EMBODIMENT, (VIRTUAL-REAL) ENVIRONMENTS AND DIGITAL SURVIVAL: TOWARD AN INTELLIGENT EDUCATIONAL ECOSYSTEM

EMBODIMENT, AMBIENTI (VIRTUALI-REALI) E DIGITAL SURVIVAL: VERSO UN ECOSISTEMA EDUCATIVO INTELLIGENTE

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ABSTRACT

Immersive virtual environments and the metaverse constitute future learning spaces that leverage a variety of technologies, which drive new educational trends and bring profound changes in the way of learning and teaching, from the point of view of the relationship reality (environments)-corporeity-virtuality. On the basis of digital survival, linked to the mechanisms of action edu-metaverse-embodiment-environment, the contribution reconstructs, through a careful review of the literature, the effects that virtual worlds produce on learning, offering, at the same time, Teaching new design potential and new spaces for intervention, which use the paradigm of embodied technologies, with the aim of achieving intelligent and ecological education.

Gli ambienti virtuali immersivi e il metaverso costituiscono futuri spazi di apprendimento che fanno leva su una varietà di tecnologie, che guidano le nuove tendenze didattiche e apportano profondi cambiamenti nel modo di apprendere e di insegnare, dal punto di vista del rapporto realtà(ambienti)-corporeità-virtualità. Sulla base del digital survival, legato ai meccanismi di azione edu-metaverse-embodiment-enviroment, il contributo ricostruisce, attraverso un'accurata revisione della letteratura, gli effetti che i mondi virtuali producono sull'apprendimento, offrendo, al contempo, all'insegnamento nuove potenzialità progettuali e nuovi spazi di intervento, che utilizzano il paradigma delle tecnologie incarnate, con l'obiettivo di realizzare un'educazione intelligente ed ecologica.

KEYWORDS
Metaverse, Embodiment, Digital survival, Virtual world, Virtual reality, Environment, Higher Education

Metaverso, Embodiment, Digital survival, Mondo virtuale, Realtà Virtuale, Ambiente, Istruzione superiore
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1. Introduction

"We are at the beginning of a new chapter for the Internet", so Mark Zuckerberg, Founder and CEO of Facebook, expressed himself on October 28, 2021, announcing the "metaverse" and the birth of Meta, which could represent the beginning of a new era for the whole of humanity.

Facebook has officially changed its name to "Meta", which derives from the "meta universe", a platform that will make the Internet more engaging and embodied and that will allow the individual to stay "inside the experience", instead of looking at it from the outside as a simple spectator. This project, which Zuckerbeg calls "fascinating and at times dystopian", outlines a future in which you can go to work, meet and spend your free time using holograms that will allow you to virtualize experiences that were once exclusively, or even partially, physical.

In the same direction Negroponte (2021) describes digital survival as a state of social existence in digital form, which contemplates a new way of existing and living in the digital space, where the sum of experiences, feelings and actions that occur in the digital environment will bring new cognitive models that will reverberate in the behaviours of individuals, influencing also habits and styles of study.

Thus, the daily experience, information and skills that students and teachers will need will be summarized and sorted into categories on the intelligent interface to match the needs of the recipients and structured "tailored" for them.

Students' access to information corputies will be efficient, targeted and rapid, although to be kept at bay, since intelligent technology could have, in addition to positive impacts, also negative impacts, such as, for example, the possibility of causing cognitive and physical overload and cognitive prejudices and generating risks of different nature, also involving ethical issues. The multiplicity then of technologies involved in virtual reality, which includes sophisticated 3D graphics, avatars and instant communication tools, etc., make VR an ever-changing and varying field of endeavor.

With the arrival of the era of the metaverse, a term first used in 1992 in a science fiction novel Snow Crash written by American novelist Neal Stephenson (1992), digital survival is gradually changing, especially following the impact of the COVID-19 pandemic, when students relied on the Internet to study, socialise, have fun, etc., thus securing their basic learning and social needs while transforming the lives of individuals.

This also brought with it the importance of exploring the multiple influences of smart technologies on students' learning behaviour in educational contexts, since in their application potential lies the principle of building a knowledge society in which “everyone can learn things anytime and anywhere”.

Framework

The aim of smart educational ecosystems is to promote the design of smart education (Zheng, 2017; Fu, Zhao, & Huang, 2022) to be exploited as an educational resource to improve students' cognitive abilities and the level and functionality of the entire ecosystem, which is designed on the basis of education enhanced by the metaverse, virtuality and ecological principles.
Technologies are employed to build systems in which interaction (Sibilio, 2020) and mutual adaptability of elements and environments fully consider the needs of teachers and learners, incorporating intelligent instruction into the entire educational process, which transforms traditional intervention spaces (Ayiter, 2019) by adopting real teaching resources, flexible teaching modes and individualised and personalised approaches to learning. This enables solutions to educational problems in a scenario that integrates and promotes the sharing of resources and nurtures educational forms of co-design and co-development.
At the moment, as confirmed by systematic reviews (Peixoto et al., 2021; Wang et al., 2018) and the present study, research in this area is still in its infancy and the literature (Prieto, Lacasa, & Martínez-Borda, 2022) shows how important it becomes to take an ecological theoretical perspective in this area, where the development of a smart education ecosystem based on the metaverse and virtual reality constitutes the hope of providing in education solid references to promote strategically integrated, interactive and individualised interventions and forms of design.
VR, in fact, engages the brain's motor system and builds muscle memory and can help people learn all kinds of skills, leveraging the strengths of the metaverse and virtuality that - within three-dimensional and symbiotic spaces in which physical persons can move and interact through customised avatars - include spatial training, engaging limbs and body in different tasks that are often impractical in real life.
The simulation of scenarios for routine operations, the response to problems, emergencies, stressful situations, decision-making processes, critical procedures, high consequence events, etc., occurs in controlled environments that can become structurally and intentionally educational, increasing understanding and learning at different levels and related skills, as well as body awareness, which allows you to be embodied from the sensory-motor point of view by including action-oriented body patterns (Maturana & Varela, 1987).
The interrelation between perceptual, motor, cognitive and emotional characteristics allows to "experience" in an extensive, multidimensional and multisensory perspective within an educational process that sees the development of the bodily self as "embodiment", to which specific functional rules are subject (de Vignemont, 2011).

While it is true, therefore, that in education, and specifically in higher education, the metaverse and virtuality provide opportunities for university students to delve into different learning contents, pursue meaningful learning objectives and perform different functions (meeting tutors, visiting libraries, working with colleagues, etc.) by bringing people together in different places and spaces, it is equally true that they enable the individual to learn in a more flexible and faster way by providing opportunities for experiential and embodied skills that employ real-world scenarios and situations in which it is possible to make mistakes without consequences.

Such virtual environments, when well designed, combine virtual reality with data science and spatial design to enhance student engagement, trust, and application at multiple levels. In terms of the benefits of virtual environments on learning, the literature highlights many aspects, such as learning by experience, deliberate practice, state-dependent learning, visualization, embodied storytelling, interactivity and multisensoriality, building human capacity in difficult conditions, practicing transversal skills in safe environments such as sensitive or difficult conversations, accessibility for people with disabilities, educational accessibility, experiences of Immersive, engaging and interactive learning through virtual simulations, enhanced collaboration, facilitation, visual realism, learning from mistakes, meaningful and diverse experiences, personalized learning and so on.

Virtual reality consists of simulating a realistic experience, or a sense of presence, based on the perceptual senses on which actions are performed. Presence in VR-based interventions is often mediated by inducing the user's high immersion of virtual selves and realistic interaction between virtual and real worlds (Jeong, 2020).

Figura 1. *A Taxonomy of Mixed Reality Visual Displays* (Milgram & Kishino, 1994)

At the core of the metaverse are extended reality technologies, which include virtual reality, augmented reality, and mixed reality. The metaverse should work in the same way as the actual application of virtual reality to simulate a hybrid experience that people can manipulate and explore as if they were there.

However, in a logic of continuity with virtual reality (VR), to try to fully understand the metaverse, several authors have tried to synthesize the characteristics that an application should possess in order to be considered as such (Prieto et al., 2022) as shown in Table 1.

Castronova (2008)	Dionisio et Al. (2013)	De Decker (2020)
Interactivity	Realism	Inmersive
Embodiment	Ubiquity	Accessible
Persistence	Interoperability	Synthesized
	Scalability	Multi-layered
		Collaborative

Tabella 1. *Caratteristiche del metaverso* (Pietro, 2022, p. 137)

Interactivity, embodiment, and persistence, realism, ubiquity, interoperability, scalability, immersion, accessibility, synthesis, stratification give the system the qualification of metaverse (Castronova, 2008; Dionisio et al., 2013; Decker and Peterson, 2020), pointing out one or the other characteristic depending on the underlying interpretative model.

The use of the metaverse would therefore offer a high degree of freedom for the creation and sharing of engaging learning experiences by allowing education systems to collect hitherto untapped data to obtain insights into student behavior, to monitor their progress, to identify their gaps, continuously improving the learning experience with the intent to achieve personalized education.

Useful data on student actions include usage, performance, attention, engagement, feelings, and predictive analytics. Teachers can also play a more active role in collecting data and analysing lessons on the effectiveness of learning environments.

Research

Methodology

The present study focuses on the examination and understanding of the key elements of all those empirical studies that highlight the effects of virtual environments on student learning in higher education contexts. Therefore, the goal is to reconstruct an interpretative framework within which it is possible to identify those elements useful for building a smart education ecosystem based on the

metaverse, virtual reality and embodied technology and their dynamic and scientific assumptions.
Starting with a review of the scientific literature, which involved a systematic selection of records/contributions, typical of the rigour of meta-analysis, and capable of bringing out the most significant evidence in the literature in order to direct future research in this area, this study, by elaborating on some basic questions, attempts to identify the factors that could influence an intelligent educational ecosystem and their relationships, taking into account both its effects and limitations.
Without any claim to be exhaustive, the meta-analysis combined data from multiple evidence studies conducted on keyword selection, generating a conclusive figure to answer the ability of smart technologies to have an effect on learning in higher education contexts and factors that could become part of a smart education ecosystem.

Procedure
The corpus considered included articles containing all types of primary research related to articles published between 2013 and 2023 in English, peer-reviewed and of which the full text was available. To be included in the corpus, studies had to measure learning progress using validated instruments that accounted for precise effects.
The keywords and their combination have been derived from the previous systematic analysis of the publications published so far, which have been connected to the study variables and also linked to the concept of smart education. Some key keywords such as embodiment, metaverse, virtual reality etc. served as pillars to initiate research and pursue its central objective with the intent to produce implications for the smart education ecosystem.
Each search was carried out by consulting databases. Specifically, the following search engines were used: Google Scholar, EBSCO and ERIC, in which the following keywords were entered: "effects of metaverse" OR "effects of virtual reality" OR "effects of augmented reality" AND "teaching" AND "learning" AND "higher education" AND "embodied". Duplicates or texts not relevant to the objective of this study were eliminated (Tables 2 and 3).
A total corpus of 270 articles was identified, of which 57 were then analysed and reviewed. For the selection of the articles and their review, a search strategy was employed that emphasised outcome-based evidence research and its critical appraisal, making use of a synopsis format of questions and keywords, and adding an assessment of the relationship between target variables and intervention effectiveness. This involved using meta-analysis to identify important dimensions, factors and moderators.

Avoiding common sources of potential bias and possible confusion, careful selection was made in the sample and analysis of the missing data. Studies classified as at risk of confusion were generally compared, without taking into account the temporal dimension in learning progress.
The main causes of the selection bias were found, however, in the use of convenience samples and the insufficient consideration of self-selection by the participating universities and students.
We ensured that the studies analyzed were sufficiently bias-free, uniform and not too dissimilar in design and outcome, so that they could be compared, to avoid a wrong estimate of the effect of exposure to the virtuality of an outcome/condition. Each study was assigned an overall rating against the significance of the results and based on the estimate and domain with the highest risk of bias (none, low, moderate, high).

Drafting of a research protocol

1. Bibliographic **research** strategy (EBSCO, Scopus etc.) with temporality 2013-2023
2. Definition of inclusion and exclusion **criteria** and selection of studies
3. Data extraction method that included a data **extraction card** and a program for archiving in Excell
4. Identification of the **corpus** of articles
5. Method used to establish the presence of potential **biases** (theoretical, methodological, etc.)
6. **Synthesis** measurement
7. Evaluation of **the quality** of studies
8. Extraction of individual study **data**
9. Interpretation and comment on overall **results**
10. **Critical** summary of results

No	Selection criteria
1	Year of publication
2	Tongue
3	Model or theory
4	Objective
5	Study design
6	Study methodology
7	Instrument(s)
8	Technology
9	Level of education (Higher Education)

Table 2. *Corpus selection criteria*

No	Inclusion criteria	Exclusion criteria
1	*Articles that...*	*Articles that...*
2	concern metaverse systems in higher education	concern metaverse systems not applied to the field of higher education
3	contain a comprehensive research framework	do not contain an exhaustive research framework
4	are written in English	are published in languages other than English
5	are published between 201 3 and 2023	are prior to 2013
6	are relevant to the objective of the research and the full text is present	are duplicated, do not have the entire text or are not relevant to the objective of the research

Table 3. *Inclusion and exclusion criteria*

The number of articles identified at a first examination of the bibliographic research (starting from the keywords identified), the number of those subsequently excluded on the basis of the preliminary reading (with the motivation), the number of the remaining excluded studies (on the basis of an in-depth reading of the works "in extenso") have led to identify the final corpus of the works included.
Based on the scenarios and characteristics described above, a reading grid was then constructed for a scientific and objective evaluation of the smart factors (which for reasons of space cannot be the subject of this contribution), in which the eco-technological ecosystem highlights dimensions and factors that are fundamental for fostering the development of smart education.

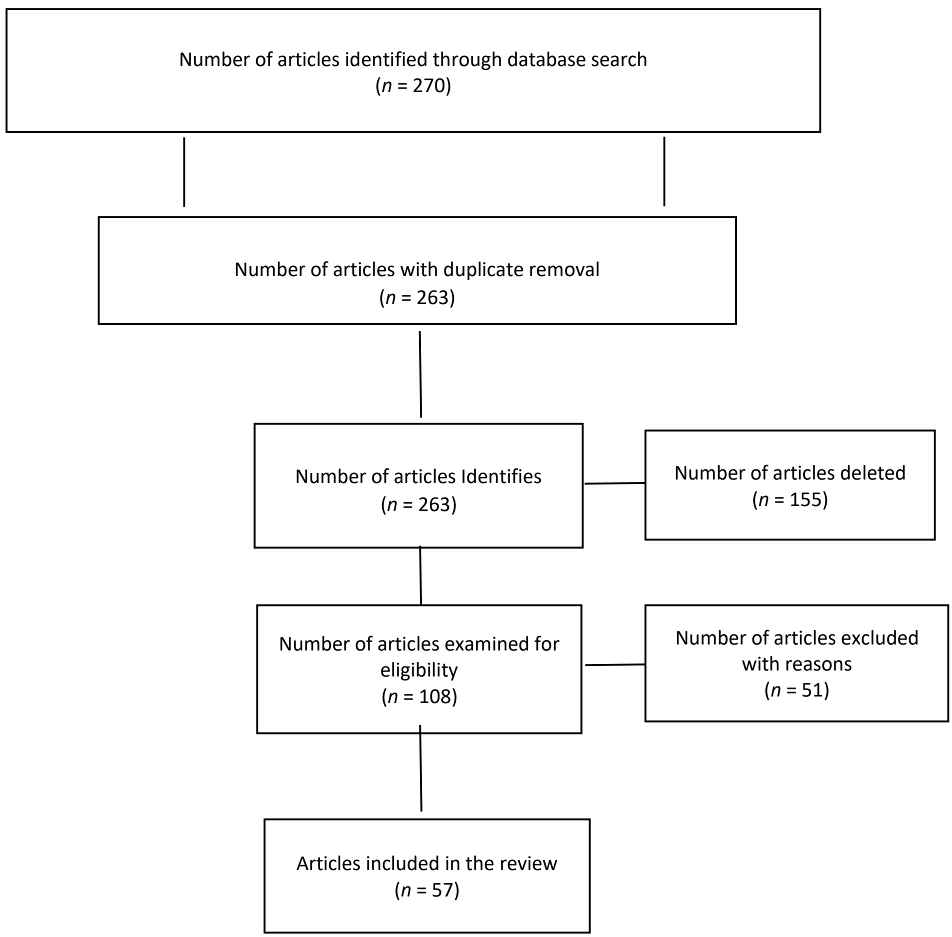

Figure 2. *Flow chart on conducting the systematic literature review* (Natalini & Orecchio, 2023)

Studies classified as critically ill risk of bias were excluded. These are therefore not part of the 57 studies included in our systematic review. A concise and immediate representation of the study selection process is provided by the flowchart below (Figure 2).

Specifically, in order to assess the quality of the studies, a sensitivity analysis was carried out to assess the extent to which the studies were of uncertain methodological quality and contributed to the direction of the results, making assumptions in this regard, how the authors interpreted and discussed the results, paying attention to whether or not they were derived from the data presented and were not confused with other general considerations, and that the lack of evidence

of effectiveness was not confused with evidence of ineffectiveness, i.e. with a lack of studies; and finally that negative results were discussed and not omitted.
The systematic literature review involved the combination of four separate sub-indices representing the quality of evidence on each dimension: number of participants, methodology, effect and consistency of results.

Results

As hypothesised, the results of the individual studies are, on the whole, fairly consistent, but not always in terms of the effects and the variety of technologies involved. In fact, it was noted that the systematic review itself was powerful enough to demonstrate the effectiveness of the interventions before this emerged from the individual studies. A distinction in the review, represented by the level of education involved and the subject of the study, guarded against confusion regarding factors and effects.
The results show that research on the adoption of the meta-verse in higher education contexts is progressively increasing, but that there is still a long way to go for a comprehensive and clear understanding of the effectiveness of some factors over others and their influence with respect to different types of abilities. They revealed how the most accredited research needs to be replicated and how many studies need to be extended to different countries in order to understand the influence of certain socio-cultural factors acting in higher education contexts.
Most of the selected articles emphasised the importance of initiating prospective studies that should consider students from different subject areas. In many of the studies reviewed, the discipline taught was a key issue, although this aspect should be further investigated in order to understand its significance. It also emerged that, in order to ascertain how metaverse and virtual reality are educationally relevant, specific studies should be undertaken to investigate the reasons for its use in comparison to more traditional modes.
The results highlight the usefulness of the methodology to measure the uptake of various research on the metaverse also using appropriate models in use and also confirm expectations that such models have not yet been widely used to evaluate the application of the metaverse in educational contexts. There is, in fact, a certain discrepancy between the model or theory adopted in the studies analysed and some of the evaluations carried out on them during the discussion phase, giving the idea of a lack of clarity regarding the underlying reasons for the use of a specific technology.
Indeed, the evidence literature shows that different forms of virtual and augmented reality, due to their immersive and interactive properties, induce an increase in motivation to achieve educational goals, engagement, and interest (Elsayed & Al-Najrani, 2021; Squires, 2017; Jdaitawi et al., 2023; Horlock, 2020; Di

Natale et al., 2020; Huifen et al., 2021; Matovu et al., 2023; Erlandsson & Ivarson, 2021; Sontay, Karamustafaoglu, 2021), reflection (Nah et al., 2022), knowledge retention (Pirker & Dengel, 2021), second language and vocabulary learning (Liao, 2020; Qui et al., 2023; Qui et al., 2022; Chen et al., 2022; Lai & Chen, 2023; Hein et al., 2021; Bahari, 2022; Huang et al., 2021), divergent thinking (Ichimura, 2023), cognitive thinking (Kairu, 2021), academic help (Nersesian et al. 2020), engaging on environmental and sustanable issues (Stenberdt & Makransky, 2023; Sims, 2022; Barnidge et al, 2022; Cosio et al., 2023; Queiroz et al., 2018), spatial skills (Jiang et al., 2022) and spatial memory (Atta et al., 2021). Finally, the various forms of virtual reality and augmented reality would appear to allow for the development of creativity and critical thinking (Marshall, 2023), as well as lightening the cognitive pathway of information from sensory input to long-term memory, but sometimes leading to cognitive and physical overload (Ladendorf et al., 2019).
Virtual reality technologies, therefore, would appear to result in a high level of attendance for students (Tepe et al, 2022; Hube, Pfeffel, & Müller, 2022) and have some effect in improving performance in different disciplines (Cao & Hsu, 2022; Omurtak & Zeybek, 2022; Akçayır et al., 2017; Coban et al., 2022; Yilmaz et al., 2021), but also empathy (Trudeau, 2023) and spatial skills (Reit, 2020).
These findings are all in need of further study. It was also noted that in order to better understand the underlying links between the factors considered in the studies and those influencing learning, mixed studies including interviews or focus groups should be used in conjunction with experimental studies. Current and previous studies seem to provide information on the use of various research methods, i.e. quantitative, qualitative and mixed methods, and the influence of the metaverse within higher education structures, as validated by previous studies.
In the analysis of the studies considered, the results from a pedagogical perspective point to the fact that the metaverse seems to have a strong impact on cognitive learning, but prospective decision-making processes mainly concern the relevance and applicability of technologies over others, particularly when it comes to accepting the assistance of synchronous or asynchronous methods. This could be important in helping teachers choose the technology that best complements their lesson plans and develop appropriate planning. In essence, numerous theoretical, methodological and pedagogical implications are provided by the systematic review.
However, literature suggests that with the emergence of the metaverse era, new opportunities are opening up for education and for the implementation of advanced thinking in students and for the development of teaching that opens up a sustainable educational future. Immersive virtual environments and the metaverse constitute future learning spaces that leverage a variety of technologies, driving new educational trends and bringing about profound changes in the way we learn and teach, from the perspective of the relationship between reality

(environments)-body-virtuality. On the basis of a development trend, that of digital survival, linked to the mechanisms of edu-metaverse-embodiment-enviroment action, the contribution, starting from the idea of a balanced system of embodied interaction, stands to reconstruct a model of intelligent educational ecosystem, which builds modular learning scenarios and spaces, which, through integrated technological devices structure an idea of education embodied interaction, which combines experience, body and spatial investigation, as new educational modes in the reality-virtuality symbiosis that operates a trans-spatial and corporal fusion. The meta-analysis identifies characteristics and evidence meanings of this combination of body (real-virtual), environment (natural-virtual), which further underlines the potential of virtual worlds for embodied and extended cognition: the boundaries between real, virtual and corporeality can be highly permeable (cognitively permeable), offering teaching new design potential and new spaces for intervention.
It emerges how from embodied virtuality to educational and social ecology, virtual spaces and times are defined where the ecological balance of the interaction between education, environments, corporeity and virtuality allows educational resources to be harnessed to enhance the cognitive capabilities of students and the level and functionality of the entire educational ecosystem, allowing them to turn to consider symbiotic, dynamic, balanced and sustainable smart systems that integrate the effects, interconnection, self-regulatory forms and learning elements with instructional design, instructional resources, assessment and other factors using the paradigm of embodied technologies, with the goal of realising smart and ecological education.

Conclusions

This study constitutes a review of the literature and is not intended to be exhaustive of the entire available scientific universe, but rather to offer only a limited sampling that was directed at examining certain features related to evidence studies focusing on the effects virtuality and the metaverse might have on learning processes from specific embodied technology models.
The limitations of the study concerned the small number of sampled contributions, selected by year of publication, study methodology, model, theory, technology and objective of the study.
The selected studies have shown how in the last two years there has been a greater attention to research on the empirical metaverse and how it is necessary to implement research in this area, in the light of a responsibility more inspired by ethics (Rivoltella & Panciroli, 2022) to validate metaverse models pedagogically increasingly effective and oriented to a conscious use of virtual reality and technologies that support learning behaviors of quality.

Some factors have limited the systematic review carried out, which could usefully be implemented to allow the development of a more comprehensive picture by querying and integrating different sources and databases, extending the research also to different levels and degrees of education, and publications also involving books and book chapters, to accurately understand emerging research of high high quality in this area.

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