BEYOND DIGITAL BOUNDARIES: INTEGRATING BODILY EXPERIENCE AND EMOTIONS IN ARTIFICIAL INTELLIGENCE-ASSISTED LEARNING

OLTRE I CONFINI DIGITALI: INTEGRARE L'ESPERIENZA CORPOREA E LE EMOZIONI NELL'APPRENDIMENTO ASSISTITO DALL'INTELLIGENZA ARTIFICIALE

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ABSTRACT
Advanced technologies like VR, AR, and AI are transforming education, offering immersive and personalized learning. Their impact on adolescents' physical and emotional experience is understudied. This research uses a questionnaire to explore how these technologies affect students' learning, focusing on their emotional and physical engagement.

Le tecnologie avanzate come la VR, AR e AI stanno trasformando l'educazione, offrendo un apprendimento immersivo e personalizzato. Il loro impatto sull'esperienza fisica ed emotiva degli adolescenti è poco studiato. Questa ricerca utilizza un questionario per esplorare come queste tecnologie influenzino l'apprendimento degli studenti, concentrandosi sul loro coinvolgimento emotivo e fisico.

KEYWORDS
Virtual Reality (VR); Augmented Reality (AR); Immersive Learning; Educational Technologies; Emotional and Physical Engagement.
Realtà Virtuale (VR); Realtà Aumentata (AR); Apprendimento Immersivo; Tecnologie Educative; Coinvolgimento Emotivo e Fisico.

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Introduction

Technological evolution is undoubtedly redefining the social and educational landscape, bringing with it as many opportunities as complex challenges. In a world increasingly influenced by digitalization, the boundary between digital and traditional teaching is dissolving, necessitating new ways of thinking and recent innovative pedagogical approaches. Post-digital teaching, a term coined to describe this new paradigm, deviates from traditional technological determinism and aims to integrate technologies in a way that they become a transversal element rather than a slogan-like model. This approach responds to the need for critical pedagogy that effectively meets the needs of a constantly changing context. As emphasized by Jandrić & Hayes (2020), the post-digital challenge is not limited to understanding and using technology but exploring how it can be employed to realize pedagogical visions that promote critical and creative skills. In the current Italian school context, the concept of "Critical Making", proposed by Ratto (2021), emerges, emphasizing the importance of the direct connection between design and production, thus facilitating a holistic approach to learning. This is closely linked with the Maker Culture, which encourages students to become active creators, not just passive consumers of content. This culture supports the development of vital skills such as collaboration, management, autonomy, entrepreneurship, and creativity, which are essential in the contemporary job market. The role of education, therefore, must evolve to prepare individuals to navigate this new digital context effectively. It is essential that educational systems are flexible and designed to integrate advanced technologies such as artificial intelligence and robotics, but also to develop transversal skills that help students face complex challenges and thrive in diverse professional environments. The integration of digital technologies in teaching not only transforms the way we teach and learn but also promotes broader student engagement in processes that value both theory and practice. This can lead to a deeper understanding and greater ability to apply knowledge in practical and meaningful ways, thus preparing students to contribute actively to society in innovative and conscious ways. This research aims to explore the use of Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) technologies and their impact on the learning experience of adolescents. The focus of the project is to understand how the physical and emotional interaction promoted by these technologies can enhance or, conversely, hinder educational outcomes. Author Rivoltella (2019) has emphasized the importance of investigating these aspects to enrich the understanding of the effects and tools of digital education. To pursue this goal, the project employs a quantitative methodological approach, using a closed questionnaire as the main data collection tool. In this

regard, the study by Ghedin & Mazzocut (2017) involved the design of questionnaires necessary to collect information regarding the perceptions, preferences, and perceived effectiveness of VR, AR, and AI among students from various educational levels. The study involved a group of 255 teachers from Primary, Lower Secondary, and Upper Secondary schools and aimed to investigate teachers' perceptions regarding the sharing of values and inclusive practices adopted from the perspective of Universal Design for Learning in their respective schools. The results highlighted a good prospect for the dissemination of an innovative and inclusive educational approach in the Italian context. The use of technologies allows for the collection of quantitative data that can be analyzed to determine the impact of these technologies on learning. Another and shareable aspect, for the purposes of this study, is the integration of technology in K-12 educational contexts, which is among the development priorities of international educational systems. This study on technology-integrated teaching, accompanied by evidence-based teaching strategies, aims to effectively support the integration of technology in the classroom (Karchmer-Klein et al., 2023; De Marco, 2023; Messi et al., 2022). After this premise, the ambitions of this research are twofold: on one hand, to enrich the academic debate on educational technologies through new empirical evidence; on the other, to provide concrete indications for the development of pedagogical practices that fully exploit the benefits offered by these technological innovations. By doing so, the study aims to contribute significantly to both educational theory and practice, suggesting effective ways to integrate these advanced tools into teaching and learning processes.

1. Innovations and Applications of Virtual Reality and Augmented Reality

Virtual Reality (VR) and Augmented Reality (AR), despite often being confused regarding their uses and potential, have gained notable popularity in various sectors in recent years. The term "Virtual Reality" was introduced in 1989 by Jaron Lanier, an American computer scientist, who described it in an interview as an exclusively digital reality, existing only as an electronic and not physical representation. Lanier explained that VR is not simply a computer but a technology that uses computerized devices to create a shared reality experience, influencing only the sensory perception of the individual without directly altering the internal reality of the brain (Kelly et al., 1989, p. 110). VR creates interactive digital environments that allow users to immerse themselves in alternative worlds through headsets, sensory gloves, joysticks, and interactive suits, isolating them from the external environment and interacting in real-time with three-dimensional

scenarios. The experience is made more authentic by the ability of virtual scenes to adapt to head movements, changing the visual perspective based on the user's orientation. There are various forms of VR, including non-immersive VR, which allows viewing and interacting with digital environments on a screen while maintaining control over the surrounding physical environment, useful in the absence of equipment for full immersion. Soroko et al. (2021) proposed a classification of VR technologies based on the level of realism perceived by the user and the accessories used. Among these are fully immersive VR, which offers detailed simulations of virtual worlds, and semi-immersive VR, which integrates virtual and real elements, as in-flight simulators. Non-immersive VR and collaborative infrastructure VR, such as in games or virtual social environments, allow more limited interactions with the virtual world. Similarly, AR enhances existing reality by overlaying digital elements such as graphics, text, and audio onto the physical space, integrating with reality to improve user experience and knowledge without limiting interaction with the environment. The notion of AR was coined in 1992 by Thomas Preston Caudell of Boeing, to help technicians visualize wiring instructions through high-tech glasses. Mixed Reality (MR), on the other hand, combines elements of VR and AR, creating environments where the virtual and real coexist in various proportions. These technologies have historical roots predating the 21st century, as demonstrated by the development of the first stereoscopes by Charles Wheatstone in 1838 and the accounts of virtual reality in science fiction works from 1935. Research and development continue to evolve, with significant milestones such as the creation of the first wearable headset by Ivan Sutherland in 1968 and the introduction of Oculus VR by Palmer Luckey in the early 2000s. Today, VR and AR are applied in a wide range of sectors, from training to marketing, particularly revolutionizing education and learning through new immersive and interactive technologies. The use of immersive technologies like VR and AR in education has proven to be extremely effective for learning various subjects, ranging from sciences (Tsivitanidou et al., 2021; Sun & Chen, 2020; Schutera et al., 2021; Gopalan, Zulkifli, & Aida, 2016) to humanities and arts, including language learning and cultural heritage studies (Alizadeh, 2019; Pinto et al., 2021; Chin & Wang, 2021). VR and AR technologies have also been recognized for their role in enhancing motivation (Gopalan et al., 2016; Di Serio et al., 2013) and in applying principles of constructive learning (Chen, 2009; Huang et al., 2010).

Immersive VR simulations through HMD devices have proven particularly valuable in scientific education. The use of simulated environments significantly enhances scientific learning (Chen et al., 2017), promoting STEM education (Soroko et al., 2021). The advantages of HMDs include the ability to generate 3D stereoscopic

visualizations, facilitating the understanding of complex scientific theories, abstract phenomena (Tsivitanidou et al., 2021), and the visualization of typically inaccessible elements, such as airflow around a car or human anatomy. VR allows students to immerse themselves in alternative dimensions, actively interacting with the digital world and receiving real-time feedback, thus improving understanding through practical experience (Pinto et al., 2021). HMDs also extend the field of view into the virtual environment, intensifying emotional responses to stimuli (Gall & Latoschik, 2020). Recent studies have highlighted the effectiveness of virtual environments for social and emotional learning. Tan et al. (2022) discovered a significant impact on empathy and the ability to understand others' perspectives. Another interesting study by Sülter et al. (2022) examined the use of the VR Speak App-Kids! with elementary students, reducing public speaking anxiety and modifying participants' maladaptive cognitions, such as nervousness and perception of negative judgment, through the simulation of a child audience. VR interaction offers authentic learning, as demonstrated by Han and Resta (2020), who studied a collaborative online course between the USA and Israel on platforms like Second Life, noting significant changes in students' learning perspectives. The combination of VR and gamification, where game elements are applied in educational contexts, has shown benefits in stimulating active and participatory learning (Kim et al., 2018; Kapp, 2012). Finally, it is also essential to consider the role of contexts, which are crucial for the effectiveness of immersive technologies. Asad et al. (2022) highlighted the importance of user-friendly technologies for experiential learning. Rogers (2020) pointed out how affordable and accessible VR environments, like using Google Cardboard, can be effective for geoscientific education, providing mini-immersive experiences that integrate field teaching and laboratory activities. Alizadeh (2019) analyzed the educational use of platforms like Google Expeditions and Tour Creator, which allow virtual trips.

2. Methods and Materials

To investigate the impact of Virtual Reality (VR) and Augmented Reality (AR) technologies on the physical and emotional engagement of students, this study adopts an experimental approach, dividing participants into two distinct groups: the experimental group and the control group. The sample consists of 50 high school students, aged between 15 and 18 years, of mixed gender. The selection of participants was conducted through a stratified sampling process to ensure representativeness of gender, age, and educational background. Before the start of the study, informed consent was obtained from all participants and their families,

ensuring their understanding of the study's objectives and procedures. Students were randomly assigned to one of the two groups to ensure fairness. The experimental group (intervention) participated in learning sessions that integrated the use of VR and AR technologies. These technologies were used to create engaging learning experiences, allowing students to explore educational content interactively and in three dimensions. The control group, on the other hand, followed a traditional learning path, without the use of VR or AR technologies. The educational material and teaching methods used for this group were designed to meet the learning objectives of the experimental group but were presented in conventional formats, such as frontal lessons, printed texts, and static visual aids. The experimental procedures of the study took place during the first semester, in which both groups participated in the same learning units and covered the same curricular topics to ensure comparability of learning outcomes. At the end of the first study period, participants completed a questionnaire to measure their emotional and physical engagement, as well as their perception of the effectiveness of the teaching methodologies used. The questionnaire included multiple-choice questions, Likert scales, and comparative assessment questions to collect quantitative data on the learning experiences of students in both groups. The questions were designed to evaluate engagement, content retention, skill development, student satisfaction, and the innovativeness of the approach.

3. Analisi Comparativa dell'Efficacia di Tecnologie Educative: Realtà Virtuale, Realtà Aumentata e E-learning Tradizionale

To better understand the positioning of VR and AR technologies compared to other educational methodologies, we conducted an in-depth comparison between VR, AR, and traditional e-learning. The aim of this comparative analysis was to evaluate the effectiveness of these technologies in terms of student engagement, content retention, and the improvement of critical skills. We measured various aspects such as the level of interaction, emotional engagement, and student satisfaction through post-session questionnaires and behavioral analysis during the lessons.

Aspect	Virtual Reality (VR)	Augmented Reality (AR)	Traditional E-learning
Student Engagement	High	Medium	Low
Content Retention	Very High	High	Medium
Skills Development	High	Medium	Low
Student Satisfaction	Very High	High	Moderate
Innovativeness of Approach	Very High	High	Low

Table 1

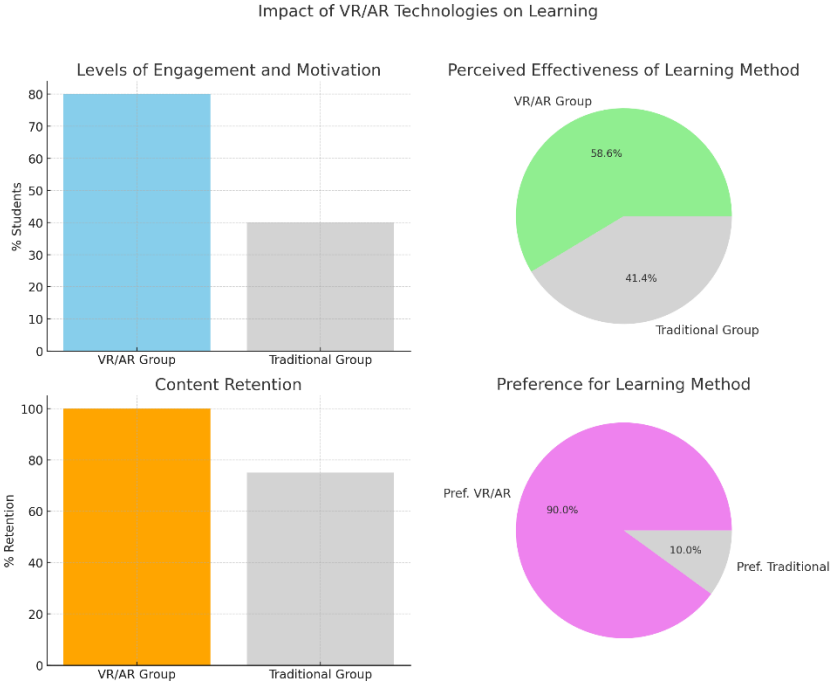
(Comparison of the Effect of Educational Technologies on Student Performance and Satisfaction)

These results suggest that both VR and AR offer significant advantages over traditional e-learning, especially in terms of student engagement and content retention. VR, in particular, has been rated very positively for its impact in facilitating immersive and interactive learning. These insights underscore the importance of integrating immersive technologies into educational environments to enrich the learning experience and improve academic performance.

4. Results

The study involved 50 students, equally divided between the experimental group (using VR and AR technologies) and the control group (using traditional learning methods). Both groups consisted of students from the 3rd to the 5th year of high school, aged between 15 and 18 years, with a balanced gender distribution. The experimental group reported significantly higher levels of engagement and motivation, with 80% of the students indicating a “high” or “very high” level of emotional and physical engagement, compared to 40% in the control group. In assessing the perceived effectiveness of the learning method, 85% of the experimental group believed that VR and AR technologies improved their understanding of the subject, compared to 60% of the control group who found traditional methods effective. A follow-up test conducted two weeks after the learning sessions showed that the experimental group had a 25% higher retention rate of the subject matter compared to the control group. Additionally, 90% of the

students in the experimental group expressed a preference to continue using VR and AR technologies in their learning, highlighting the immersive experience and the ability to visualize complex concepts as key factors (Graphs 1 - 2 - 3 - 4).



Graph 1: Levels of Engagement and Motivation

Graph 2: Perceived Effectiveness of Learning Method

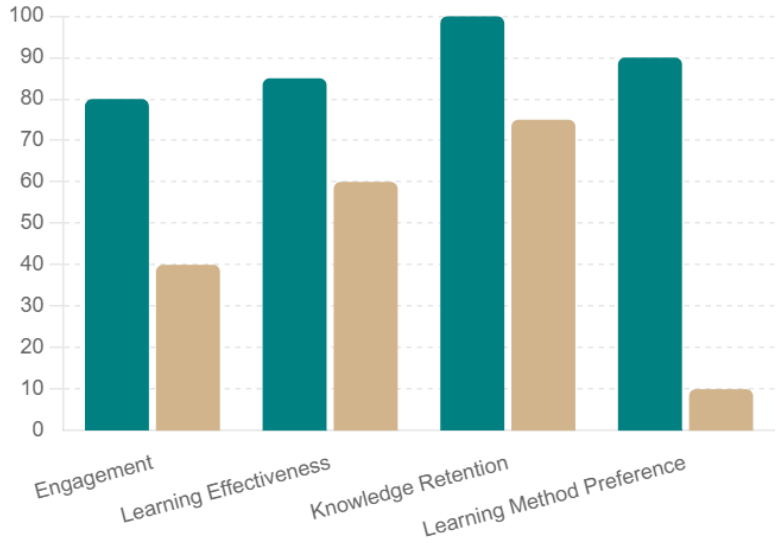
Graph 3: Content Retention

Graph 4: Preference for Learning Method

5. Discussion

I risultati di questo studio suggeriscono che l'integrazione delle tecnologie VR e AR nei contesti educativi migliora significativamente il coinvolgimento, la motivazione e la conservazione delle conoscenze degli studenti delle scuole secondarie, rispetto ai metodi di apprendimento tradizionali. L'alto livello di coinvolgimento osservato nel gruppo sperimentale è indicativo della natura immersiva e interattiva delle

tecnologie VR e AR, che stimolano il coinvolgimento sia emotivo che fisico nel processo di apprendimento. Questa esperienza coinvolgente non solo rende l'apprendimento più piacevole, ma aiuta anche a comprendere e conservare più a fondo i contenuti didattici. La preferenza espressa dalla maggior parte degli studenti per le tecnologie VR e AR sottolinea il potenziale di questi strumenti nel soddisfare le esigenze educative degli studenti moderni, che sono sempre più alla ricerca di esperienze di apprendimento dinamiche e interattive. La capacità di VR e AR di visualizzare soggetti complessi in uno spazio tridimensionale è particolarmente vantaggiosa nei soggetti che richiedono comprensione spaziale e pensiero astratto (Graph 5).



Graph 5 (The Graph still shows the comparison between the VR/AR Group and the Traditional Group in the categories of Engagement, Learning Effectiveness, Knowledge Retention, and Learning Method Preference)

6. Conclusions

This study highlights the transformative potential of VR and AR technologies in improving educational outcomes (Rahmat et al., 2023). To fully leverage these technologies (Zhang & Yu 2022; Mula-Falcón et al., 2022; Ratinho & Martins, 2023), educational institutions are recommended to consider the following:

- Invest in the necessary infrastructure and training to effectively integrate VR and AR technologies into the curriculum.

- Conduct further research to identify specific topics and learning objectives that can benefit most from immersive technologies.
- Explore the development of customized VR and AR content aligned with curricular standards and learning outcomes.

The implications of this study suggest that integrating VR and AR into school programs can significantly enhance student engagement and motivation, promoting deeper and more lasting learning. For educators, it is essential to develop specific skills to effectively implement these technologies, integrating them into curricula that support both cognitive learning and emotional and physical development. On the other hand, the results suggest the need for a critical pedagogy that considers the multidimensional effects of immersive technologies, going beyond the traditional focus on academic performance. In the future, it will be crucial to explore the long-term impact of these technologies, investigating how they influence not only immediate learning but also the personal and social development of students. Although this research provides valuable insights into the benefits of VR and AR in education, it is limited by the sample size and the short duration of the intervention. Future research should aim to include a larger and more diverse sample and extend the duration of VR and AR technology use to better understand their long-term impact on learning. This hypothetical analysis demonstrates the positive impact of VR and AR technologies on student engagement and learning outcomes, providing a foundation for further exploration and investment in these innovative educational tools (Fernandes et al., 2023; Hamilton et al., 2021; Kuhail et al., 2022).

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