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Exploring students' acceptance and continuance intention in using immersive virtual reality and metaverse integrated learning environments: The case of an Italian university course

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Abstract

Immersive virtual reality (IVR) and Metaverse applications are gaining attention in the educational field, showing potentials in transforming traditional learning methods by supporting active and experiential forms of learning. Our study, conducted within the context of an Italian university course, employs the Extended Expectation-Confirmation Model (EECM) as a theoretical framework to explore the key aspects of students' acceptance and continued intention to use IVR and Metaverse integrated learning environments in educational settings. The EECM, which bridges the gap between pre-adoption expectations and post-adoption experiences, provides a comprehensive perspective for exploring technology adoption in education. Students' attitudes were assessed before and after they completed an elective course offered by the university that delved into IVR and Metaverse applications. During the course, students explored the theoretical and practical applications of these technologies, engaging in a variety of experiences, from immersive relaxation exercises to immersive educational platforms in the emerging Metaverse. Contrary to common assumptions, pre-adoption factors like performance and effort expectancy had limited impact on expectancy confirmation. However, when students' initial expectations matched their experiences, their perceptions of the technology's usefulness, satisfaction, and confidence in its use were positively enhanced, influencing their continued intention to integrate these tools in education.

Keywords Immersive virtual reality · Metaverse · Technology acceptance · UTAUT, Expectation-confirmation model · Extended expectation-confirmation model

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1 Introduction

Over the past decade, Immersive Virtual Reality (IVR) has gained significant attention across various fields, including higher education. While the integration of immersive technologies into academia is predominantly in experimental stages, pilot projects are emerging in university environments aiming at leveraging the potential of immersive media in fostering innovative learning and teaching methods (https://www.analyticsinsight.net/top-10-universities-offering-metaverse-related-research-courses-more/). Research conducted so far indeed revealed several benefits of IVR in education, not just as a novel tool to deliver lectures, but specifically for its opportunity to enhance the learning experience. Drawing from the theoretical foundations laid by Dalgarno and Lee (Dalgarno & Lee, 2010) on non-immersive virtual reality learning affordances, Di Natale and colleagues (Di Natale et al., 2020) described the primary educational affordances of IVR, shedding light on its cognitive and affective benefits in academic contexts. Specifically, IVR's unique ability to offer three-dimensional and interactive hands-on experiences not only facilitates a deeper understanding of complex concepts but also enhances students' affective engagement, subsequently boosting students' learning motivation (Di Natale et al., 2020; Hamilton et al., 2021; Radianti et al., 2020).

As the literature highlights the potentials of IVR and its initial integration into academic curricula, it becomes essential to examine the attitudes of key stakeholders involved in its application in educational settings, including both students and educators. The successful implementation of a new educational tool, such as IVR, depends not only on its technological capabilities but also on the perceptions and attitudes of its primary users (Granić, 2022; Granić & Marangunić, 2019): students, being the potential end-users of this technology, play a crucial role. Any reluctance or hesitation they exhibit towards the technology can significantly hinder its effective integration as a supportive learning tool. Hesitation towards new technological tools can arise from several determinants, such as unfamiliarity with the technology, apprehension towards change, or concerns about potential technical issues. Such reluctance may discourage students from using IVR, thereby undermining its efficacy.

Therefore, extensive research has been dedicated to examining students' expectations of IVR, aiming to pinpoint the key determinants influencing their potential intent to adopt it in educational settings. Several models have been developed his context (Ajzen, 1991; Davis, 1989; Rogers, 1962). The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) has emerged as one of the leading frameworks in this context, trying to synthetize in one model the determinants specified by previous models. The UTAUT highlights the role of users' expectations in terms these constructs such as *performance expectancy* and *effort expectancy*, respectively. Performance expectancy is delineated as an individual's belief that technology usage can enhance performance, while effort expectancy reflects one's perceptions of the ease or difficulty associated with the technology. The UTAUT model extends this understanding by introducing two additional determinants: *social influence*, that is the extent to which individuals feel that key people in their lives believe they should use the new technology, and *facilitating conditions*, that is an individual's belief in the existence of necessary organizational and technical infrastructures to support the system's use. Moreover, UTAUT posits that factors like gender, age, experience, and voluntariness of use can influence how these determinants impact user intention and behaviour. The UTAUT have been used to investigate study students' intention to adopt IVR, focusing on pre-adoption determinants.

The UTAUT is a pre-adoption model, investigating factors influencing an individual's intent to use technology before its actual use. Until now, most of the research on IVR has focused on these pre-adoption intentions, likely due to various challenges associated with implementing IVR in educational programs. These challenges include technical complexities in implementation, the challenge of integrating theory with hands-on practice, and the scarcity of educators skilled in both content delivery and immersive classroom management. Nevertheless, an emerging body of research underscores the importance of examining post-adoption intentions, reflecting an individual's propensity to persist with a technology after initial exposure. In this post-adoption domain, Bhattacherjee's Expectation-Confirmation Model (ECM) (Bhattacherjee, 2001) serves as a critical theoretical guide. The ECM posits three key variables: the *confirmation of expectations* based on actual experience with the technology, the *post-adoption perceived usefulness* of the technology, and the user's *satisfaction* following its use. Notably, the model suggests that both confirmation of expectations and user satisfaction drive perceptions of usefulness, which, in turn, informs the continued intention to use a technology.

Given the growing interest towards integrating IVR in educational settings, it becomes crucial to consider both pre-adoption and post-adoption determinants to get a comprehensive understanding of student engagement with this tool, highlighting the factors that either encourage or deter its continued use. Within this context, the Extended Expectation-Confirmation Model (EECM) introduced by Gupta and colleagues (Gupta et al., 2020) offers a valuable framework. Although not originally developed for educational settings, the EECM seeks to bridge the gap between pre-adoption and post-adoption considerations. Expanding upon Bhattacherjee's (2001) ECM, the EECM incorporates elements from Venkatesh's (2003) UTAUT, effectively blending both stages of technology acceptance. The EECM argues that acceptance of a technology is influenced by several factors both pre-adoption and post-adoption. These include pre-adoption expectations, such as *pre-adoption performance expectancy* and *pre-adoption effort expectancy*, and post-adoption factors such as *post-adoption perceived usefulness*, *satisfaction*, and *post-adoption self-efficacy*. Thus, the EECM model provides an integrated and comprehensive view of user decision-making related to technology acceptance and continuance intention to adopt it, taking into consideration both the pre-adoption expectations and post-adoption experience.

The present study aims to apply the EECM to the analysis of the acceptance and continued use of IVR in university education context. The goal is to provide useful information for stakeholders involved in the adoption and implementation of this technology to maximize the benefits to students and improve the quality of education. Our goal is to explore how university students' attitudes toward the use of IVR as a teaching tool change before and after participating in an elective specialized module of a psychology course in which this technology is used. Specifically, the module offered university students a theoretical framework to conceptualize the potential applications of IVR in psychology, as well as hands-on experiences to develop concrete knowledge about the tools and techniques used in these contexts. These include immersive relaxation protocols, body swapping techniques, Metaverse platforms for learning, among others. Given the dynamic nature of the adoption process, which takes place through pre- and post-adoption phases, we chose to take a longitudinal approach to data collection. We believe this approach will allow us to gain a more accurate and comprehensive view of how students' attitudes and intentions change over time in response to direct experience with IVR. Finally, it is important to note that, to our knowledge, there is no precedent for such research. Although IVR is gaining increasing attention as a potential teaching tool, its implementation in university classrooms is still relatively limited. Therefore, we hope that the results of our study can help fill this gap in the existing literature and provide valuable insights for those interested in integrating IVR into higher education. Specifically, with this work we aimed to give a first answer to the following research question: *how does direct experience with IVR influence students' post-adoption perceptions and intention to continue using this technology for learning*?

2 Theoretical background

2.1 IVR in education

Recent reviews on the application of IVR in education reveal promising outcomes. Building upon the foundational work of Dalgarno and Lee (2010), Di Natale and colleagues (2020) conducted a comprehensive review that underscored the effectiveness of IVR as a teaching tool. Their findings suggested that the immersive nature of IVR piques student interest, motivates learning and fosters a deeper understanding of educational contents. This arises from the potential of IVR to engage students in a fully immersive, interactive environment that foster sense of presence - i.e., the sense of "being there" in a virtual environment (Coelho et al., 2006), and embodiment - i.e., the sensations of being inside, having, and controlling a virtual body (Kilteni et al., 2012) which contribute to favour active learning. Thus, instead of being passive recipients of information, students become active participants in their learning process, a transformation that can drastically enhance the learning outcomes.

In particular, four unique educational affordances (Dalgarno & Lee, 2010) have been identified among IVR studies (Di Natale et al., 2020). First, IVR has ability to create rich, interactive, and customizable learning environments. Therefore, thanks to its immersivity and interactivity, IVR offers students the possibility to firsthand explore complex scenarios fostering an enhanced spatial understanding of the subject matter. The heightened sense of presence in IVR ensures that students feel deeply engaged with the virtual surroundings, thus promoting a more active way of learning than traditional learning methods. Second, IVR promotes experiential hands-on learning experiences. It provides a safe environment where students can experiment, make errors, and rectify them without real-world repercussions. Similarly, it offers tangible, three-dimensional sensory experiences that allow students to embody concepts, making learning more meaningful and memorable. Third, IVR serves as a bridge to contextualize learning, enhancing the transfer of knowledge to real-world scenarios. By facilitating situated learning, it ensures that knowledge gained in the virtual realm is effectively applied in analogous real-world contexts. Finally, the immersive and interactive nature of IVR amplifies the motivational appeal of educational content. This results in heightened student interest, satisfaction, and perceived learning outcomes.

Therefore, IVR offers the opportunity to personalize the learning experience for different needs. One can, for example, walk inside a cell to understand biology (Parong & Mayer, 2018), be transported back in time to explore a historical event (Parong & Mayer, 2021), or learn languages in contextualized environments (Repetto et al., 2021). In summary, IVR offers a new perspective on learning, allowing students to immerse themselves in virtual environments and interact with simulated objects and scenarios. This innovative technology has the potential to radically transform the way we teach and learn, opening new opportunities for engagement, and experiential learning.

2.1.1 Social IVR in education: the metaverse

In their theoretical framework, Dalgarno and Lee (2010) emphasized the potential of VR systems to offer students opportunities for collaborative learning. Nonetheless, in their comprehensive review, Di Natale and colleagues (2020) did not uncover any studies supporting the advantages of IVR for collaborative learning. This could be attributed to the fact that, at the time of their research, IVR systems were not yet sophisticated enough to support collaborative activities. Instead, the affordance of collaborative learning seemed better suited for less-immersive technologies, such as multi-user virtual environments based on desktop virtual worlds (Bower et al., 2014).

Today, a recent technological advancement that has gained popularity in recent years is the “Metaverse” – a perpetual and multi-user phygital environment (Mystakidis, 2022). The Metaverse can be accesses with different tools (i.e., desktop-based applications, laptops, headsets); when referring to IVR Metaverse, we consider all those digital environments accessible through VR head-mounted displays. The combination of these technologies provides a new type of learning experience: a virtual social one. The sense of presence, immersion, embodiment, and identity (Mystakidis, 2022) are still present in the Metaverse technology, when accessed with IVR tools. Indeed, the primary features offered by the Metaverse lies in its capacity to sustain real-time interactions (Riva et al., 2019). These can be done with other peers and instructors’ avatars, intelligent non-player characters, and virtual learning resources (Zhang et al., 2022). Compared to traditional 2D web-based systems, social IVR platforms provide more immersive spatial affordances, ultimately resulting in increased student engagement and interest in distance learning (Mystakidis, 2020).

A systematic literature review on social IVR in education (Mystakidis et al., 2021) highlights that, in terms of cognitive aspects, social IVR enhance knowledge acquisition, retention, higher-order thinking, and problem-solving skills. It also encourages active engagement and support practical learning. Socially, it promotes successful collaboration, create a sense of presence, and foster communities of practice. For what concern the affective aspects, social IVR offer a stress-free environment, boost motivation, and lead to higher academic achievement. Overall, the authors state that these technologies can provide a rich and immersive educational experience that benefits both cognitive and affective aspects of learning (Mystakidis et al., 2021). Another study suggests that social IVR represent an optimal tool for construction safety and health education, allowing students to engage in role-playing, dialogic learning, and social interactions (Le et al., 2015).

By taking advantage of the Metaverse characteristics, it is possible to design *experiential learning* activities (Bartolotta et al., 2023; Lee & Hwang, 2022; Priest, 2023). For example, by facilitating role plays, cooperative problem solving, group projects, and collective brainstorming sessions, hands-on training etc.

These distinct aspects of IVR and Metaverses – the experiential learning, active participation, collaboration, and socialization – signify a paradigm shift in education (Mystakidis et al., 2021). This new perspective transforms learning from a text-based, teacher-centered process to an experiential-based, learner-centered one. As the body of research on individual and lab controlled IVR for education purposes continues to grow, it is still needed to assess how IVR and Metaverse technologies applied in a *social* and *ecological* (I.e., life-like classroom) learning experiences affect the adoption of these tools by students.

2.2 Technology acceptance models to investigate students' attitudes towards IVR

2.2.1 Pre-adoption technology acceptance and behavioural intention to use

Numerous models have been developed to investigate users' behavioral intentions to adopt new technologies, including IVR. Davis' Technology Acceptance Model (TAM) (Davis, 1989), Rogers' Diffusion of Innovations Theory (Rogers, 1962), and Ajzen's Theory of Planned Behavior (Ajzen, 1991) are among the most prominent. Recognizing the diversity of models, Venkatesh's (2003) Unified Theory of Acceptance and Use of Technology (UTAUT) was a substantial effort to integrate their basic concepts, giving a complete framework for understanding and predicting technology adoption. The UTAUT proposes four main constructs that influence behavioural intention and actual use of a technology. *Performance expectancy* refers to the degree to which an individual believes that the use of a technology will increase his or her productivity and performance. In the context of learning with IVR, if a learner believes that IVR can improve his or her understanding of course material and offer deeper and more engaging learning, he or she will be more likely to adopt and continue using this technology. In addition, the feeling of "presence" offered by the IVR could increase students' interest and engagement, further enhancing their performance. *Effort expectancy* refers to the perceived ease of using a technology. The idea is that people are more likely to adopt a technology if they believe it will be easy to use and will not require significant effort to learn its use. If an IVR application is intuitive, easy to use, and does not require advanced technical skills, students may find it less intimidating and thus would be more likely to use it. Good user interface design and appropriate training can further reduce the perceived barrier to IVR use. *Social influence* indicates the degree to which an individual perceives that people important to him or her expect him or her to use a particular technology. This construct is based on the concept of social pressure found in other theories of technology acceptance. Students might be influenced by peers, teachers, family members or authority figures who approve of the use of IVR in education. If these reference persons perceive IVR as a useful learning tool and actively promote it, students might be more inclined to adopt it. *Facilitating conditions* this refers to the individual's perception of the resources and technical support available to use the technology. This construct recognizes that the user's ability alone is not sufficient to predict technology use; the technological and support environment plays a crucial role. In the case of IVR, facilitating conditions could include the availability of virtual reality devices, technical support, resources and training. If these conditions are met, students will feel more comfortable using the IVR for learning. The UTAUT also suggests that age, gender, experience, and voluntariness to use technology may moderate the effect of these independent variables on behavioural intention and actual technology use. In summary, the UTAUT provides an integrated and comprehensive framework for understanding and predicting technology acceptance and use. Through identifying and combining the key factors that influence technology acceptance, the UTAUT has great applicability in a wide range of technology contexts.

The UTAUT, and the model from which it was inspired, have been extensively used to investigate students' pre-adoption attitudes and intention to use different technologies in education (Granić, 2023), including IVR (e.g., Al Farsi, 2023; Di Natale et al., in press; Shen et al., 2019; Zhao & Cleesuntorn, 2023) and social IVR or Metaverse platforms (e.g., Al-Adwan et al., 2023; Barrett et al., 2020; Teng et al., 2022). These studies collectively contribute to our understanding of how pre-adoption models can be applied to assess attitudes and intention regarding IVR and, more recently Metaverse technologies, in educational settings.

2.2.2 Post-adoption technology acceptance: a longitudinal perspective

So far, most existing studies on students' attitudes toward IVR have primarily focused on correlational research, often limited to investigating pre-adoption factors or assessing attitudes based on a single experience offered in lab-controlled settings (e.g., Barrett et al., 2021; Makransky & Lilleholt, 2018). This gap in research may be attributed to the absence of dedicated courses on IVR until recently, resulting in a lack of longitudinal studies examining attitudinal changes following participation in a specific university course. This might be attributed to several reasons. Firstly, the implementation of IVR experiences has several technical complexities and costs, such as the need for a space dedicated to the store and usage of several IVR headsets, software licences, a lab technician dedicated to this scope etc. Secondly, bridging the gap between theoretical concepts that need to be assessed during a course and corresponding practical application in VR remains a substantial hurdle. Lastly, identifying and training educators/teachers capable of effectively managing immersive educational experiences has proven elusive. These challenges might have collectively contributed to the delay in the widespread adoption of IVR technology.

Nevertheless, various studies have underscored the importance of considering how attitudes change after actual use of a product (e.g., a technological tool) or service. In educational research, the Expectation Confirmation Model (ECM) by Bhattacherjee (2001) is the predominant approach for investigating post-adoption attitudes, often combined with other models. The ECM was originally developed to understand consumer satisfaction and post-purchase behavior in the marketing domain. At its core, the ECM posits that users form initial expectations about a technology before using it. Once they start using it, they compare their actual experiences with their initial expectations. This leads to a confirmation or disconfirmation of those expectations, which in turn influences their perceived usefulness of the technology and overall satisfaction with it. The combination of these factors determines the user's intention to continue using the technology. Therefore, this model assesses three main aspects: whether a technology meets user expectations, its usefulness after adoption, and the user's satisfaction with it. Essentially, when a user tries something new and it confirms or exceeds their expectations, they are more likely to continue using it. In educational contexts, the ECM has been instrumental in examining why certain technological tools gain traction among students and educators, while others fall by the wayside. This model has found substantial relevance in the field of educational technology adoption (e.g., Al-Mamary et al., 2023; Dai et al., 2020; Rabaa'i et al., 2021; Taghizadeh et al., 2022).

Some studies have attempted to combine both pre- and post-adoption mechanisms to provide a more comprehensive analysis of students' attitudes towards technologies (Courtois et al., 2014; Raes & Depaepe, 2020; Tao et al., 2022). This combined approach is essential to capture a comprehensive view of a student's experience Combining both phases allows researchers to identify critical stages where educators and educational institutions can work to effectively incorporate a new technology such as IVR in dedicated courses. For example, while pre-adoption factors might focus on alleviating anxieties and setting realistic expectations, post-adoption factors could target enhancing user satisfaction, reinforcing positive behaviors, and strengthening learners' self-efficacy. Such combined studies are particularly beneficial for technologies like IVR, where the user experience can evolve significantly from initial exposure to habitual use. They shed light on the dynamic nature of attitudes, revealing how and why they shift over time. This is especially relevant in educational contexts where technologies are used as integral parts of the learning experience. Regarding IVR and Metaverse applications, to the best of our knowledge, no research has yet explored pre-post attitudes changes, likely due to the aforementioned limitation (e.g., costs, no trained professionals, etc.). Therefore, we employed a pre-post approach using the UTAUT combined with the ECM. While this approach has been utilized in other contexts (Gupta et al., 2020), it has not yet been applied in the educational domain.

2.3 The present study

During the pandemic and in the post-pandemic era, several universities have begun to activate IVR courses for their students. One noteworthy example is Stanford University, which introduced the first virtual reality class using Oculus Quest 2 (https://news.stanford.edu/2021/11/05/new-class-among-first-taught-entirely-virtual-reality/). Now, several universities around the world, including Italy, are beginning to deliver IVR pilot courses with the intent of studying their effectiveness on the learning experience and understanding how to support their application to other courses. Therefore, it would be crucial to move beyond understanding students' expectations and comprehend how their actual use shapes their continued intention to adopt this tool in education. For this purpose, in line with previous studies (Agbo et al., 2023; Ding, 2023), we focused on a particular case, specifically of an Italian university course that provided an in-depth combination of theoretical insights and practical hands-on experiences with IVR technologies in the realm of psychology.

In the present study, we aimed at investigating university students' continuance intention to adopt IVR for educational purposes, by tracking students' attitudes before and after completing a course that provided hands-on IVR experience. For this purpose, we combined the UTAUT framework to assess pre-adoptive variables like *performance expectancy* and *effort expectancy*, and the ECM framework to evaluate post-adoptive variables including *confirmation*, *post-adoption perceived usefulness*, *satisfaction*, *post-adoption self-efficacy*, and *continuance intention* (Fig. 1). This approach has been previously adopted by Gupta and colleagues (2020), who proposed the Extended Expectation Confirmation Model (EECM) to investigate users' intention to continue using a m-wallet system.

2.3.1 Hypotheses

Prior research suggests that users' initial beliefs and expectations about a technology shape their subsequent experiences with it. These pre-adoption factors, rooted in cognitive psychology, indicate that users come to new technological experiences with certain anticipations, which play a crucial role in determining their initial engagement. Therefore, we hypothesized that pre-adoption dimensions would affect confirmation. Specifically:

- *H1a: pre-adoption performance expectancy will have a significant impact on confirmation.*
- *H1b: pre-adoption effort expectancy will have a significant impact on confirmation.*

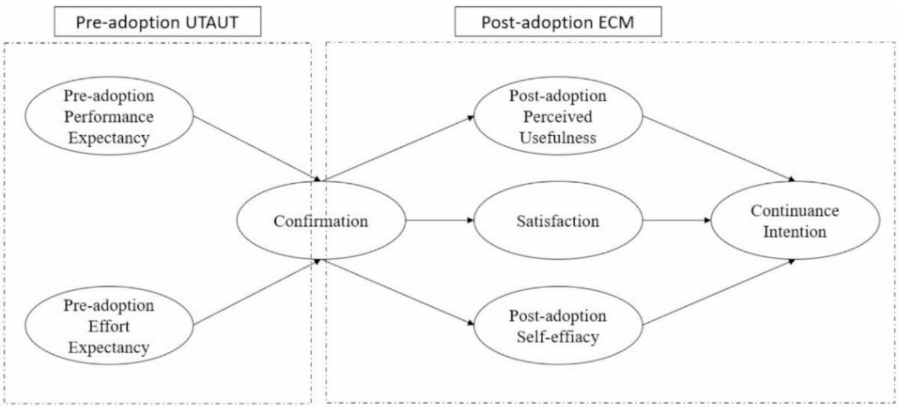

Fig. 1 The EECM used for this study, adapted from (Gupta et al., 2020)

Confirmation in the context of technology adoption refers to the degree to which users' initial expectations match their actual experiences. It's believed that when users perceive their experiences as confirming their expectations, their post-adoption beliefs, including perceived usefulness, satisfaction, and self-efficacy, are positively reinforced (Bhattacherjee, 2001). As a result, we hypothesized that confirmation would significantly affect post-adoption dimensions. In particular:

- *H2a: confirmation will have significantly impact on post-adoption perceived usefulness.*
- *H2b: confirmation will have significantly impact on satisfaction.*
- *H2c: confirmation will have significantly impact on post-adoption self-efficacy.*

After adopting a technology, users' intentions to continue its use are influenced by several post-adoption beliefs (Bhattacherjee, 2001; Gupta et al., 2020). The degree to which the technology is found useful, the level of satisfaction derived from its use, and users' confidence in their ability to use it (self-efficacy) all significantly contribute to whether they decide to persistently use the technology. In light of this considerations, we hypothesized that post-adoption dimensions would significantly impact on continuance intention.

- *H3a: post-adoption perceived usefulness will have significantly impact on continuance intention.*
- *H3b: satisfaction will have a positive impact on continuance intention.*
- *H3c: post-adoption self-efficacy will have a positive impact on continuance intention.*

3 Methodology

3.1 Sample and data collection

For this exploratory study, we recruited a convenience sample consisting of students enrolled in a five-week elective module of a university course focused on the applications of IVR in psychology. In this module, students gained hands-on experience with IVR during each lesson to learn about its potential use in the field of psychology. A description of the contents of each lesson is provided in Table 1.

Out of the 32 students enrolled in the integrative module, 28 agreed to participate in the study. 25 students (F = 19; Mage = 23.4, SDage = 1.76) completed both pre and post questionnaires. More than half of the students (60% total) already tried IVR before attending the integrative module (24% rarely, 32% sometimes, 4% frequently) while 40% of them never used it. The study was approved by the local ethical committee of the Department of Psychology of Università Cattolica del Sacro Cuore, Milan, Italy.

Table 1 A description of the theoretical explanations and practical activities carried out during the integrative module

	Theoretical Part	Practical Part
Lecture 1	Historical overviews about immersive technologies as well as the potential applications of these tools in various fields, including design, education, and healthcare promotion.	Students had practical experience of what social VR is by using the Metaverse application AltSpaceVR (accessed with an Oculus Quest 2) and making a gamified collaborative experience.
Lecture 2	Students learnt about the body swap technique, an experimental method that involves individuals temporarily experiencing the perspective or sensations of another person typically used for therapeutic interventions.	Students had practical experience of the body swap technique by using an application developed with Unity (accessed with an Oculus Rift) and experiencing being embodied in another person body.
Lecture 3	Students were presented with topics related to relaxation techniques typically used to reduce stress, anxiety, and tension and promote a state of calm and relaxation.	Students had practical experience of relaxation techniques by using an application developed by Become (accessed with an Oculus Quest 2) and experiencing the scenario called "The Secret Garden" (Riva et al., 2020)
Lecture 4	Students were presented with topics related to metaphoric IVR typically used in company settings to support personal growth and self-development.	Students had practical experience of metaphoric virtual environments by using the Become application (accessed with an Oculus Quest 2) and experiencing the scenarios called "The River and the Leaf" and "The Backpack and the Mountain".
Lecture 5	Students were able to evaluate IVR application for individual well-being promotion. They started thinking about their team projects in which present new ideas for applications in one of the fields presented so far.	Students had practical experience of other social VR is by using the Metaverse applications Remio and RecRoom (accessed with an Oculus Quest 2).

https://www.discoverbecome.com/

3.2 Measures

Pre-adoption items were adapted based on the UTAUT. Two core constructs were incorporated: *performance expectancy* (3 items, $\alpha = 0.81$, $\omega = 0.82$), which assesses the perceived usefulness of IVR for study purposes, and *effort expectancy* (3 items, $\alpha = 0.83$, $\omega = 0.84$), which measures the perceived ease of use and learning of IVR. These constructs were derived from previous research by Teng et al. (2022). Items were measure using a 7-point Likert scale ranging from 1 (completely disagree) and 7 (completely agree).

For the post-adoption variables, we focused on aspects related to *confirmation* (3 items, $\alpha = 0.90$, $\omega = 0.91$), *post-adoption perceived usefulness* (3 items, $\alpha = 0.79$, $\omega = 0.83$), *satisfaction* (3 items, $\alpha = 0.97$, $\omega = 0.97$), *self-efficacy* (3 items, $\alpha = 0.88$, $\omega = 0.89$), and *continuance intention* (3 items, $\alpha = 0.94$, $\omega = 0.94$). The *confirmation* construct encompasses the alignment of users' expectations with their actual experience in IVR learning, whereas *post-adoption perceived usefulness* gauges the anticipated improvements in learning productivity and academic performance. The *satisfaction* construct evaluates the overall user experience in the IVR environment, and *post-adoption self-efficacy* measures user confidence and comfort in utilizing IVR for learning. Finally, the *continuance intention* construct taps into the user's intention to persist in using IVR for learning in the future. The items were largely drawn from the studies of Li et al. (2022) and Gupta et al. (2020) and were assessed on a 7-point Likert scale ranging from 1 (completely disagree) and 7 (completely agree). The actual items representing each of these constructs and the Italian-adapted items can be found in the Supplementary Materials section.

3.3 Procedure

At the beginning of the course, the research team introduced the study to the student participants, administering an initial survey (T0). Prior to completing this survey, the participants were provided with informed consent and data processing forms, which they were asked to read thoroughly and sign. The T0 survey took approximately five minutes to complete, minimizing the intrusion on the students' course time. In the T0 survey students assessed the items related to pre-adoption attitudes toward IVR in education.

At the end of the course, a second survey (T1) was administered. This subsequent instrument required about ten minutes for completion and assessed students' post-adoption attitude towards IVR and their continuance intention to use it in education. The procedure is shown in Fig. 2.

3.4 Data analyses

For our analysis, we employed both descriptive and inferential statistics to assess the relationships among the study's constructs. Preliminary analyses included computation of means and standard deviations to describe the central tendency and dispersion of each variable. Pearson correlation analyses were conducted to examine the relationships among all the key variables, including pre-adoption and post-adoption attitudes, confirmation expectancy, and continuance intention. Separate regression models were built to test the hypotheses—H1a, H1b, H2a, H2b, H2c, H3a, H3b, and H3c.

Fig. 2 The procedure of the study

Table 2 Person correlations

	Mean SD	1	2	3	4	5	6	7
1. perceived usefulness pre	5.54 (0.89)	-						
2. perceived ease of use	5.31 (0.85)	0.30	-					
3. confirmation expectancy	5.06 (1.27)	0.14	-0.13	-				
4. perceived usefulness post	4.96 (1.45)	0.18	-0.16	0.89***	-			
5. satisfaction	5.53 (1.60)	0.17	0.10	0.85***	0.85***	-		
6. self-efficacy	4.94 (1.40)	0.00	0.13	0.59**	0.61**	0.84***	-	
7. continuance intention	4.93 (1.54)	0.27	-0.06	0.82***	0.82***	0.85***	0.75***	-

Note. * <0.05, ** $p<.01$, *** $p<.001$

Table 3 Regression analyses

Predictor	Outcome	β	SE	t
Confirmation expectancy	*Perceived usefulness post*	1.02	0.11	9.16***
	Satisfaction	1.06	0.14	7.58***
	Self-efficacy	0.65	0.18	3.50**
Perceived usefulness post	*Continuance intention*	0.86	0.13	6.83***
Satisfaction	*Continuance intention*	0.93	0.12	7.84***
Self-efficacy	*Continuance intention*	0.83	0.15	5.50***

Note. * <0.05, ** $p<.01$, *** $p<.001$

4 Results

4.1 Pearson correlations

Pearson correlations (shown in Table 2) did not show significant associations between pre-adoption performance expectancy, effort expectancy, and confirmation, thereby failing to support H1a and H1b.

On the contrary, confirmation expectancy strongly correlated with post-adoption perceived usefulness (r=.89, $p<.001$), satisfaction (r=.85, $p<.001$), and self-efficacy (r=.59, $p<.01$), supporting H2a, H2b, and H2c. In terms of H3a, H3b, and H3c, Pearson correlations revealed strong relationships between post-adoption perceived usefulness and continuance intention (r=.83, $p<.001$), satisfaction and continuance intention (r=.85, $p<.001$), and self-efficacy and continuance intention (r=.76, $p<.001$).

4.2 Regression

Regression analyses (shown in Table 3) further highlighted that confirmation expectancy was a significant predictor of perceived usefulness post-adoption (β=1.01, t=9.02, $p<.001$), satisfaction (β=1.06, t=7.42, $p<.001$), and self-efficacy (β=0.64, t=3.42, $p<.01$), confirming H2a, H2b and H2c. Moreover, post-adoption perceived usefulness (β=0.88, t=7.09, $p<.001$), satisfaction (β=0.82, t=7.68, $p<.001$), and self-efficacy (β=0.83, t=5.44, $p<.001$) were all strong predictors of continuance intention, confirming H3a, H3b, and H3c.

While the study did not find support for the influence of pre-adoption dimensions on confirmation, the data strongly upheld the role of confirmation in affecting post-adoption dimensions. Moreover, the study provided compelling evidence of the significant impact of post-adoption variables on continuance intention.

5 Discussion

The integration of IVR technology into educational settings represents a captivating frontier, particularly within higher education. As institutions strive to harness its transformative potential, a deep comprehension of the underlying factors influencing its acceptance becomes imperative. This study undertook the task of unravelling these determinants within the context of a university course that integrated IVR, guided by the EECM. The EECM, introduced by Gupta and colleagues (2020), offers a comprehensive lens through which to examine technology acceptance. By seamlessly bridging the pre-adoption and post-adoption realms, it provides a holistic framework that captures the dynamic and intricate nature of technology adoption processes. This is especially vital in the case of IVR, where initial experiences can make or break its acceptance trajectory.

Our study aimed to apply the EECM to capture university students' acceptance and continued intention to use IVR as an integrated tool in educational settings. By tracking students' attitudes before and after a course offering diverse IVR experiences, we hoped to shed light on the dynamic nature of the adoption process. The course, focusing on applications of IVR in psychology, provided students with a range of experiences, from immersive relaxation protocols to Metaverse platforms for learning. Our hypotheses, grounded in the EECM, posited relationships between pre-adoption dimensions and confirmation, as well as between confirmation and post-adoption dimensions. Specifically, we hypothesized that pre-adoption performance and effort expectancies would influence confirmation, which in turn would impact post-adoption perceived usefulness, satisfaction, and self-efficacy. These post-adoption dimensions were then posited to influence continuance intention.

In terms of our hypotheses, we did not uncover a statistically significant relationship between pre-adoption factors, notably performance expectancy and effort expectancy, and the confirmation of expectations. This finding contrasts with prior research on students' intention to adopt IVR (e.g., Barrett et al., 2021; Di Natale et al., in press; Shen et al., 2019) or Metaverse (e.g., Al-Adwan et al., 2023; İbili et al., 2023) in educational settings.

The divergence in our results may be attributed to a couple of factors. Firstly, our study participants consisted of students who voluntarily enrolled in this elective module. Their voluntary participation suggested a pre-existing positive disposition or interest toward IVR technology. This pre-existing disposition may have set a naturally high bar for their expectations. Secondly, as the elective module was integrated into a broader course on psychotechnologies, students might have already been exposed to pertinent technology concepts from prior coursework. This prior knowledge might have influenced their expectations.

While our findings did not support the direct influence of pre-adoption dimensions on confirmation, they underscored the essential role played by confirmation in shaping post-adoption dimensions. Notably, in line with previous studies in the educational field (e.g., Dai et al., 2020; Persada et al., 2021; Rabaa'i et al., 2021), confirmation expectancy emerged as a significant predictor of post-adoption perceived usefulness, satisfaction, and self-efficacy. Furthermore, these post-adoption dimensions demonstrated robust predictability of continuance intention. This underscores that, while initial expectations may not directly sway confirmation, once students' expectations align with their actual IVR experiences, it profoundly affects their perception of usefulness, satisfaction, and confidence in the technology. This, in turn, has a substantial impact on their intention to persist with IVR for learning purposes.

Our study contributes to the burgeoning body of literature that underscores the central importance of experiential congruence in technology-driven education. When learners perceive that their anticipatory beliefs about IVR align with their actual experiences, they not only acknowledge its educational value but also experience heightened satisfaction and confidence in its application.

5.1 Limitations and future research

The primary limitation of this study is its focus on a specific case of an elective module of a university course. While the in-depth exploration of specific field cases offers valuable insights (Agbo et al., 2023; Ding, 2023), the findings are naturally bound to the context of this particular course and to consequent limited small sample size. To fortify the robustness and applicability of the findings, future research should prioritize replication with larger and more diverse samples. In particular, future investigations should consider diversifying the participant pool to include individuals with a broader spectrum of attitudes and experiences with IVR. The exclusive participation of students enrolled in a psychotechnology course, who voluntarily opted for this IVR-integrative module, introduces a potential self-selection bias. These students likely possessed a pre-existing high interest or favourable disposition toward IVR technology. Furthermore, future studies should extend our results by involving students who participate in university course on diverse topics. The subject-specific focus of the course content, specifically IVR applications in psychology, raises concerns about the generalizability of the findings to other disciplines. While this specificity facilitated an in-depth exploration within the realm of IVR, it inherently restricts the applicability of the results to diverse academic domains This strategic step would mitigate the inherent self-selection bias and allow for the assessment of pre-post adoption intentions in courses spanning various disciplines, such as history, literature, science, physics, and beyond.

Addressing these limitations in subsequent studies would not only enrich the understanding of IVR acceptance within diverse educational contexts but also pave the way for more inclusive and comprehensive integration of IVR technology across a multitude of disciplines.

5.2 Implications and conclusion

This study embarked on a comprehensive exploration of pre and post-adoption intentions within the context of an immersive and long-term IVR course. To the best of our knowledge, this study represents a pioneering work, offering a longitudinal assessment of pre-post adoption intentions of IVR and Metaverse technology in an educational setting.

Despite not uncovering a statistically significant relationship between pre-adoption factors, such as performance expectancy and effort expectancy, and the confirmation of expectations among students, the study highlighted the central role of confirmation in shaping subsequent post-adoption dimensions—namely, perceived usefulness, satisfaction, and self-efficacy. Moreover, these post-adoption dimensions emerged as robust predictors of continuance intention. This underscores that students' positive experiences with IVR and Metaverse technologies in the classroom profoundly influence their intentions to persist in using IVR for learning purposes.

From a theoretical perspective, this study delivers a substantial contribution by applying the EECM to the nuanced context of IVR technology adoption in education. The EECM, initially introduced by Gupta and colleagues in 2020, serves as a formidable framework for understanding technology acceptance and utilization, effectively bridging the gap between pre-adoption and post-adoption phases. While employed in various technological domains, its application within the immersive realm of technologies like IVR within educational settings remains largely unexplored. By extending the EECM's scope to encompass IVR and Metaverse applications, this study enriches our theoretical comprehension of technology acceptance dynamics within educational contexts. It recognizes the unique challenges posed by immersive technologies, where initial experiences wield significant influence over acceptance, and aligns them with well-established theoretical constructs. This augmentation presents a more comprehensive model for elucidating the adoption of IVR technology.

The study's outcomes carry substantial practical implications for educational institutions willing to integrate IVR technology into their courses. Institutions are encouraged to conduct assessments of students' pre-existing levels of familiarity with IVR technology and their expectations regarding the course in question. This valuable information should be used to tailor course content and deliver specialized training programs to students with varying degrees of technology proficiency. Such an approach ensures that students can extract maximum educational benefits from IVR technology.

Moreover, the research underscores the profound significance of experiential congruence in technology-driven education. When students perceive that their initial expectations regarding IVR are met, it not only heightens their recognition of its educational worth but also amplifies their satisfaction and confidence in its utilization. This phenomenon possesses far-reaching implications for advancing technology acceptance and adoption in educational settings.

In summary, while this study did not provide direct evidence supporting the influence of pre-adoption dimensions on confirmation, it undeniably underscores the indispensable role of confirmation in shaping subsequent post-adoption perceptions and intentions. These findings not only offer pragmatic insights for educational institutions and technology developers but also beckon forth an expansive realm of further research into the multifaceted dynamics of IVR and Metaverse technology acceptance within educational contexts.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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