Model of Information Systems (IS), originally created in 1992 by Delone and McLean, offers a detailed and comprehensive definition of the success of these systems. Specifically, Delone and McLean [48] have set six basic dimensions that determine the success of an information system: the quality of information, the quality of the system, the degree of use, the satisfaction of users, the individual influence and the organizational effect.

The Unified Theory of Acceptance and Use of Technology (UTAUT) [40] has emerged as one of the leading frameworks, attempting to synthesize into one model the determinants identified by previous models. The UTAUT model highlights the importance of users' expectations, such as performance expectation and expectation of effort. Performance expectation refers to one's belief that the use of a technology will improve their performance, while the expectation of effort is related to one's perception of how easy or difficult it is to use this technology. The UTAUT model expands this perception by adding two additional critical factors: social influence, which refers to the extent to which people believe that people think they think they should use new technology. In addition, the model argues that factors such as gender, age, experience and whether technology is voluntarily becomes or not can affect the way these factors shape the intent and behavior of users.

The Technology, Organization, and Environment (TOE) Framework, developed by Tornatzky et al. (1990) [38], is defined as a framework that helps explain the organizational characteristics that influence a firm's or organization's decision to adopt technological innovations. The three levels of the model are technology, organization, and environment. These three levels influence the process by which organizations adopt and embrace new technologies, presenting both their limitations and opportunities. The TOE framework has been examined by various studies, such as the adoption of electronic data interchange, the adoption of RFID technology, the adoption of e-business, the adoption of ERP by enterprises, the adoption of e-government, and the adoption of electronic signatures.

Institutional theory emphasizes logical myths, homogeneity, and rules to explain why an organization or group adopts a particular attitude or technology. Thus, according to this theory, there are normative and imitative pressures for the adoption of information and communication technologies in various sectors (Teo et al., 2003) [36].

In relevant research [39], various measurement scales have been developed for the acceptance or adoption of new technologies in various sectors. Çelik (2020) [6] developed the effectiveness scale of using Web 2.0 tools for teachers. Horzum and Aydemir (2014) [14] conducted a scale development study to measure teachers' educational self-efficacy regarding the educational use of Web 2.0 tools. In addition, some studies aimed to measure satisfaction from interacting with websites [20]. The study by Liu et al. (2021) [23] developed the "Web3 Awareness Scale," a comprehensive tool designed to accurately measure university students' awareness and understanding of Web3.

In the research by Koutromanos et al. (2023), which focused on the adoption of augmented reality (AR) in mobile teaching, a variant of the TAM (Technology Acceptance Model) model was used. The main findings of the research showed that the intention of teachers to use AR was influenced by attitude, perceived usefulness, and facilitation conditions. In turn, attitude was influenced by perceived enjoyment and perceived usefulness. Perceived usefulness was influenced by perceived enjoyment and perceived relative advantage [18].

The study by (Al-Adwan et al., 2023) [2] examines the acceptance of the metaverse by university students in Jordan. In particular, it modifies the Technology Acceptance Model (TAM), incorporating perceived enjoyment and perceived risk in cyberspace as direct predictors of intention to use metaverse-based learning technologies. At the same time, it considers personal IT innovativeness and self-efficacy as personal characteristics that emerge as key determinants for the acceptance of the metaverse in the field of education.

Another research by (Wiangkham & Vongvit, 2023) [43] examines the factors influencing the intention to use metaverse technology in the field of engineering education. It uses an extended Unified Theory of Acceptance and Use of Technology (UTAUT) model, incorporating variables such as hedonic motivation and habit while introducing trust in technology and cybersecurity as critical factors in the adoption and acceptance of the metaverse in education. The

DOI: 10.17148/IJIREEICE.2025.13811

study by (Al-Adwan & Al-Debei, 2023) [2] considers that the use of the metaverse in higher education has not been adequately examined in the relevant literature and therefore attempts to explore possible determinants by utilizing the above factors. Furthermore, it examines whether social influence positively affects Gen Z students' behavioral intention to use the metaverse in their learning. The research (Yang et al., 2022) [44] examines college students' willingness to utilize metaverse technology to study basketball courses while examining factors that may influence the use of this technology. To achieve this goal, the conceptual model of the research is based on the UTAUT model. In particular, habit, attitude, and behavioral intention appear as important factors influencing usage. In this context, hedonic motivation factors, facilitating conditions, and performance expectancy exert a significant influence on attitudes. The research (Hwang et al., 2023) [15] emphasizes the critical role of learning motivation in sustaining student learning performance in the metaverse. Despite the allure of new technologies, student performance depends on their motivation levels, highlighting motivation as a key factor for effective learning in the metaverse. The study [1] (Aburayya et al., 2023) focuses on the perception of medical students regarding the utilization of the metaverse. The research's conceptual model incorporates elements from the Technology Acceptance Model (TAM), focusing particularly on perceived value and perceived ubiquity as determinants of metaverse adoption. This research concludes that educational systems worldwide will be affected by the evolution of the metaverse. The study of (Teng et al., 2022) examined the factors influencing student adoption of a metaverse educational platform using an extended UTAUT model and incorporating perceived risk, which was shown to play an important role in this study. This is due, according to this study, to the fact that service providers require users to enter basic personal information, which is considered a deterrent to using the metaverse [35].

For this research, in addition to ease of use and usefulness, the TAM+ model we created takes into account other variables that influence teachers' intention to adopt metaverse technology in education, and it is TAM+: Technology Acceptance Model+ (Enjoyment, Motivation Enhancement, Remote Support, Teaching Support, Innovation, Addiction, Safety).

2.3 Statistical methods and applications

The present study adopted a mixed methodology, combining qualitative and quantitative research approaches. Specifically, the discussion method was used with the aim of recording the opinions and intentions of the teachers. This method is part of qualitative research, providing an in-depth understanding of the experiences and interpretations of the participating teachers. Quantitative research techniques and methods were also used, such as descriptive and inductive analysis, as well as the bootstrap sample method, to generate additional samples of quantitative data in order to verify our research hypotheses in a more reliable way.

Qualitative research has attracted the interest of the social sciences in recent years, with numerous applications in various fields [16]. The definition of qualitative research varies, with three main approaches shaping the landscape. According to the first, qualitative research interprets and transforms the world, producing representations of the self through notes, interviews, discussions, photographs, and other media. In qualitative research, an interpretive, naturalistic stance is adopted, studying phenomena in their natural environment and interpreting the meanings people attach to them. The second approach focuses on the context of the research, separating the qualitative from the quantitative. Qualitative research takes place in real settings, in the "real world," studying people in their natural environment. Finally, the third approach focuses on the object of study, emphasizing meaning rather than behavior. Qualitative researchers focus on how people experience events, interpreting the experiences and the meanings they ascribe to them. Among the methods of qualitative research are group discussions with the help of a moderator. Group discussions, also known as "focus groups," are a qualitative research method. Participants are invited to discuss a specific topic or question with the help of a moderator.

Statistical analysis is an integral part of any research study. Its purpose is to draw conclusions about the population from which the data come, which may be numerical or qualitative [9]. Descriptive statistics come to meet the need to organize and summarize this data before any analysis. Usually, studying the entire population is difficult to impossible. Therefore, we take a sample, which we study in order to draw conclusions about the population. Descriptive statistics cover this part, offering methods for collecting, organizing, presenting, and studying sample data. Summary presentation is achieved in two ways: frequency tables and graphs. Each method helps reveal important characteristics of the data and, by extension, the population.

Inductive statistical analysis being the sibling of descriptive statistics, looks to the future. By extracting information from a sample of data, inductive statistics aims to draw conclusions and predict future trends for the sampled population. Acting as a bridge from the specific to the general, inductive statistics is a cornerstone for informed decision-making in a multitude of scientific fields. Many times, in various quantitative research studies, we focus on

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.414 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 13, Issue 8, August 2025
DOI: 10.17148/IJIREEICE.2025.13811

the question of whether the value of the parameter exceeds a critical threshold [19]. For example, the average blood pressure of patients in a clinic. It is important to know whether this average value exceeds the corresponding limit of the healthy population. To answer such questions, we use statistical hypothesis testing.

We define two basic assumptions:
1. **Null Hypothesis (H0):** The value of the parameter does not exceed the critical limit.
2. **Alternative Hypothesis (H1):** The value of the parameter exceeds the critical limit.

The **null hypothesis (H_0)** represents the baseline assumption, while the **alternative hypothesis (H_1)** reflects the condition under investigation. Hypothesis testing evaluates whether the data provide sufficient evidence to reject H_0. The **significance level (α)** indicates the acceptable probability of error, commonly set at 0.05 (95% confidence) or 0.01 (99% confidence). A result with **$p < \alpha$** leads to the rejection of H_0 in favor of H_1.
The **t-test (Student's t-test)** is a statistical method used to compare means and assess whether differences are significant [12] (Gialamas et al., 2024). It can evaluate:
1. Whether a sample mean differs from a known value (**one-sample t-test**),
2. Whether two independent groups differ (**independent samples t-test**), or
3. Whether paired measurements show significant change (**paired samples t-test**).

2.4 Bootstraped sample methods

The bootstrap method is another resampling technique which allows estimating the variability of estimators without using additional data, but only with the help of the original sample [5]. The increase in computing power that occurred during the 1980s, combined with the flexibility to apply the bootstrap to a wide range of problems, but also the directness that the method provides intuitively, contributed decisively to its establishment as one of the most popular nonparametric tools. The basic bootstrapping process involves the following steps:
1. First, you select k samples from the original data set, with repetition (i.e. the same items can be selected more than once).
2. Then, for each of these samples, you calculate the statistical measure of interest.

The result of this process is that you have k different estimates for that statistical measure, which you can use to calculate a confidence interval for that measure.

III. OUR METHODOLOGICAL APPROACH

The study includes a review of the relevant literature, qualitative and quantitative approaches to determine the level of acceptance of the metaverse in education by Greek teachers. The results of the literature review were used to design questions and create the appropriate questionnaire. The sample of the empirical study consists of teachers who participated in the laboratory session entitled "Design, Implementation and Evaluation of Learning Environments in 'Metaverse,'" which took place in the framework of the 15th International Conference on Informatics in Education (15th CIE: http://events.di.ionio.gr/cie/index.php/el/2020-09-08-12-49-30/cie-2023). This conference is organized by the IT departments of the Universities of Piraeus and Ionian and the Hellenic Society of IT Scientists for 15 consecutive years. The activities of the conference include invited speeches, round table discussions, and useful workshops targeting current educational needs. All actions were offered online through the Zoom platform and live-streamed on YouTube. The laboratory session was also recorded and videotaped so that we could edit it at a later time offline for further analysis and qualitative study.

The research questions of the empirical study were the following:
RQ1. Do Greek teachers believe that the metaverse will enhance students' motivation to learn?
RQ2. Do educators think the metaverse will be easy to use as a teaching space?
RQ3. Do educators think the metaverse will be useful in educating students?
RQ4. Do educators believe that the metaverse will provide enjoyable educational experiences?
RQ5. Do educators think the metaverse will support distance learning?
RQ6. Do teachers think the metaverse will support teaching?
RQ7. Are educators willing to utilize the metaverse in the educational process in the future?
RQ8. Do educators think the metaverse will create addiction in students?
RQ9. Are teachers concerned about security and privacy issues from using the metaverse?

3.1 Key axes and data collection tool

The main focus of this study revolves around the factors that play a role in interpreting and determining the level of acceptance of the metaverse as a technology that supports the educational process. Moreover, these factors can be

DOI: 10.17148/IJIREEICE.2025.13811

considered as indicators of the overall acceptance of this technology. Based on field research, key parameters have been identified, including, but not limited to: the enhancement of student motivation, the ease of use and usefulness of the metaverse in education, the pleasure of using it, the ability to support teaching and distance learning, the intention of teachers to use the metaverse, the risks of addiction and negative effects on students, and the issue of security and privacy of students and teachers from any leakage of personal data.

3.2 Questionnaire structure

The factors mentioned above resulted IN the main axes in the formulation of the questionnaire. These axes led to the formulation of closed-ended questions. The questionnaire was based on theories around technology acceptance by Davis, innovation theory by Rogers (2003) [32] and related questionnaires that examine teachers' views on the adoption of IT technologies in education. The questions came from widely used and validated scales which we modified and extended to adapt them to the present research study. We created the TAM+ model which is an extension of the TAM and is oriented to determine the degree of acceptance of metaverse technology in education.

The first dimension of the questionnaire, **(Indicator 1) Enhancing Learning Motivation,** explores the extent to which teachers consider it important to utilize the metaverse to increase student motivation. Five questions were used to determine the index, which determine teachers' opinions on whether the metaverse enhances students' interest as well as students' motivation to learn. More specifically, the questions aim to determines whether the introduction of the metaverse into the educational environment can generate interest and excitement among students, as well as enhance their motivation for active participation and learning.

The second dimension, **(Indicator 2), Perceived Ease of Use**, explores the extent to which teachers believe that the metaverse in general is easy or not to use in the educational process. This axis represents the teachers' general beliefs about the difficulty or easy of use of the specific spatial.io platform and not their perceptions about their own ability to teach through the metaverse. This factor refers to the degree to which the end user perceives that a technology does not require much effort to successfully use it. The likelihood of adoption and use of a new technology such as metaverse is greater when users understand the technology to be easy to use. Venkatesh et al., (2003) [40] previously found that the perception of factors such as ease of use, usefulness, and enjoyment influences people's intention to use a system.

The third dimension, **(Indicator 3) Perceived Usefulness**, investigates at a first level, the extent to which educators believe that the metaverse, (specifically the virtual worlds they have experienced), will be useful to be used as an educational tool. Perceived usefulness has been defined as "the extent to which an individual believes that using a particular system would enhance their work performance" [8] but also as "the value provided to the individual by the technology".

The fourth dimension, **(Indicator 4) Perceived Enjoyment**, consists of four questions and explores the extent to which teachers believe that teaching with virtual worlds will be enjoyable for themselves and their students. Perceived enjoyment represents the degree to which a person experiences pleasure as a result of using a particular technology. The pleasure and entertainment that humans derive from engaging with virtual worlds [13], are one of the key factors in their adoption for a long time.

The fifth dimension, **(Indicator 5) Support Distance Education**, focuses on distance education and presents significant body of research. It consists of three questions, which analyze the teachers' belief about whether virtual worlds can work as a supporting tool for the distance education process. In this way, it seeks to highlight the role of virtual worlds in shaping a more flexible, interactive and effective distance learning process.

Accordingly, the sixth dimension, **(Indicator 6) Teaching Support**, focuses on teaching support through the metaverse. This dimension consists of five questions, which examine teachers' beliefs about the possibilities provided by the metaverse as a space to support teaching. It highlights how virtual worlds can enhance teaching through interactive learning environments and offer new perspectives for adapting learning contents.

The seventh dimension, **(Indicator 7) Intention to Participate**, explores teachers' intention to utilize the metaverse in their classroom. Any reluctance or hesitancy towards technology can significantly hinder its effective integration as a supportive learning tool. Restraint towards new technological tools can be caused by a variety of reasons, such as lack of experience with technology, fear of change, or concerns about potential technical problems. This reluctance can prevent teachers from adopting the metaverse, negatively affecting its effectiveness. According to Rogers, people adopt an innovation, starting from its relative advantage, which is defined as "the degree to which an innovation is perceived as better than the idea it replaces" [32].

The eighth dimension, **(Indicator 8) Student Addiction**, examines students' addiction to the metaverse and reflects concerns about any negative effects. It consists of two questions, which investigate whether teachers believe that the use of the metaverse could lead to bad habits in their students due to excessive use. This indicator reveals concerns about the potential addictive behavior of students in the metaverse and investigates the potential impact on their overall education. Educators must carefully evaluate how the metaverse is integrated into the educational environment to ensure healthy and balanced participation of students without overlooking any negative effects on their behavior.

The ninth dimension, **(Indicator 9) Security-Data Protection**, explores whether educators believe that the metaverse will cause privacy and security issues. Risk perception is often considered as the main barrier to user adoption of innovative technologies [47]. In virtual worlds such as the metaverse, protecting user privacy and ensuring data security is an extremely important issue [21].

In relation to the necessity of conducting this research, an electronic questionnaire was distributed through google forms and 38 primary and secondary teachers of various specialties responded to it. The purpose of the questionnaire was to record the attitudes and opinions of teachers regarding the introduction of the metaverse in teaching and learning. The questionnaire was anonymous and included, apart from demographic information, questions on a five-point Likert scale. The **Likert scale** is used by the researcher to determine whether and to what extent the target audience agrees with the statement that answers the question. Responses to each question ranged from 1 to 5, with 1 indicating complete lack of agreement and 5 indicating complete agreement. The numbered scale contained the following designations: **1=Strongly Disagree, 2 = minimal agreement, 3 = moderate agreement, 4 = great agreement and 5 = absolute agreement**. The questionnaire was designed with Google Sheets software, with appropriate parameterization to allow the selection of one alternative answer per question and it is mandatory to fill in all the questions for the successful completion and submission of the questionnaire form online. At the same time, the questions were designed according to the perceptual and educational level of the participants, according to the basic principles of drafting such a questionnaire, avoiding multiple refusals and complex questions, briefly formulating the questions and clearly defining the questions.

3.3 Type of research

Convenience sampling was followed in this research, where the sample is selected from a part of the population to which there is easy access [15]. In the case of the present research, it was convenient to use the teachers of the specific laboratory session as a sample. Such a sample is not fully representative of the population from which it is drawn, but is taken for the convenience of research and the direct collection of empirical data. The sample consisted of 38 male and female teachers. The total population of active teachers in Greece, according to the Ministry of Education, is approximately 128000. This sample size (N=38) can provide reliable information for this research, with a confidence level of 90% and a margin of error of 14%. These values were calculated using the online tool https://purecalculators.com/el/sample-size-calculator . Also according to Louangrath & Sutanapong (2019), a sample size of 30 individuals maintains a 95% confidence interval in quantitative studies [49]. In addition, in order to strengthen the probative value of the original sample, we used the bootstrapped sample method. For the statistical processing of the research data, Excel software and SPSS software, were used.

3.4 Limitations of the research

Limited access to metaverse infrastructure and equipment creates a barrier for researchers to collect and study metaverse exploitation and design large-scale processes to draw safe conclusions. A notable limitation of the research is due to the newcomer character of the metaverse in the educational field, especially in Greece. The lack of a critical mass of teachers with experience in utilizing the metaverse, in primary and secondary education, is a challenge. In particular, the absence of established practice makes it difficult to draw data and conclusions, and at the same time, the lack of infrastructure and appropriate technological equipment, poses additional obstacles to teachers' familiarity with the metaverse and its possibilities, which was necessary in our research.

The present study was limited to Greek teachers who, for a period of one month, made trial use of virtual worlds in the metaverse. Thus, the results of this research reflect the conclusions of a small but representative group of teachers at a specific point in time. An additional limitation may be the fact that the sample size was not very large, it only targeted the specific audience and there is no great stratification, in terms of level of education, years of service, and teacher specialties. Adding more factors might lead to a better interpretation, but would increase the complexity of the model and exhaust the mood of the research participants. However, the sample is sufficient to assume that the sample mean of each variable is asymptotically normally distributed.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.414 ⪤ Peer-reviewed & Refereed journal ⪤ Vol. 13, Issue 8, August 2025
DOI: 10.17148/IJIREEICE.2025.13811

In order to strengthen the generalizability of the findings, future studies should replicate the educational intervention in a different and larger population, under different conditions and with a longer duration of the educational intervention. Also, combined research based on quantitative and qualitative methods would lead to more reliable conclusions.

3.5 The Testing Environment

The present scientific research focuses on the use of virtual worlds in education, specifically, through the metaverse. In order to enable educators to test and gain relevant experiences, we designed and developed pilot virtual worlds for history, science and IT using the metaverse spatial.io platform. This practice was necessary for the research as the teachers had no previous experience of using the metaverse and therefore could not form an opinion. This lab session was experiential and helped in understanding virtual worlds in the metaverse. Workshop participants navigated virtual worlds, to realize their potential, not only as users but also as creators of new worlds for their own teaching needs. The "possibility to experiment with an innovation on a limited basis" (Rogers 2003) [32], has been cited as a factor that positively influences the decision to adopt it. Rogers (2003) suggests the "trial use" factor, which focuses on the adoption of a new technology for a limited period of time [32]. The purpose of the trial is to evaluate the technology and familiarize organizations with its capabilities and benefits.

The initial educational virtual world of the pilot approach (https://tinyurl.com/wusxp394), represents an ancient Greek theater, and is a gathering place for teachers (Fig. 1).

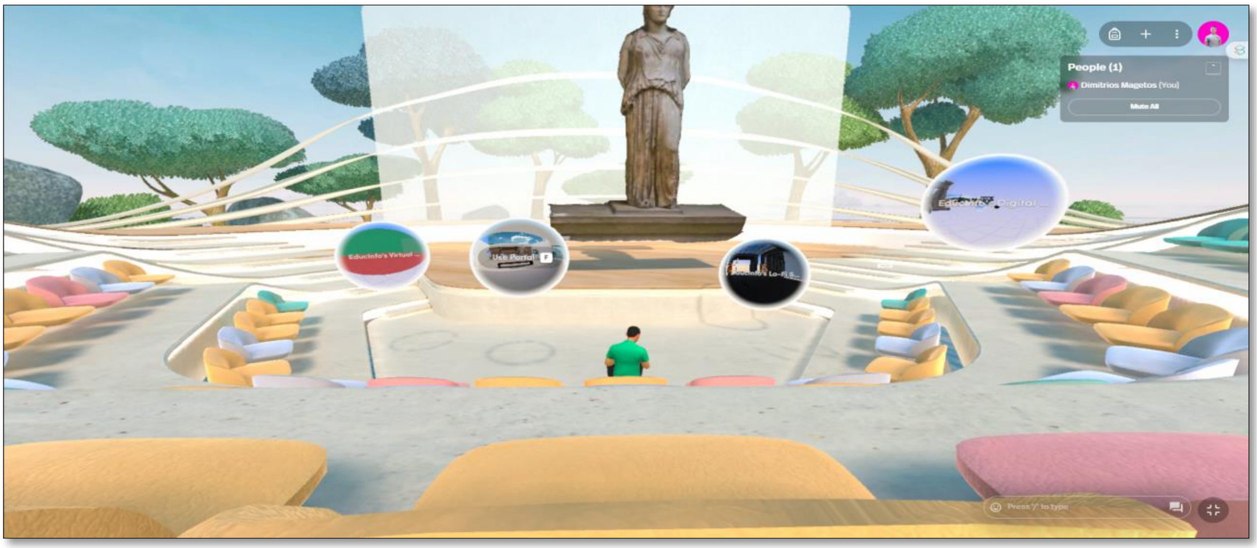

Figure 1: Virtual reception area for students in the metaverse classroom

In this initial world there are connections that lead to the other worlds, leaving the possibility for teachers to choose the world they are most interested in. The 3D educational worlds are navigated through avatars, where teachers can easily navigate through the virtual space. Communicating with avatars is an essential part of the learning experience and helps create a more engaging learning environment where conversations and collaborations are enhanced through virtual presence. Educators can interact with virtual characters, ask questions, be instructed to move around or teleport to other worlds, and work together to solve challenges. Interactions are designed to encourage active participation and immersion in educational content. Users could interact with objects and explore virtual worlds, from wherever and whenever they wanted, without space-time limitations.

One of the virtual worlds (http://tinyurl.com/2rv7fpm3) is specially designed for teaching in the time of the golden age in Athens while another is in the form of a museum for the history of Ancient Sparta (http://tinyurl.com/4unkuzw8) Educators in this world can explore it by browsing and interacting with 3D resources. During this experience, users will be transported to Athens, exploring sights and representations of the time, thus providing a vivid picture of ancient Greek cultural heritage.

A third virtual world has been created specifically for teaching science (Fig. 2). Here, educators can explore digital learning objects that have been embedded in the virtual world through repositories of open educational resources, such as Sketchfab or Photodetro [50]. Another virtual world is dedicated http://tinyurl.com/w8kh5ty3 to anatomy courses of the human body and includes three-dimensional representations, offering an extensive and realistic picture of the human body.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁝ Peer-reviewed & Refereed journal ⁝ Vol. 13, Issue 8, August 2025

DOI: 10.17148/IJIREEICE.2025.13811

Figure 2: Virtual teleportation space for teaching computer science courses

3.6 Metaverse Spatial

The choice of the spatial.io platform to implement educational virtual worlds [4] and demo scenarios was based on several critical reasons. First, the platform supports up to 50 users in its free version, making it suitable for the scenario. In addition, it is accessible in a web or desktop environment, allowing users without XR equipment to participate [25]. The ability to use a camera is added as a means of communicating and connecting the avatars to the real world. Spatial audio is also a key feature, allowing simultaneous conversations in the same space, which is especially useful when users are divided into subgroups. Screen sharing enhances collaboration by allowing users to present their work, while virtual worlds can be enriched with 3D content from appropriate repositories. Finally, support for viewing 3D objects allows direct viewing of objects in the virtual space, offering a motion environment in 3D space, adding extra dimensions to the training experience.

The metaverse platform https://www.spatial.io has been used for various purposes in education, culture, event presentation, entertainment, fashion, tourism. For the city of Valencia (Spain), a virtual tourism office was created with three separate 3D models to represent key tourist attractions in Valencia, by the Design and Construction Institute of the Technical University of Valencia [25]. On the spatial.io platform Johns Hopkins University (http://tinyurl.com/mr4bpyjp), has created an impressive virtual space that reflects the university's campus. Using their personal avatar, the user is able to navigate this virtual space, discovering the various buildings, areas and resources the university has to offer. This iconic development combines technology and education, offering users an immersive experience of familiarizing themselves with the university environment through virtual reality. In addition, the International University of Greece offers on the spatial.io platform an exciting virtual space (available here: http://tinyurl.com/yc3zcvyy), which mirrors the spaces of the IT department. With their personal digital avatar, the user can explore their teaching and research centers, interact with colleagues and get a complete picture of the university environment. This innovative approach to digital education enhances student interaction and engagement by offering an advanced way to discover the academic environment.

The virtual worlds developed on the spatial.io platform constitute Desktop Virtual Worlds providing an excellent user experience without the need to procure expensive equipment [52]. By using simple devices such as a mouse and keyboard, users can interact with the virtual world without complex and expensive equipment. It is an innovative approach that enables learning with the use of basic devices, thus promoting education and access to 3D educational worlds with equipment normally available in schools. Pilot worlds offer educators the ability to test so that they can assess the impact of virtual worlds on learning.

3.7 Model ADDIE

In the process of designing and developing the experimental virtual worlds, we adopted the instructional design model ADDIE [24], which includes five stages (Analysis, Design, Development, Implementation, Evaluation). During this process, we utilized open 2D and 3D educational resources, from various Greek and international repositories [50]. At the analysis stage, we assessed the need for the virtual world and determined the goals of the educational process. In the design stage, we defined details of the training content and designed the virtual world [41]. A detailed content plan was developed, including interactions with the avatars, 3D objects, and training scenarios. In the development stage, the plan was implemented. The implementation involves enriching the virtual world with open educational resources from various repositories. In the implementation stage, the virtual world is ready for use and teacher training takes place,

DOI: 10.17148/IJIREEICE.2025.13811

while intended use scenarios are organized. Finally, the evaluation phase analyzes the results of the implementation, collecting feedback and evaluations from users.

3.8 Conducting Research

This research draws upon a diverse range of sources to gain a holistic understanding of the subject. Scientific publications provide the foundation with their in-depth knowledge and theoretical underpinnings. Tech blogs supplement this with the latest developments and trending topics within the field. Business reports further inform the analysis by exploring the commercial aspects and practical applications of the technology. Finally, social media data adds a human dimension, capturing the real-world perspectives and user experiences shared on popular platforms.

The literature search was conducted in various databases, such as Google Scholar, with the aim of enhancing the understanding of the Metaverse and its applications in education. The main questions guiding this research were:

- **Metaverse and Education:** How is the Metaverse defined and what are its potential applications in education?
- **Acceptance of Metaverse Technology:** What factors influence the acceptance of Metaverse technology by educators and students and what theories address the issue of metaverse adoption in education?

The empirical research, to determine the acceptance of the metaverse by teachers, was implemented in three phases:
a) Creation of a Questionnaire-Pilot application of it by five teachers in order to verify the understanding of the questions, and their reformulation where necessary.
b) Creating an Educational Intervention – Distributing an online questionnaire during the intervention process.
c) Data collection-statistical analysis. Mean values, standard deviations (SD), medians and interquartile ranges were used for the description of quantitative variables. The results were visualized with appropriate statistical charts. Also, based on this sample, we attempted to test hypotheses and verify them in the general population.

In the **first phase**, a literature review was carried out and a test questionnaire was developed based on the classical theory of creating questionnaires according to the Likert scale structure. In particular, the elements of the questionnaire, the related concepts, and the design of the scale of evaluation of preferences and attitudes were determined. A pilot application was carried out and according to the comments of the teachers in the pilot phase, the questionnaire was reformulated and improved where necessary. In the **second phase,** the content and objectives of the educational intervention were formulated, which were implemented during the laboratory session. In the **third phase**, in addition to the statistical processing of the answers to the electronic questionnaire, the oral opinions and personal comments of the participating teachers during the discussion held with them were recorded and analyzed.

Teachers from various regions of Greece participated in the conference remotely through the ZOOM platform. At the same time, the conference was broadcast live on YouTube. At the beginning of the laboratory session, the participating teachers were informed about the purpose of the laboratory session as well as the research. Theoretical issues related to the metaverse and its use in education were then presented so that participants would gain the necessary knowledge and were invited to log into the pilot virtual worlds on the spatial.io platform, which we created for training purposes. The respective virtual worlds contained interactive 2D and 3D open educational resources for the subjects of history, science and IT.

Participants were instructed to create personal avatars and navigate the virtual worlds, interacting both with each other and with the objects in the respective virtual worlds. Since virtual worlds were desktop-based and 3D virtual worlds were presented on computer and mobile phone screens, navigation could be done without special equipment, with just a mouse and keyboard. Teachers also had available educational material that they could access asynchronously for further study and engagement with the virtual worlds, in order to gain greater experience and become more familiar with the spatial platform. When distributing the questionnaires, the participants were informed that their participation was voluntary, that the questionnaire was anonymous and that their answers would be strictly confidential.

IV. EVALUATION RESULTS

The sample of the statistical survey consists of 38 teachers, men and women, of various specialties, mainly with postgraduate degrees, from various regions of Greece. In the context of this research, a discussion was also conducted to clarify theoretical and practical issues, as well as for teachers to freely express their opinions about the experiential experience they had in the metaverse through the pilot virtual worlds they toured.

DOI: 10.17148/IJIREEICE.2025.13811

4.1 Quality analysis

In the discussion, a variety of views and challenges perceived by educators regarding the integration of the metaverse into education emerged. The views recorded cover a wide range of topics, including concerns about technological infrastructure, student addiction, potential inappropriate behavior in virtual worlds, and more. In addition, conflicting views, potentially unexplored problems and perspectives for future research were highlighted, adding further qualitative information to the debate surrounding the role of the metaverse in the educational process.
Important concerns and opinions, as expressed by the teachers themselves, are listed in the following table I:

TABLE I. Table with teachers' opinions in the context of the discussion

Teachers' opinions
According to the teacher (E1), technological infrastructure challenges emerge as important. He points out the need for powerful computers and fast internet access to effectively exploit the metaverse.
Teacher training emerges as necessary, according to E2's point of view, for the effective use of the metaverse in the educational context.
Communities of learning and practice about the metaverse, as E3 highlights, can generate interest and promote the educational use of the metaverse, and suggests their immediate creation.
E4 expresses the hope that the metaverse will prove to be a viable technology, underscoring the importance of innovation in education.
Concerns about the security of student and teacher data are raised by E5, while E6 points to the risk of student addiction and confusion between virtual and real worlds.
E7 expresses concern that students may spend valuable time in the metaverse on entertainment rather than real learning.
Expectations and a positive approach are mentioned by E8, E11, and E13, who see the metaverse as an innovative learning tool.
E9 points out the importance of ergonomics to prevent eye strain, while E10 compares the metaverse experience to the games students play.
E12 expresses the willingness to participate in further research but also the need to investigate metaverse technology, while E14 points out the realistic form of virtual worlds.
Concerns about the risk of student addiction (E19) and the need for adult supervision (E26) are reported in the area of safety and behavior management.
The importance of further training and research on the educational value of virtual worlds is mentioned by E22.
E23 proposes the creation of ready-made virtual worlds by the Ministry of Education for various subjects.
E24 emphasizes that virtual worlds that do not require specialized equipment will be accessible and effective in school education.
E25 expresses concern about potential inappropriate and violent behavior in virtual worlds.
E27 refers to security issues and points out the lack of identification by the spatial platform, which can lead to malicious intrusion into the virtual classroom.
E28 refers to the pedagogical and technological conditions that must be met for the effective implementation of the metaverse in education.
According to E29, the metaverse offers an opportunity for creative education, encouraging students to develop skills such as innovation and collaboration.
It is important to develop tools and resources, according to E30, that will encourage educators to integrate the metaverse into the classroom environment in order to realize its full potential.
E31 emphasized that education about the use and best practices of the metaverse must be extended to all levels of the educational community, from teachers to students and parents.
E32, believes that virtual worlds can be used in life and distance learning.
E33 emphasized that navigating the metaverse with avatars is fun and that interactions with space and objects are crucial to effective teaching.
E34 emphasized that the three-dimensional objects present in the virtual worlds are interesting and will motivate the students.

4.2 Statistical processing of questionnaires

After the "cleaning" of the response data was completed, the analysis of the results began, which included two phases: a) descriptive statistical analysis, to classify and analyze the quantitative characteristics of the survey, and b) inductive analysis, for examining and generalizing the research hypotheses to the general population.
Descriptive statistical analysis is used to summarize the main characteristics of the corded responses. More specifically and according to Papageorgiou (2015) [30], descriptive statistical analysis transforms the primary data in such a way as

DOI: 10.17148/IJIREEICE.2025.13811

to facilitate the understanding and interpretation of the results. The use of descriptive statistical analysis in this study aims to capture, classify and analyze the quantitative characteristics of the research, which are presented below. Next, the results of the descriptive statistical analysis are presented, while the results of the inductive statistical analysis are presented in the next section in the table II.

According to the method of Cronbach's alpha [7], the reliability of both the total index and the individual indicators shows a high degree of reliability. The value of Cronbach's alpha, overall is 0.94, which demonstrates stability and consistency of measurements. The high value of Cronbach's alpha confirms the internal consistency of the measure and the homogeneity of the questions that make up the questionnaire and the specific data set. This indicates that the measurements taken are reliable and can be considered representative of the characteristics that the measure seeks to measure.

4.3 Demographic distribution and statistical analysis

65% of the participants were male and 35% were female. Of the teachers in the sample, 80% held a master's degree. 60% of them had more than 20 years of educational service. 25% taught in primary school, 75% in high school. The participating teachers came from various regions of Greece, with the largest percentage from the prefecture of Attica. 75% were permanent teachers, 23% were substitutes and 2% were hourly. As it was found, a very large percentage of the participants (90 %) did not know about the metaverse and its educational use, while the rest had very little knowledge. A very large percentage of the teachers in the sample consider the metaverse to be an innovation. A large percentage, of the teachers (Indicator 1=74%), answered that the metaverse will greatly strengthen students' motivation to learn. For the ease of use (Indicator 2=76%) the teachers found it a bit difficult to use at first, probably because they had no previous experience. However, they eventually got used to it and felt more comfortable. Regarding the usefulness of the metaverse in education (Indicator 3) a 37% responded very positively while 39% of teachers believe that it will be very useful. A very large percentage (Indicator 4=92%) consider the educational worlds in the metaverse to be a pleasant experience. 87% of teachers agree that the metaverse can offer distance education (Indicator 5) as well as self-learning. Additionally, a large percentage agree that it can provide teaching support (Indicator 6) to a greater exten than 89%. 90% of teachers, (Indicator 7) intend to use the metaverse in the educational process. A fairly large percentage of teachers are concerned about the metaverse creating negative effects on students and addiction (Indicator 8=60%). Teachers also express concern regarding the issue of students' personal data (Indicator 9=56%) and their personal privacy.

A detailed presentation of the answers to the corresponding questions per indicator follows in the next section (Table II).

Indicator 1, **Enhancement Learning Motivation**, consists of five statements and overall, the results of indicator 1 indicate a positive and encouraging climate regarding the use of Virtual Worlds (VW) technology in the educational space to enhance students' motivation to learn. For statement 1, we observe that there is a high percentage of positive evaluations, demonstrating that participants consider VW technology important for student learning. For statement 2, we also observe a high percentage of positive ratings, indicating that participants would support the use of VW technology in the classroom. Regarding statement 3, we again observe a high percentage of positive ratings, indicating that participants believe that integrating VW technology into teaching would help students learn. Regarding statement 4, we again observe a high percentage of positive evaluations, indicating that the participants believe that the integration of VW technology into the curriculum will increase student motivation. Finally, regarding statement 5, we notice that there is also a high percentage of positive evaluations, indicating that the participants believe that VW technology enhances the learning process.

For **Indicator 2**, P**erceived ease of use**, it appears that the use of (VW) faces quite positive elements, despite the first difficulties faced by users. Of interest is the rapid understanding and familiarity of users with VW, as they report that they learned to use it quickly. This ease of understanding opens perspectives for the acceptance and integration of VW into the educational process. Also important is the fact that participants believe they can benefit from using VW without much effort. This suggests that the integration of VW into the educational environment could be met with a positive perception by stakeholders. Finally, the experience of the participants leads to the conclusion that teaching with the application of VW could be a simple process for them. This opens up prospects for the integration of technology into the educational process, promoting the effective transfer of knowledge and skills to students.

For **Indicator 3**, **Perceived Usefulness**, from the teachers' responses, there is a positive response regarding the usefulness of the metaverse in teaching and learning. For statement 1, participants overwhelmingly believe that VWs have the potential to support the creation of complex learning environments. For statement 2, expressing the ability of

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 8, August 2025
DOI: 10.17148/IJIREEICE.2025.13811

VWs to help create multiple teaching representations, this statement was well received. For statement 3, if the participants believe that VW will be useful in teaching and learning, generally high acceptance is expressed.

For **Indicator 4**, **Perceived Enjoyment**, the majority of teachers (92%) consider it pleasant to utilise the metaverse in teaching and learning. The evaluation of the data shows the following favourable conclusions: The educational use of VWs is expected to be pleasant for the students. VWs contribute to students' openness to new technologies, providing them with a pleasant learning environment. Teaching through VW is described as a pleasant experience, highlighting the positive effect of VW on the educational process. Teaching experiences with VW systems are rated as not causing significant stress, supporting the claim that the use of such platforms is quite acceptable to teachers.

The analysis of **Indicator 5 on Distance Education** and Self-Learning shows positive aspects, making it clear that Virtual Worlds (VW) technology contributes positively to these areas. More specifically, teachers largely accepted that: VW technology emerges as a tool that can support independent learning at home. This means that students can take advantage of technology to carry out educational activities outside of school. VW technology provides support capabilities for distance courses. This paves the way for effective online course delivery and takes advantage of the ability to connect with students regardless of their location. VW technology appears to be able to support self-learning, making the online environment conducive to the development of autonomous educational endeavours.

The analysis of the responses to **Indicator 6**, which refers to T**eaching Support,** highlights the positive contribution of virtual world (VW) technology to the educational process. In particular, teachers largely accept that: VW technology offers possibilities for the use of a wide variety of educational strategies. This enhances the ability of teachers to adapt their teaching according to the needs and characteristics of students. VW technology helps teachers implement activities that might have been difficult to implement without it. This support allows educators to deliver more engaging and tailored learning experiences. VW technology affects human interactions between teachers and students, creating new ways of communication and collaboration. VW technology can support the assessment process by offering tools and capabilities for more efficient and coherent assessment. The only negative aspect pointed out is the lack of time to integrate VW technology into the curriculum. This challenge highlights the need for effective training and support in order to achieve full teacher acceptance of technology.

The analysis of the responses to **Indicator 7**, **Intention to Participate**, shows that the teachers express a potentially positive participation intention regarding the use of VW. Their perspective is shaped as follows: A large percentage state that teaching through VWs would be an interesting experience, causing a positive interest in their participation. There is a great deal of acceptance of trying new approaches to teaching through VWs. A large percentage of teachers recognise the use of the metaverse in education as an innovation.

Analysis of responses to **Indicator 8**, **Student Addiction**, reveals concerns about potential student addiction to the metaverse. The results show that a significant percentage of teachers (43%) quite believe in the potential addiction of students to the metaverse, while 30% express the opinion that it can potentially create negative habits in students. These results highlight the importance of carefully monitoring and managing students' relationships with the metaverse, as well as the need to develop outreach and awareness programmes.

Analysis of responses to **Indicator 9, Security-Privacy**, reveals that there is significant concern among educators about potential security issues and privacy violations in the metaverse. In particular, it is observed that a significant percentage expresses concern about the possible leakage of personal data when using the metaverse platform. In addition, the concern extends to the potential misuse of personal information by educational platforms, with the fear being that the platforms will use users' personal data for their own benefit. These sensitive security and data protection issues require careful management and the adoption of effective policies to ensure the confidentiality and security of students' personal information.

TABLE II. Statistical measures of acceptance rates

Indicators	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mean	3.89	3.62	4.01	4.41	4.29	4.03	4.46	3.54	3.61
S.E. Mean	.08	.09	.10	.07	.09	.07	.07	.11	.10
Median	4.00	4.00	4.00	5.00	5.00	4.00	5.00	4.00	4.00
Mode	4.00	4.00	5.00	5.00	5.00	4.00	5.00	4.00	4.00
Std Dev	1.05	1.12	1.08	.74	.98	1.00	.80	1.21	1.06
Range	4.00	4.00	4.00	3.00	4.00	4.00	3.00	4.00	4.00

4.4 Inductive statistical analysis

During the inductive analysis process, our primary intention was to extensively examine the hypotheses raised in the research. We analyzed these hypotheses using the t-test statistical measure [22] in order to examine their fulfillment in the total population. This process aimed to determine the extent to which our results could be considered representative and applicable on a wider scale. In this way, we sought to fully understand the generalizability of our findings and their potential applicability at a wider level.

The design of testing the null hypotheses, that is, the ones we seek to reject, are these follows:

1. Educators do not believe that using the metaverse will enhance students' motivation to learn.
2. Educators do not believe that the Metaverse is easy to use.
3. Educators do not believe that the metaverse is useful in education.
4. Educators do not believe that the metaverse can make teaching and learning enjoyable.
5. Educators do not believe that the metaverse offers distance education.
6. Educators do not believe that the metaverse can provide support for teaching.
7. Educators do not intend to use the metaverse as an educational innovation in the future.
8. Educators do not believe that the metaverse will cause addiction and unpleasant effects on students.
9. Educators do not believe that the metaverse poses problems for the privacy and security of personal data for teachers and students.

We then used the t-test statistic to examine the fulfilment of these hypotheses in the larger population. To check each hypothesis, we used the answers to the relevant questions, which formed each sub-indicator, and checked if the average of these answers was greater than 3 with a one-sided t-test.

The results of the case control are shown in detail in the following sections.

The **one-side t-tests** (Table III) revealed that educators hold a positive attitude towards the **use of the Metaverse in education**, while also expressing some concerns. Specifically, teachers believe that the Metaverse **enhances students' learning motivation** ($t = 11.70$, $p < 0.05$), is **easy to use** ($t = 6.84$, $p < 0.05$), and that its **perceived usefulness** is high ($t = 10.00$, $p < 0.05$). Furthermore, they report that the **learning experience is enjoyable and stress-free** ($t = 20.43$, $p < 0.05$) and that the Metaverse **supports distance and self-regulated learning** ($t = 13.99$, $p < 0.05$).
Additionally, participants believe that the Metaverse **facilitates lesson organization** ($t = 14.15$, $p < 0.05$) and express a **strong intention to adopt it** ($t = 19.44$, $p < 0.05$). However, educators also report **statistically significant concerns** about **potential student addiction** ($t = 4.82$, $p < 0.05$) and **safety issues** within the Metaverse environment ($t = 6.18$, $p < 0.05$).

TABLE III. Summarizes the results of the one-side t-tests

Variable	t	p	Decision
Enhancing students' motivation	11.70	<0.05	Reject H_0
Ease of use	6.84	<0.05	Reject H_0
Perceived usefulness	10.00	<0.05	Reject H_0
Enjoyable and stress-free learning experience	20.43	<0.05	Reject H_0
Support for distance & self-regulated learning	13.99	<0.05	Reject H_0
Facilitation of lesson organization	14.15	<0.05	Reject H_0
Intention to adopt the Metaverse	19.44	<0.05	Reject H_0
Concern about potential student addiction	4.82	<0.05	Reject H_0
Concern about safety issues	6.18	<0.05	Reject H_0

4.5 Empirical Validation with Bootstrapped Sampling: Enhancing the Reliability of Findings

In the context of the present study, the bootstrapped sampling method was also utilized in order to enhance the statistical power and conduct an in-depth re-evaluation of the research measurements. The adoption of this methodology allowed for random sampling with replacement from the original data set, resulting in the creation of 100 new experimental samples. Each sample was created from the initial sample of the corresponding answers of the 38 teachers, resulting in a total of 3800 sample answers for each indicator. In detail, the tests were carried out as follows: For each indicator, the means and standard deviations of the bootstrapped samples were calculated. These were then compared with the corresponding values of the original sample. The comparison showed great similarity in values, highlighting the robustness of the measurements and their resistance to any random fluctuations. Then, a t-test was conducted on the bootstrapped samples in order to evaluate the statistical significance of the differences. The results of the t-test validated the initial hypotheses, which were formulated based on the original sample. The implementation of the bootstrap method acted as a catalyst to draw more reliable conclusions, considering a significantly larger sample than the original one. A key finding of the research is the full validation of the original hypotheses, which were formulated based on the original sample. The convergence of the measurements, both in the original sample and in the corresponding bootstrapped samples, lends credibility to the findings and strengthens the validity of the conclusions.

V. DISCUSSION OF RESULTS

Creating virtual-physical blended classrooms, where students and teachers can participate in shared educational metaverses, can overcome the limitations of conventional software platforms [42]. Metaverse expands the possibilities of distance education, creating an engaging and immersive learning environment [46]. Creating a personalized teaching experience and a personalized learning environment is crucial, as different variations of this combination will certainly bring innovations to education, but also highlight its strengths and weaknesses. The integration of technologies such as augmented reality and the Internet of Everything will play a decisive role in the educational services of the metaverse. Overall, the introduction of the metaverse in education is a promising prospect, but it requires careful planning, coordination, and evaluation to ensure its effectiveness and sustainability [42]. However, it is necessary to consider potential risks, such as privacy violations and psychological problems, and develop appropriate strategies to address them.

The research on teachers' acceptance of the metaverse was based on solid theoretical foundations and valid research scales. The use of grounded theory and valid research lends credibility to research findings. The adoption of standardized research scales allows for comparison with previous studies and for drawing generalizations. In-depth analysis of the data leads to useful insights to support the adoption of the metaverse in education.

Among other things, the research also highlights theories and methodologies for developing educational virtual worlds in the metaverse, which are not just an implementation technique but also emphasize the utilization of pedagogical parameters. In particular, it utilizes the ADDIE model, which is a widespread model for the design and implementation of educational programs. The design of virtual worlds is a dynamic and evolving process, and future research should explore this chapter thoroughly.

But apart from the existence of theoretical foundations, the adoption of the metaverse in education is directly based on the existence of appropriate technological tools. The statistical analysis in this study was not limited to simple descriptive measures but extended to inductive analysis with hypothesis testing. This means that the study did not stop at just describing the data but proceeded to draw conclusions about the wider population. It was based on the formulation of hypotheses, and then statistical tests were used to test these hypotheses, and finally results were interpreted. Based on the statistical tests, the results were interpreted, and conclusions were drawn.
In the present analysis, interaction with teachers revealed important topics arising from the introduction of the metaverse into the educational space. Initially, it was observed that the majority of teachers, 90%, treat the metaverse as a novelty, while at the same time they express ignorance about the concept and existence of the metaverse. Research findings from (Gartner, 2022) [11] come to advocate the view that the majority of the public does not yet have a clear understanding of the metaverse concept. Specifically, the survey found that 58% have heard of the metaverse but are unable to explain exactly what it means, and 6% feel they have a sufficient understanding of the metaverse to explain it to others.

Educators recognize the potential benefits of the metaverse in the educational space; they believe it will spark students' interest and enhance learning motivation. At the same time, however, they express concerns about its possible unnecessary use and loss of valuable time and express their concern for the protection of personal data. In addition, there is concern about the increased risk of youth addiction to the metaverse and about the risk of inappropriate behaviour and cyberbullying. At this point it's worth mentioning the Meta created a protection zone of 1.2 m, to prevent harassment in an environment VR. The new feature will give avatars in online Horizon Worlds and Horizon Venues a visible "personal boundary" of more than one meter to prevent others from getting too close (Meta, 2021) [26].

The attractiveness and interesting experience offered by the metaverse can lead to excessive and long hours of use by students, negatively affecting the daily lives and personal development of young people. The potential for isolation from the real world and obsession with the virtual space of the metaverse raises concerns about loss of social contact

DOI: 10.17148/IJIREEICE.2025.13811

and reduced participation in physical activities. In addition, the teachers emphasise that the use of the metaverse by young students should be done under adult supervision, and there should be identification of the authorised users in order to avoid issues of intrusion by persons unrelated to the educational process. Here we will emphasise the importance of having preventive means to protect minors in virtual worlds, especially from abuse, cyber-harassment, and bullying, while recommending the training of teachers about the possibilities and risks of using the metaverse.

In addition, teachers point out the need for modern infrastructure in schools to avoid delays in its implementation. Educators also believe that the metaverse can support live and distance education, but technological and pedagogical prerequisites should be met in order to be effective in its use. At this point, we emphasize that virtual worlds will produce high-definition images, graphics, and videos to ensure an immersive user experience, which requires high-performance infrastructures such as 5G and 6G networks with low latency and high bandwidth, as well as cloud infrastructure and edge computing. Therefore, it is necessary to develop careful implementation strategies that address these issues in order to enable effective integration of the metaverse into teaching.

The results of their empirical research largely agree with the findings of the literature review. Our review of the scope of the metaverse highlights benefits and issues, risks and challenges of its application, both in education [29] as well as in other areas of its application. In terms of benefits, based on the article, we can list the following important ones: The metaverse supports interdisciplinary learning and cross-cultural education by removing physical space-time, geographical and cultural limitations. It provides a safe environment for simulating dangerous or expensive experiments or phenomena. The simulation feature allows students to gain experiences and face challenges through a safe and controlled environment. It is suitable for the representation of historical events or the structure and experimentation of natural or artificial systems. The 3D environment of the metaverse is emerging as a significant boon in the educational field. The ability to present information and educational content in a 3D environment enhances the experientiality and active participation of students. Educators can create educational scenarios and environments that allow students to interact with the content, which can be multimedia, offering a more realistic and active learning experience. The spatial representation of information contributes to a better understanding of cognitive objects.

VI. FUTURE WORK AND OPEN ISSUES

The present research is an important step towards understanding the metaverse in education, laying the foundation for future studies. But the metaverse technology is relatively new, and its application in education as well as in various other areas of human activity has not been fully evaluated. The suitability of the metaverse for educational purposes and the ways in which it can be leveraged to benefit teaching and learning for a modern and sustainable next-generation education are worth exploring in depth.

Research should focus on the benefits that the metaverse can offer in relation to traditional educational methods, as well as the educational areas and learning contexts in which it can be integrated. It should focus on the ways in which educators can leverage the metaverse to design and implement innovative educational scenarios. Developing methods to evaluate the effectiveness of educational applications in the metaverse is essential. Also needed is the exploration of innovative methods and tools for designing and developing virtual worlds in the metaverse that promote effective learning and active student participation.

Research should focus on ways we can ensure a safe and smooth student experience in the metaverse. It must focus on the necessary infrastructure, technological tools, and educational materials for the smooth and effective adoption of the metaverse in education (European Commission, 2021) [10]. The mapping and comparative evaluation of the available metaverse platforms based on educational criteria is necessary in order to make an in-depth study of the capabilities and functions of different metaverse platforms with the aim of evaluating their suitability for specific educational needs. Extensive application and extension of existing theories of technology acceptance within the context of the metaverse should be done with the aim of understanding students' attitudes and intentions. The metaverse should be extensively piloted in various educational contexts, such as primary, secondary and tertiary education, distance education and special education, and its suitability explored.

VII. CONCLUSION

Based on the research and analysis data, important conclusions are drawn regarding the introduction of the metaverse into the educational process. The majority of teachers (90%) perceive the metaverse as an innovation, however, they declare limited or no knowledge about its concept and applications in education, a finding that is consistent with international research, which shows that the general public does not yet have a clear understanding of the term. Despite

DOI: 10.17148/IJIREEICE.2025.13811

this initial lack of familiarity, teachers recognize the potential of the metaverse and believe that it can enhance students' interest and learning motivation, support distance education and self-directed learning, but also create immersive and interactive environments that promote experiential and experiential learning. Furthermore, they recognize its contribution to interdisciplinary learning and cultural interconnection, overcoming spatial and temporal constraints.

At the same time, however, educators express significant concerns about the integration of the metaverse into the educational process. The main areas of concern are the potential addiction of students and excessive involvement in the virtual environment, social isolation and reduced physical activity, as well as the risks of personal data breaches, cyberbullying and harassment. The need for preventive measures, clear protection zones for minors and user identification is considered imperative, while the importance of informing and training educators about the possibilities and risks of the metaverse is underlined.

The successful and substantial integration of the metaverse into education presupposes both the existence of modern technological infrastructures and the adoption of appropriate pedagogical approaches. The operation of virtual worlds requires strong networks (5G/6G), low latency, cloud and edge computing, in order to ensure a seamless and high-definition experience. At the same time, the design of learning experiences must be based on models such as ADDIE, so that the development is not only technological but also pedagogically informed. Therefore, the introduction of the metaverse in education is a promising but complex process, requiring strategic planning, gradual implementation, continuous evaluation and the development of a strong framework for student protection, in order to fully exploit the potential of this technology and avoid possible side effects.

ACKNOWLEDGMENT

We thank Professor Ch. Douligeris, the CIE organizing committee and fellow educators for their participation in the research.

REFERENCES

[1]. Aburayya, A., Salloum, S., Alderbashi, K., Shwedeh, F., Shaalan, Y., Alfaisal, R.,& Shaalan, K. (2023). SEM-machine learning-based model for perusing the adoption of metaverse in higher education in UAE. *International Journal of Data and Network Science*, *7*(2), 667-676.

[2]. Al-Adwan, A. S., Li, N., Al-Adwan, A., Abbasi, G. A., Albelbisi, N. A., & Habibi, A. (2023). Extending the technology acceptance model (TAM) to Predict University Students' intentions to use metaverse-based learning platforms. *Education and Information Technologies*, *28*(11), 15381-15413.

[3]. Al-Adwan, A. S., & Al-Debei, M. M. (2023). The determinants of Gen Z's metaverse adoption decisions in higher education: Integrating UTAUT2 with personal innovativeness in IT. *Education and Information Technologies*, 1-33.

[4]. Ball, M. Framework for the Metaverse. (2024). Available online: https://www.matthewball.vc/all/forwardtothemetaverseprimer (accessed 12 January 2024).

[5]. Batsidis, A., Papastamoulis, P., Petropoulos, C., & Rakitzis, A. 2022. Nonparametric Statistics. Kallipos, Open Academic Editions. https://hdl.handle.net/11419/9290

[6]. Çelik, I. (2020). Social media-specific epistemological beliefs: A scale development study. *Journal of Educational Computing Research*, *58*(2), 478-501.

[7]. *Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 16(3), 297–334. https://doi.org/10.1007/BF02310555 Crowley, S. L., & Fan, X. (1997). Structural equat.*

[8]. Davis, F. D., & Venkatesh, V. (1996). A critical assessment of potential measurement biases in the technology acceptance model: three experiments. *International journal of human-computer studies*, *45*(1), 19-45.

[9]. Economou, P., Malefaki, S., & Batsidis, A. 2022. Probability- Statistics. Kallipos, Open Academic Editions. https://hdl.handle.net/11419/965.

[10]. European Commission. Digital Education Action Plan (2021). Available at: https://education.ec.europa.eu/el/focus-topics/digital-education/action-plan.

[11]. Gartner. (2022). What's New in the 2022 Gartner Hype Cycle for Emerging Technologies. https://www.gartner.com/en/articles/what-s-new-in-the-2022-gartner-hype-cycle-for-emerging-technologies.

[12]. Gialamas, V., Lavidas, K., & Manesis, D. 2024. Statistical methods and techniques in the social sciences using SPSS. Kallipos, Open Academic Editions. https://hdl.handle.net/11419/12680

[13]. Holsapple, C. W., & Wu, J. (2007). User acceptance of virtual worlds: The hedonic framework. *ACM SIGMIS Database: The DATABASE for Advances in Information Systems*, *38*(4), 86-89.

[14]. Horzum, M. B., & Aydemir, Z. (2014). Web 2.0 tools and educational usage self-efficacy: A scale development study. Procedia-Social and Behavioral Sciences, 116, 453-458.

DOI: 10.17148/IJIREEICE.2025.13811

[15]. Hwang, G. J., Tu, Y. F., & Chu, H. C. (2023). Conceptions of the metaverse in higher education: A draw-a-picture analysis and surveys to investigate the perceptions of students with different motivation levels. *Computers & Education*, *203*, 104868.

[16]. Issari, P., & Pourkos, M. (2015). Qualitative research methodology. Kallipos, Open Academic Editions. https://dx.doi.org/10.57713/kallipos-473.

[17]. Kaddoura, S., & Al Husseiny, F. (2023). The rising trend of Metaverse in education: challenges, opportunities, and ethical considerations. *PeerJ Computer Science*, *9*, e1252.

[18]. Koutromanos, G., Mikropoulos, A. T., Mavridis, D., & Christogiannis, C. (2023). The mobile augmented reality acceptance model for teachers and future teachers. Education and Information Technologies, 1-39.

[19]. Lagoumintzis, G., Vlachopoulos, G., & Koutsogiannis, K. 2015. Research methodology in the health sciences. Kallipos, Open Academic Editions. https://hdl.handle.net/11419/5363

[20]. Lascu, D. N., & Clow, K. E. (2008). Web site interaction satisfaction: Scale development considerations. *Journal of Internet Commerce*, *7*(3), 359-378.

[21]. Lee, J. (2022). A study on the intention and experience of using the metaverse. *Jahr: Europski časopis za bioetiku*, *13*(1), 177-192.

[22]. Linardis, A., Maravelakis, P., & Fragoulis, G. (2023). Data analysis [Chapter]. In Linardis, A., Maravelakis, P., & Fragoulis, G. 2023. Data collection methods using digital questionnaire and survey methodology [Undergraduate textbook]. Kallipos, Open Academic Editions. https://hdl.handle.net/11419/11735.

[23]. Liu, H. X., Chow, B. C., Liang, W., Hassel, H., & Huang, Y. W. (2021). Measuring a broad spectrum of eHealth skills in the Web 3.0 context using an eHealth Literacy Scale: Development and validation study. Journal of medical Internet research, 23(9), e31627.

[24]. Magetos, D., Kotsifakos, D., & Douligeris, C. (2023). "Educational Virtual Worlds for Vocational Education and Training Laboratories," 2023 8th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference (SEEDA-CECNSM), Piraeus, Greece, 2023, pp. 1-6, doi: 10.1109/SEEDA-CECNSM61561.2023.10470662.

[25]. Martí-Testón, A., Muñoz, A., Gracia, L., & Solanes, J. E. (2023). Using WebXR Metaverse Platforms to Create Touristic Services and Cultural Promotion. Applied Sciences, 13(14), 8544.

[26]. Meta, I. (2021). A social technology company. *Meta*, *12*(11), 2021.

[27]. Morton J. Metaverse Timeline. (2024). https://metaverse-timeline.com/

[28]. Mystakidis, S. (2022). Metaverse. Encyclopedia, 2(1), 486-497.

[29]. Onu, P., Pradhan, A., & Mbohwa, C. (2023). Potential to use metaverse for future teaching and learning. *Education and Information Technologies*, 1-32.

[30]. Papageorgiou, I. (2015). Sampling Theory . Kallipos, Open Academic Editions. https://hdl.handle.net/11419/1297.

[31]. Park, S. M., & Kim, Y. G. (2022). A metaverse: Taxonomy, components, applications, and open challenges. IEEE access, 10, 4209-4251.

[32]. Rogers, E. (2003). M., Diffusion of innovations. *New York: The Free*.

[33]. Sideridis, G. D., Kaissidis, A., & Padeliadu, S. (1998). Comparison of the theories of reasoned action and planned behaviour. British Journal of Educational Psychology, 68(4), 563-580.

[34]. Suh, W., & Ahn, S. (2022). Utilizing the metaverse for learner-centered constructivist education in the post-pandemic era: An analysis of elementary school students. *Journal of Intelligence*, *10*(1), 17.

[35]. Teng, Z., Cai, Y., Gao, Y., Zhang, X., & Li, X. (2022). Factors affecting learners' adoption of an educational metaverse platform: An empirical study based on an extended UTAUT model. *Mobile Information Systems*, *2022*.

[36]. Teo, H., Wei. K. K. and Benbasat, I., 2003, "Predicting intention to adopt interorganisational linkages: an institutional perspective, MIS Quarterly, vol. 27(1), pp. 19-49.

[37]. Tlili, A., Huang, R., Shehata, B., Liu, D., Zhao, J., Metwally, A. H. S., ... & Burgos, D. (2022). Is Metaverse in education a blessing or a curse: a combined content and bibliometric analysis. Smart Learning Environments, 9(1).

[38]. Tornatzky, L. G., Fleischer, M., & Chakrabarti, A. K. (1990). The processes of technological innovation. *(No Title)*.

[39]. Uysal, M., Üstünda?, M. T., Çelik, A., TANRIVERD?, M., Ceran, O., & Zafer, A. Y. A. Z. (2024). Development of Web3 Awareness Scale as the next evolution of the internet. Participatory Educational Research, 11(1), 247-265.

[40]. Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425-478.

[41]. Vosinakis, S. (2015). Virtuals Worlds. Kallipos, Open Academic Editions. https://dx.doi.org/10.57713/kallipos-678.

[42]. Wang, M., Yu, H., Bell, Z., & Chu, X. (2022). Constructing an Edu-Metaverse ecosystem: A new and innovative framework. IEEE Transactions on Learning Technologies, 15(6), 685-696.

DOI: 10.17148/IJIREEICE.2025.13811

[43]. Wiangkham, A., & Vongvit, R. (2023). Exploring the Drivers for the Adoption of Metaverse Technology in Engineering Education using PLS-SEM and ANFIS. *Education and Information Technologies*, 1-28.

[44]. Yang, F., Ren, L., & Gu, C. (2022). A study of college students' intention to use metaverse technology for basketball learning based on UTAUT2. *Heliyon*, *8*(9).

[45]. Zhang, X., Chen, Y., Hu, L., & Wang, Y. (2022). The metaverse in education: Definition, framework, features, potential applications, challenges, and future research topics. *Frontiers in psychology*, *13*, 1016300.

[46]. Barráez-Herrera, D. P. (2022). Metaverse in a virtual education context. Metaverse, 3(1), 1-9.

[47]. Wang, X., Guo, Q., Ning, Z., Guo, L., Wang, G., Gao, X., & Zhang, Y. (2024). Integration of sensing, communication, and computing for metaverse: A survey. ACM Computing Surveys, 56(10), 1-38.

[48]. DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: a ten-year update. Journal of management information systems, 19(4), 9-30.

[49]. Louangrath, P. I., & Sutanapong, C. (2018). Validity and reliability of survey scales. International Journal of Research & Methodology in Social Science, 4(3), 99-114.

[50]. Magetos, D., Kotsifakos, D., & Douligeris, C. (2023, March). The Utilization of Open Educational Resources in Didactic Theory and Practice for the Teaching of Electrokinesis in Vocational Education and Training. In *International Conference on Remote Engineering and Virtual Instrumentation* (pp. 1107-1120). Cham: Springer Nature Switzerland.

[51]. Magetos, D., Mitropoulos, S., & Douligeris, C. (2024, September). The Evolution of the Web and its impact on Education: From Web 1.0 to the Metaverse. In *2024 9th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference (SEEDA-CECNSM)* (pp. 103-108). IEEE.

[52]. Mitropoulos, S., & Magetos, D. (2024). Incorporating metaverse technology into the adult distance learning process for open universities. Paper presented at I·HE2024, Limassol, Cyprus. https://doi.org/10.5281/zenodo.14220974

[53]. Magetos, D., & Mitropoulos, S. (2025a). Effectiveness of educational virtual worlds in the metaverse: A study based on the ARCS model. *International Journal of Latest Engineering Research and Applications (IJLERA)*, 10(6), 1–10. DOI:10.56581/IJLERA.10.6.01-10

[54]. Magetos, D., & Mitropoulos, S. (2025b). The metaverse in education: A literature review. *International Journal of Latest Research in Engineering and Technology (IJLRET),* 11(6), 48–58. https://doi.org/10.56581/IJLRET.11.06.48-58

[55]. Magetos, D., & Mitropoulos, S. (2025c). Gamification of Educational Virtual Worlds in the Metaverse. *International Journal of Latest Research in Engineering and Technology (IJLRET),* 11(7), 65-77.

[56]. Park, S. M., & Kim, Y. G. (2022). A metaverse: Taxonomy, components, applications, and open challenges. *IEEE access*, *10*, 4209-4251.

