DISCOVERING AND INTERACTING WITH ARTWORKS USING VIRTUAL MEDIATORS

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ABSTRACT
This study investigates the potential of immersive edugames to support socio-emotional inclusion within technology-enhanced environments. Participants of different ages and backgrounds engaged with virtual rooms using Meta Quest 3S headsets, exploring and interacting with digital artworks. Two rooms displayed paintings from the XVI-XVII centuries, a third one let visitors interact with artifacts from the National Archaeological Museum of Sannio Caudino and Archaeological Museum of Carife. After the experience, participants completed a questionnaire assessing usability, perceived inclusivity and potential discomfort. Findings highlight generally positive perceptions of accessibility and engagement, alongside variability in perceived inclusiveness and discomfort. Results suggest that immersive edugames may function as affective mediators in cultural heritage contexts.

KEYWORDS
Edugames; virtual museum; inclusive education.

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1. Introduction

In today's ever-evolving world, in which technologies heavily influence the way we approach our reality, it is fundamental to address their relationship with educational ecosystems. We believe technology has always been, since the birth of humanity, a tool to change our way of living. That change has often been for better, but sometimes it has emerged as profound transformation of human life. The tools technology offers gift us with the potential to rethink our positioning in the world, our world-building, and to redefine our relationship with what has been left behind by the ones who came before us. Most of all, we think, we need to understand how new technologies redefine the relationship between learning environments, emotional engagement and social participation. It is very well documented (Radianti et al., 2020; Qian & Clark, 2016) how Virtual Reality (VR), Artificial Intelligence (AI), immersive storytelling and game-based learning are increasingly employed within pedagogical contexts to support experiential learning and inclusive educational practices; but, also, these innovative technologies very positively influence the way people learn and interact with culture. Fundamental to this framework, immersive edugames represent an extremely interesting ecosystem in which people might come in contact with present and past knowledge; they also constitute a particularly relevant field of investigation because they integrate narrative interaction, embodied cognition and emotional participation into technology-enhanced learning environments.

Neurodiversity and Special Educational Needs (SEN) are two small parts of a bigger picture that we might call "affective education" or "socio-emotional inclusion" that, in recent years, have received increasing attention in pedagogical research. The increasing use of digital environments in schools, museums and informal learning contexts has generated new questions regarding accessibility, participation and emotional mediation. In this perspective, virtual environments are not merely technological tools, but relational and symbolic spaces capable of influencing perception, motivation and identity construction. The present study engages with these themes at a theoretical level; however, it should be noted that neurodiversity and SEN

profiles were not systematically assessed among participants, and the empirical findings are therefore not directly generalisable to these populations.

The contribution is situated within the scientific framework proposed by the REN International Conference 2026, Algorithmic Heartbeats. Affective Education in the Age of the Fourth Revolution and specifically addresses the thematic area dedicated to Social Robotics and Socio-Emotional Inclusion. We want to investigate how virtual reality affects people on an emotional level when they interact with artifacts and artworks, furthermore we seek a deeper understanding of social perception and self-perception while exploring virtual rooms and observing and experiencing digital reproductions of pieces of art. Edugame experiences produce a special kind of environment that might foster a fertile cultural event for many different people, helping and supporting, as a direct effect, the diffusion and promotion of culture and knowledge.

Nowadays museums and cultural heritage institutions increasingly employ immersive technologies to facilitate and broaden public participation; they try to focus, much more than in the past, on educational accessibility and social barriers. It is Hein (2006a) that states that museums are no longer static repositories of objects, but dynamic educational arenas where the community actively construct meaning through interaction and interpretation. Similarly, Hooper-Greenhill (2013) highlights the importance of visitor-centered approaches capable of transforming museums into living ecosystems in which participation is the foundation for long-lasting learning experiences. Within these perspectives, immersive technologies offer opportunities to reconfigure the relationship between subjects and artworks, enabling multisensory experiences that can enhance emotional involvement and cognitive activation. This is one of the aspects that we want to highlight in the study that we report in our paper.

The pedagogical value of immersive technologies has already been explored in relation to virtual museums and digital cultural heritage, so we want to use recent works as a stable foundation for our research. Coppola and Zanazzi (2020) underline how immersive experiences can foster emotional engagement and support museum education through interactive and narrative dynamics. Virtual Reality environments also demonstrate potential in online and distance education, especially in terms of motivation and embodied interaction (Todino

et al., 2017). Furthermore, gamification strategies appear capable of enhancing participation and engagement through reward systems, exploration and active problem-solving (Caponetto, Earp and Ott, 2014).

From an inclusive education perspective, immersive environments may facilitate differentiated forms of participation and alternative communication strategies. Research on inclusive pedagogies emphasizes the importance of accessible and flexible educational settings capable of accommodating heterogeneous learners (European Agency for Development in Special Needs Education, 2012). Within this context, technological mediation can support emotional regulation, sensory exploration and personalized learning pathways. Studies related to augmentative and alternative communication also show how digital tools may foster inclusion and participation among students with diverse communicative needs (Galdieri, 2022).

At the same time, the integration of immersive technologies raises concerns regarding emotional overstimulation, discomfort and social alienation. This is, in fact, what we tried to measure, even though it is clear that this is just a preliminary work and our research has to go much deeper and further. VR experiences can produce both positive emotional activation and forms of sensory uneasiness depending on individual characteristics, previous technological familiarity, social and educational status, prejudice towards technology and contextual factors. Therefore, investigating users' perceptions of inclusivity, accessibility and emotional comfort or discomfort becomes essential for understanding the educational sustainability of immersive systems.

The present study explores the pedagogical implications of immersive edugames designed for cultural heritage education. Participants interacted with virtual museum rooms through Meta Quest 3S headsets. Specifically, they explored a room displaying a XVI century painting, the "St. Michael archangel" by Marco Pino da Siena; then they visited a second room in which was placed the XVI century painting "St. Orsola", a work of Filippo Vitale. Finally, participants "walked" through a virtual room displaying different artifacts originally held at the National Archaeological Museum of Sannio Caudino and in the Archaeological Museum of Carife. The research aimed to investigate:

1. the perceived accessibility and inclusiveness of immersive museum environments;
2. the extent to which edugames foster engagement and interest toward artworks;
3. participants' perceptions regarding realism, usability and educational value;
4. the potential emotional discomfort associated with immersive environments.

Furthermore, the questionnaire inquired about opinion about possible application of virtual and extended reality on everyday life and different work sectors, it also registered opinions regarding AI in relation with culture and art fruition.

The study adopts an exploratory approach grounded in educational technology and inclusive pedagogy, seeking to contribute to ongoing debates on affective education and immersive learning. Particular attention is devoted to the role of virtual environments as socio-emotional mediators capable of supporting inclusive educational experiences.

2. Theoretical Framework

2.1 Immersive learning as pedagogical mediation

To integrate immersive technologies, such as virtual reality, within educational contexts it is necessary to have a strong theoretical foundation. It is important to not interpret virtual reality as a simple digital tool but rather as a mediating device capable of transforming the relationship between learners, knowledge and experience. According to Rivoltella and Rossi (2017), didactics can be understood as a complex science concerned with the processes through which educational actions are designed, mediated and regulated. In this perspective, technologies do not represent just external supports to learning; instead, they constitute an integral dimension of contemporary educational action, participating in the construction of meaning and in the regulation of learning processes (Laurillard, 2013). In their work it is highlighted how digital environments and artifacts have become structural components of educational design and media education, that is why they should be considered as active elements and not just neutral instruments. This perspective is particularly relevant when discussing immersive virtual environments, as the ones we used in our experiments. The educational experience generated through VR is not limited to content transmission but involves the learner in an embodied interaction with digital spaces, meaning that whoever gets to explore virtual rooms can fell an almost full-body involvement during the experience. That, of course, constitute an incredible boost in learning effectiveness (Makransky &

Petersen, 2021). Learning emerges through exploration, action and situated experience, consistently with enactive approaches that interpret cognition as inseparable from bodily engagement and environmental interaction (Wilson, 2002; Johnson-Glenberg, 2018). Rivoltella and Rossi further identify mediation and regulation as central dimensions of educational action, highlighting how contemporary didactics increasingly relies on environments capable of supporting dynamic interactions between subjects, contexts and learning objectives. We find it crucial that an inclusive and effective educational framework has to rely on these digital and virtual elements. They have to be taken into account when creating educational paths, alongside more traditional methods. Within immersive environments, educational mediation becomes distributed among multiple actors: the learner, the virtual environment, the cultural content and the technological interface. Consequently, the concept of virtual mediator adopted in this study refers to the ability of immersive environments to facilitate emotional, cognitive and relational engagement through interactive experiences, so that is what we measured during our study. The educational significance of this mediation process becomes particularly evident in museum education, where visitors are encouraged to actively construct interpretations rather than passively receive information. Immersion therefore transforms educational interaction into a process of situated meaning-making in which knowledge emerges through exploration and experience (Hamilton et al., 2021).

2.2 Museums as inclusive learning ecosystems

The contemporary museum is increasingly recognized as an educational institution whose mission extends beyond conservation and exhibition (Simon, 2010). According to Hein (2006a), museums are environments where visitors actively construct meaning through interaction with cultural artifacts (Falk & Dierking, 2013). Similarly, Hooper-Greenhill (2013) emphasizes the shift from object-centred to visitor-centred museum models, highlighting the importance of participation and engagement. We should also consider that museums should be interpreted simultaneously as cultural, scientific and educational institutions capable of promoting access to knowledge and fostering social participation. Museums are therefore described as places where knowledge and imagination converge, generating meaningful experiences that connect individuals with cultural heritage and collective memory (Todino 2024).

From a social perspective, one of the major challenges faced by museums concerns the phenomenon of cultural self-exclusion. Many individuals perceive museums as inaccessible spaces that are distant from their experiences, knowledge or social identities. That is why museum education is becoming more important as communities grow more complex and nuanced, as this

phenomenon continues to affect large portions of the population and can only be addressed through systemic collaborations among schools, universities and cultural institutions, both on small and large scales. This necessity helps us better understand the importance of local entities like the De Chiara De Maio Foundation, our partner in this study, who promote art as a whole, new emerging artists and art reflection in its relationship with today's issues like AI and digital transformation. The theme is particularly relevant when considering learners with Special Educational Needs and neurodivergent profiles. Traditional museum settings may unintentionally generate barriers related to communication, sensory processing, social interaction or previous educational experiences. Consequently, accessibility should not be understood merely as physical accessibility but also as cognitive, emotional and cultural accessibility. Immersive technologies offer new opportunities to address these challenges and make an impact. Virtual museums allow visitors to engage with artworks and artifacts through flexible, self-paced and multimodal interactions. By reducing environmental constraints and enabling personalized pathways, immersive environments may foster greater participation and emotional safety. That is what we want to explore and push forward with our research. In this perspective, virtual museums can be interpreted as inclusive learning ecosystems where cultural heritage becomes accessible through differentiated modes of engagement. Such environments may contribute to reducing self-exclusion while promoting participation among audiences traditionally underrepresented within museum contexts.

2.3 Edugames, multimodality and socio-emotional inclusion

The growing diffusion of edugames reflects a broader transformation in educational paradigms, characterized by increasing attention to engagement, personalization and experiential learning (Plass, Mayer & Homer, 2020). Gamification strategies draw their strengths in supporting motivation through exploration, feedback mechanisms and active participation. Immersion is a key element to engage meaningfully with games, that is why creators will go at great lengths to establish characters and narratives that captivate gamers as much as possible, they invest a lot of resources on world-building to let players feel like a living part of those worlds. Within immersive environments, these characteristics are clearly amplified by the possibility of embodied interaction and spatial exploration (Caponetto, Earp and Ott, 2014).

Technologies such as virtual reality, edugames and 3D digital assets provide opportunities to move beyond the linearity traditionally associated with educational experiences. Drawing upon Sibilio's reflections on semplessity and adaptive educational trajectories, immersive technologies allow learners to follow individualized pathways consistent with their cognitive styles and

learning needs (Sibilio, 2014). Alongside this aspect it is important to highlight how multimodality becomes, at this point, an important contribution for the inclusive education perspective. It enables users to access information through multiple channels simultaneously, integrating visual, spatial, auditory and interactive dimensions, following the guidelines that were described before. Such flexibility may facilitate participation among learners with heterogeneous cognitive profiles and different sensory preferences.

Traditional museum education often relies heavily on linguistic mediation, whereas immersive technologies expand opportunities for engagement through multisensory interaction. It is the next step for museum education to transform knowledge production, conservation and sharing. Virtual environments therefore broaden access to cultural content while promoting curiosity and active participation (Carci, Caforio & Gamper, 2019). The educational value of immersive edugames can also be interpreted through Flavell's concept of metacognition. Interactive environments encourage learners to monitor their actions, evaluate exploration strategies and regulate decision-making processes. These metacognitive dimensions contribute to the development of self-awareness and autonomous learning behaviours (Flavell 2024). Consequently, immersive edugames may function simultaneously as cognitive mediators, emotional mediators and social mediators. Through exploration and interaction, users establish personal relationships with cultural artifacts, generating experiences that combine learning, emotional engagement and identity construction.

2.4 Neurodiversity, affective technologies and emotional accessibility

New perspectives on the way learning environments are designed are paving the way for a better and more inclusive approach to neurodiversity within educational research. Rather than focusing exclusively on deficits or limitations, neurodiversity frameworks emphasize the value of cognitive differences and advocate for educational ecosystems capable of accommodating diverse ways of perceiving, processing and interpreting reality (Pellicano & den Houting, 2022). It is becoming more and more important to shift the focus from a problem-centred perspective to an accessible-designed mindset (CAST, 2018). Within this perspective, socio-emotional inclusion becomes a fundamental dimension of educational equality. Inclusive environments should support not only access to content but also emotional well-being, self-efficacy and participation.

Immersive technologies possess distinctive characteristics that may facilitate emotional accessibility. The possibility of controlling interaction rhythms, reducing social pressure and engaging in autonomous exploration may create psychologically safe conditions for participation. Moreover, virtual

environments can provide alternative communicative channels that complement traditional verbal mediation. It seems particularly relevant, at this point, the notion of affective mediation. Indeed, social robotics research focuses, most of the time, on embodied artificial agents capable of supporting emotional development, but immersive environments may perform analogous functions through virtual mediation. The educational experience itself becomes an affective agent capable of stimulating curiosity, reducing anxiety and fostering engagement. However, immersive systems may also generate sensory overload, cybersickness or emotional discomfort. Therefore, socio-emotional inclusion requires careful design choices that balance immersion with usability, personalization and emotional regulation. This is another important factor that we try to measure in our research. From this perspective, virtual museum edugames can be interpreted as emerging affective technologies capable of supporting inclusive participation through the integration of cultural heritage, emotional engagement and embodied interaction.

3. From Hein's Constructivist Museum to the Definition of Guidelines for Designing VR Experiences for Museum Education

Dewey's reflections (1937; 2024) and the subsequent systematization by Hein (1999), theorizing the "constructivist museum" model, offer a solid epistemological framework for the design of three immersive virtual experiences. These environments have been structured to operationally translate precise guidelines deducible from the constructivist paradigm. In the first instance, Hein's perspective demands the abolition, at least in a symbolic key, of those physical barriers and behavioral prescriptions that, although necessary for the preservation of artifacts, generate an emotional and experiential distance in the observer. The virtual transposition configures itself as an ecological alternative capable of overcoming such constraints. Assuming the effectiveness of the virtual representation of the real object, the design must focus on technical choices apt to optimize the level of digital fidelity. This intermodal field represents a ground of selection for academic research laboratories, capable of activating Technology Transfer processes toward institutions, such as Schools and Museums, whose institutional purposes do not primarily include scientific research applied to technologies. The high-precision acquisition of the morphological and material data of the work does not respond to a mere aesthetic imperative of philological restitution of the artist's gesture, but rather intercepts the cognitive needs of a student public immersed in digital languages. The assets thus digitized acquire the characteristics of permanence and social accessibility sanctioned by modern definitions of

museum institutions, configuring themselves as non-profit goods at the service of the collectivity. However, the mere virtual duplication of the object does not guarantee the activation of constructive learning processes; the artifact must be capable of being traced back to its original contextual matrix. Consider, by way of example, the epistemic gap between the decontextualized fruition of a vase from Magna Graecia inside a display case and the reconstruction of the interaction of use of the same object during a classical symposium. In the first case, the observer experiences a deprivation of the artifact's native affordances and functionalities. VR design therefore aims to recodify those sensorimotor interactions capable of restoring situated meaning to the object. Such an orientation highlights the role of the virtual environment as a didactic mediator facilitating the processes of multifocal access to knowledge (Bilotti et al., 2025). Immersive technologies, by allowing a high embodied (bodily and motor) involvement, configure themselves, in analogy with the laboratory practices of the constructivist museum, as "warm mediators" (Damiano, 2013). Compared to other nonetheless relevant technologies such as Augmented Reality (AR), immersion in virtual environments entirely created by computer allows greater control at multiple levels: from the creation of original settings up to the configuration of audio-visual settings (Campitiello et al., 2023), this structural plasticity constitutes the cardinal prerequisite for educational inclusion. Design and development of such virtual experiences must therefore be conceived as suggested by Universal Design for Learning (Todino, 2025), never for an ideal or standardized public, but rather for a multitude of cognitive singularities, each of these having a personal learning style as a direct consequence. In the final analysis, coherently with Hein's warning (Hein, 2006b), the museum experience in VR must trigger a virtuous circle made of applicative outcomes, albeit minimal, in our daily lives and the search for new analogous experiences. This therefore translates, already in the design phase of virtual museum education experiences, into environments potentially graftable into other formal and non-formal learning places with the necessary adjustments.

Constructivist museum characteristics	**VR Museum Education Experiences Guidelines**
Permanence	Digitization of objects and activities
Open Access	

Availability for Society	
Availability for Research	
Interpretability	Designing activities and interactions capable of accessing multiple levels of knowledge of the object
Inclusivity	Designing activities and interactions accessible to a heterogeneous public
Promotion	Activities capable of being integrated into external formal and non-formal educational contexts

4. Description of the experiences

The three designed virtual experiences are structured within an integrated immersive environment, developed using the Unity game engine. Specifically, the first two rooms are dedicated to the decomposition and interactive analysis of two historical-artistic paintings: the *Saint Michael the Archangel* by Marco Pino da Siena and the *Martyrdom of Saint Ursula* by Filippo Vitale. In the third room, the student or visitor can interact with the virtual representations of several archaeological artifacts from the Archaeological Museum of Sannio Caudino and the Archaeological Museum of Carife.

Within the rooms dedicated to painting, the software architecture is designed to foster multiple levels of in-depth study and cognitive scaffolding. Through an interactive user interface system, users have the dual possibility of isolating the individual figures that make up the scene and activating a philological reconstruction of the background, thereby isolating or highlighting the visual elements with the highest symbolic density. In the case of Vitale's work, the opportunity to benefit from close proximity allows for a macroscopic exploration of expressive and formal details which, as noted in the literature (De Luca, 2022), ideally refer to the luministic dramaturgy of the late

Caravaggio, author of the homonymous subject preserved at Palazzo Zevallos Stigliano in Naples. Similarly, within the environment dedicated to Marco Pino, interactive input enables the visual segmentation of specific groups of characters, such as the two hosts of the damned; furthermore, isolating the primary anthropomorphic action causes environmental elements otherwise merged into the overall composition to emerge, such as the marsh, the river, the city in flames, and the imposing central mandorla light. Investigated in its dual archetypal value of a protective shell and a generating seed, the latter is thus revealed in its function as a signifier of the immortality of the Christian message (De Luca, 2017). Conversely, the third room introduces a collection of three-dimensional digital replicas derived from 3D scanning processes of original archaeological artifacts and subsequently optimized using geometric modeling software. Interaction with these digital assets aims to restore, albeit within a virtual dimension, the affordances and anthropological meaning tied to their native functionality. Indeed, the selection of vases is resignified within the socio-cultural ritual of the symposium, an element of continuity among the Greek, Samnite, and Roman civilizations.

5. Method

5.1 Study design

This study employed a cross-sectional, exploratory design. No control group, randomisation or pre-test was included. The primary aim was to describe participants' perceptions of accessibility, usability and emotional comfort following a single exposure to the immersive edugame experience. Given the exploratory nature of the study, no hypotheses were tested and no inferential analyses were conducted.

5.2 Participants and recruitment

Participants were recruited through convenience sampling at public events organised by the De Chiara De Maio Foundation in three Italian locations: the Lineapelle Expo in Milan, the Frusciano Palace in Salerno, and the Foundation's gallery in Solofra. Attendance at these events was open to the general public. All individuals present were invited to try the immersive experience; those who completed it were subsequently asked to fill in the questionnaire voluntarily.

A total of 79 participants completed the questionnaire. No formal inclusion or exclusion criteria were applied beyond willingness to participate and the ability to wear the head-mounted display. No data on disability, neurodiversity or Special Educational Needs (SEN) were formally collected as part of the study

protocol, although some participants spontaneously disclosed relevant personal information during the sessions. The convenience nature of the sample limits the generalisability of the findings.

5.3 Procedure and duration

Each participant individually wore a Meta Quest 3S head-mounted display and was guided through three virtual rooms in a fixed sequence. The estimated duration of the complete immersive experience ranged from approximately 10 to 20 minutes, depending on the individual pace of exploration. No time limit was imposed. A researcher was present throughout each session to assist with device fitting and to answer technical questions; no guidance on content interpretation was provided during the experience itself.

Following the immersive session, participants were invited to complete an anonymous self-report questionnaire (see §5.4). Participation was entirely voluntary and no incentives were offered. Participants were informed that their responses would be collected anonymously and used for research purposes. Given the anonymous and non-interventional nature of data collection, no formal ethics committee approval was required under the applicable institutional procedures; nonetheless, all standard principles of research ethics were observed, including informed consent, data anonymisation and the right to withdraw at any stage.

5.4 Instrument

Data were collected using a self-report questionnaire developed ad hoc by the research team and administered via Google Forms in both Italian and English, allowing participants to choose their preferred language. The questionnaire was not previously validated and should be regarded as an exploratory instrument.

The instrument comprised three sections. The first section (7 items) addressed participants' perceptions of the immersive experience with respect to realism, accessibility, engagement, accuracy, educational value, usability, and willingness to recommend the experience. Responses were provided on a 5-point Likert-type scale ranging from 1 (very negative/strongly disagree) to 5 (very positive/strongly agree). The second section (6 items) collected participants' opinions on the potential societal impact of virtual reality and artificial intelligence; these items used varied response formats including categorical scales and comparative judgements. The third section collected

socio-demographic information (age group, gender and educational level). No learning outcomes were assessed and no validated psychometric instruments were employed.

6. Results

To gain data about the experience, participants completed a questionnaire that was created using Google Forms. It was written both in Italian and in English, so every participant could choose between the two languages.
The questionnaire is structured in three different sections: the first one inquired about the experience itself and its levels of accessibility and inclusiveness, the second one asked about the perception of Virtual Reality and Artificial Intelligence in relation to society and their own work sectors, the last one collected data about age, education level and known languages.
All participants took the questionnaire voluntarily and knowing that it collected information anonymously.
Most of the data was collected with the help of the De Chiara De Maio Foundation, thanks to their hospitality during their events organized in Milan at the Lineapelle Expo, in Salerno at the Frusciano Palace and in Solofra in their gallery.

6.1 Participants' age and education

A total of 79 participants completed the questionnaire after the immersive experience. The sample was characterized by substantial heterogeneity in terms of age and educational background. The largest age group consisted of participants between 20 and 35 years old (43.0%), followed by participants younger than 20 years (27.8%). Participants aged between 35 and 50 years represented 16.5% of the sample, while individuals older than 50 years accounted for 12.7%. Regarding gender, 55.7% of respondents identified as male, 39.2% as female and 5.1% preferred not to disclose this information.
Educational attainment was similarly diverse. The most represented category was participants holding a high-school diploma (31.6%), followed by middle-school graduates (17.7%), master's degree holders (16.5%) and bachelor's degree holders (15.2%). Smaller groups included participants with doctoral degrees (5.1%), postgraduate master's qualifications (7.6%), elementary education (3.8%) and individuals without formal qualifications (2.5%).

The heterogeneity of the sample was considered particularly relevant for assessing the perceived inclusiveness and accessibility of immersive museum environments across different educational and demographic profiles.

6.2 Perceived realism, accessibility and educational value

Overall evaluations of the immersive experience were highly positive. The realism of the virtual environment obtained a mean score of 3.91/5 (SD = 0.83), suggesting that participants generally perceived the virtual rooms as believable and coherent environments capable of supporting exploration and interaction.

Inclusiveness and accessibility had some of the highest scores. Indeed, participants rated the virtual environments with a mean score of 4.03/5 (SD = 0.92), meaning that the immersive experience was perceived as broadly accessible regardless of users' backgrounds and previous technological experience. Although it might be expected that younger participants would be more familiar with VR interfaces, the data do not allow for subgroup comparisons; no analyses were conducted to examine potential differences across age groups.

Similarly positive evaluations emerged regarding engagement with artworks. The statement investigating whether the edugames encouraged involvement and interest in the exhibited artworks obtained a mean score of 3.95/5 (SD = 0.99). These findings suggest that the game-based structure successfully promoted active participation and curiosity toward cultural heritage, even though few people further inquired about the project or the artworks displayed. Generating an active involvement about virtual reality and art conservation could be at the centre of a future project.

The highest score among the educational indicators concerned the perceived accuracy and reliability of the experience (M = 4.15/5; SD = 0.86). Participants therefore tended to trust the information and representations provided within the virtual museum environments.

The item investigating support for scientific and artistic learning obtained a mean score of 3.99/5 (SD = 0.94), indicating that users generally considered the immersive environments effective educational tools capable of facilitating understanding and knowledge acquisition. Future works could compare virtual reality learning with traditional textbook education, following, of a course, a much more detailed rendition of the artworks and an innovative way of highlighting motives, details and techniques related to those art objects.

Descriptive statistics are summarized in Table 2. As shown, all evaluated dimensions obtained mean values close to or above 4 points on a 5-point Likert scale, indicating an overall positive perception of the immersive experience.

Table 2: Full distribution of responses to the perceived experience items (5-point Likert scale: 1 = very negative / strongly disagree, 5 = very positive / strongly agree; n = 79)

QUESTION	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	M	SD
How realistic do you think it was the space you explored?	0 (0.0)	1 (1.3)	28 (35.4)	27 (34.2)	23 (29.1)	3.91	0.83
How inclusive and accessible do you think it was the virtual space you visited?	1 (1.3)	3 (3.8)	17 (21.5)	30 (38.0)	28 (35.4)	4.03	0.92
How much do you think the edugames encouraged your involvement and interest in the artwork you saw?	1 (1.3)	6 (7.6)	16 (20.3)	29 (36.7)	27 (34.2)	3.95	0.99
How accurate and reliable was your visit?	0 (0.0)	3 (3.8)	15 (19.0)	28 (35.4)	33 (41.8)	4.15	0.86
How satisfied are you about the way the context supports scientific and artistic learning and comprehension?	1 (1.3)	3 (3.8)	20 (25.3)	27 (34.2)	28 (35.4)	3.99	0.94
How easy was for you interacting with the virtual space?	2 (2.5)	4 (5.1)	22 (27.8)	18 (22.8)	33 (41.8)	3.96	1.07
Would you recommend other people to visit virtual museums?	1 (1.3)	5 (6.3)	9 (11.4)	23 (29.1)	41 (51.9)	4.24	0.98

6.3 Usability and interaction

Ease of interaction was evaluated positively, with a mean score of 3.96/5 (SD = 1.07). Although the variability observed was slightly higher than in other dimensions, the results indicate that most participants were able to interact with the immersive environment without substantial difficulties.

The relatively low level of interactional barriers is particularly significant from an inclusive education perspective. The possibility of autonomously navigating virtual spaces and directly interacting with cultural artifacts appears to have contributed to the overall positive perception of accessibility. No data on disability, neurodiversity or Special Educational Needs (SEN) were systematically collected in the present study, and no conclusions can therefore be drawn regarding the inclusiveness or effectiveness of the immersive environments for these populations. Some participants spontaneously disclosed relevant personal information during sessions, but such anecdotal observations do not constitute systematic evidence and should not be interpreted as such. Future research should examine the potential of immersive edugames within populations characterised by diverse cognitive, sensory and

communicative profiles, employing validated instruments and purposive sampling strategies.
These findings support previous research emphasizing the role of intuitive interfaces and embodied interaction in facilitating engagement within virtual learning environments (Sheehy et al., 2019).

6.4 Recommendation and acceptance of virtual museums

Participants expressed a particularly favourable attitude toward virtual museums. The item assessing willingness to recommend the experience to other visitors obtained the highest mean score among all evaluated dimensions (M = 4.24/5; SD = 0.98).
This result suggests that the immersive environments generated a generally positive user experience and were possibly perceived as valuable educational resources. The high recommendation rate may also indicate a growing acceptance of virtual museums as complementary educational spaces capable of expanding access to cultural heritage.
From a pedagogical perspective, this finding is particularly relevant because it suggests that immersive technologies may facilitate forms of participation capable of attracting audiences who might otherwise experience difficulties accessing traditional museum contexts (Hooper-Greenhill, 2013; Sheehy et al., 2019).

6.5 Emotional responses and socio-technological concerns

Despite the overall positive evaluations, participants expressed more nuanced opinions regarding the broader social implications of virtual environments and artificial intelligence.
Responses concerning possible negative societal effects of virtual environments and AI revealed heterogeneous attitudes. While many participants showed curiosity and openness toward technological innovation, others expressed moderate levels of concern regarding its future impact on society and individuals.
A similar variability emerged in responses related to emotional discomfort. Most participants reported little or no uneasiness during the immersive experience; however, a smaller subgroup reported moderate discomfort or uncertainty. These results suggest that immersive environments are not perceived uniformly and that individual differences continue to play a significant role in shaping emotional responses to virtual experiences. It should

be further investigated what may cause discomfort during the session or, at least, if pre-existing bias hinders the experience from the start.

Interestingly, qualitative comments and comparative evaluations indicated that the virtual museum was generally perceived as more reassuring than disturbing when compared with other virtual environments previously experienced by participants. Furthermore, many respondents considered the immersive experience capable of complementing rather than replacing traditional museum visits.

Additional analyses focused on participants' socio-emotional perceptions concerning immersive technologies and artificial intelligence (Table 3). The findings reveal a generally positive emotional response to the experience. In particular, 59.5% of participants reported no feeling of uneasiness while exploring the virtual environment, whereas only a small minority indicated high levels of discomfort.

Responses regarding how virtual environments might impact on society in general showed relatively low levels of concern. Approximately 30.8% of respondents (n = 24 out of 78) declared that they were not afraid of possible negative social consequences associated with virtual environments, while concerns tended to be moderate rather than extreme.

A different pattern emerged regarding artificial intelligence. The most frequent response (37.2%, n = 29 out of 78) indicated a moderate level of concern that AI may generate negative consequences for society. The questionnaire did not specify what kind of consequences those might be to not overcomplicate the data gathering phase, but this could be the subject of further investigation. Furthermore, 34.2% of respondents reported being more concerned about the increasing diffusion of AI than about other technological innovations.

When comparing the immersive museum with other virtual environments previously experienced, participants most frequently reported a neutral perception (32.9%), although a substantial proportion considered the environment more reassuring than previous virtual experiences. Similarly, when compared with real museum visits, the most frequent response was neutrality (43.0%), while positive evaluations outweighed negative ones.

These findings suggest that the immersive museum experience was generally perceived as emotionally safe and reassuring. At the same time, participants expressed a degree of critical awareness regarding the broader societal implications of artificial intelligence and digital technologies.

Table 3: Full distribution of responses to the socio-emotional and attitudinal items.

QUESTION	RESPONSE OPTIONS	N	%
Are you afraid virtual spaces may have negative effects on society? *(n = 78)*	Not at all	24	30.8
	A little	20	25.6
	Quite a lot	20	25.6
	A lot	0	0.0
	Very much	0	0.0
Are you afraid artificial intelligence may have negative effects on society? *(n = 78)*	Not at all	12	15.4
	A little	15	19.2
	Quite a lot	29	37.2
	A lot	0	0.0
	Very much	0	0.0
How preoccupied are you about AI compared to other technological innovations? *(n = 79)*	Not at all concerned	12	15.2
	Less concerned than for other technologies	10	12.7
	Indifferent	19	24.1
	Slightly more concerned than for other technologies	27	34.2
	Much more concerned than for other technologies	11	13.9
Have you felt uneasiness in the virtual space you just explored? *(n = 79)*	Not at all	47	59.5
	A little	13	16.5
	Quite a lot	10	12.7
	A lot	0	0.0
	Very much	0	0.0
How disturbing or reassuring vs other virtual spaces visited in the past? *(n = 79)*	Much more disturbing	2	2.5
	A little more disturbing	10	12.7
	Indifferent	26	32.9
	A little more reassuring	10	12.7

	Much more reassuring	15	19.0
	I wouldn't know	16	20.3
How disturbing or reassuring vs real museum visits in the past? *(n = 79)*	Much more disturbing	6	7.6
	A little more disturbing	12	15.2
	Indifferent	34	43.0
	A little more reassuring	17	21.5
	Much more reassuring	10	12.7
	I wouldn't know	0	0.0

6.6 Synthesis of findings

Taken together, the results suggest that immersive museum edugames were perceived as:

- accessible and inclusive (M = 4.03/5);
- educationally valuable (M = 3.99/5);
- reliable and accurate (M = 4.15/5);
- engaging for cultural heritage exploration (M = 3.95/5);
- easy to use (M = 3.96/5);
- highly recommendable (M = 4.24/5).

The overall pattern of responses supports the hypothesis that immersive edugames may function as effective pedagogical mediators capable of promoting engagement, accessibility and socio-emotional participation within cultural heritage contexts. At the same time, the variability observed in emotional reactions highlights the importance of designing virtual environments that remain sensitive to individual differences and diverse accessibility needs (Immordino-Yang, 2016). Whether these findings extend to neurodivergent learners or those with SEN remains an open empirical question that future research should address systematically.

7. Conclusion

This study explored participants' perceptions of immersive virtual museum environments designed as edugames and experienced through head-mounted virtual reality devices. The findings indicate that participants generally perceived the environments as accessible, usable and engaging, while expressing more varied opinions regarding emotional comfort and the broader societal implications of virtual reality and artificial intelligence. Given the

exploratory design, the convenience sample and the use of a non-validated instrument, the conclusions that follow are strictly limited to what was directly measured: participants' self-reported perceptions of the experience.

From a descriptive standpoint, evaluations across all dimensions were positive, with mean scores ranging from 3.91 to 4.24 on a 5-point scale. These results suggest a generally favourable reception of the immersive environments among the participants who took part in the study. However, the absence of inferential analyses means that no conclusions can be drawn regarding the absence of differences across age groups, gender or educational backgrounds; the observed variability in scores does not constitute evidence of equivalence across subgroups.

The virtual environments appeared to function as mediators between visitors and cultural content, supporting exploratory interaction and personal engagement with the exhibited artworks. The positive evaluations obtained in relation to usability and perceived accessibility suggest that immersive technologies may reduce some of the barriers traditionally associated with cultural participation. These findings, however, concern perceived accessibility only and cannot be extended to claims about learning outcomes or educational effectiveness, which were not assessed in the present study.

An interesting pattern emerged from the comparison between perceptions of the immersive environment and perceptions of artificial intelligence (Table 3). While participants expressed moderate concern regarding the societal implications of AI, the virtual museum itself was largely perceived as emotionally safe and reassuring. This finding aligns with perspectives on affective mediation suggesting that well-designed immersive environments may reduce resistance toward digital innovation by providing controlled and engaging experiences.

It should be explicitly noted that no data on disability, neurodiversity or Special Educational Needs were systematically collected in this study. Consequently, no conclusions can be drawn regarding the inclusiveness or effectiveness of the immersive environments for neurodivergent participants or learners with SEN. Some participants spontaneously disclosed relevant personal information during sessions, and informal observations suggested a positive reception; however, such anecdotal evidence does not constitute systematic evidence and should not be interpreted as such.

Future research should investigate these dynamics through larger, purposively sampled groups, with particular attention to participants with SEN and neurodivergent profiles, employing validated instruments and standardised

procedures. Longitudinal studies could examine the impact of repeated exposure on motivation and socio-emotional development. Further inquiry may also address the sources of discomfort reported by a minority of participants, including possible links to the Uncanny Valley effect and individual differences in cybersickness susceptibility.

More edugames are currently in development, some following the same structure as those described in this study and displaying additional artworks (such as the *Rape of Europa* vase from the Archaeological Museum of Sannio Caudino and an etching by Pablo Picasso on the same mythological subject) while others will adopt different architectures and display different types of cultural objects. One project in early production will recreate an Italian tannery from the early twentieth century, complete with its machinery and artisans at work.

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