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Constructing Geographical Knowledge through On-Site, Immersive, and Digital Exploration: A Comparative Study in a Multicultural Neighbourhood

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Abstract

This paper presents a comparative study examining how different modes of territorial interaction shape the construction of geographical knowledge. Conducted in May 2025, the research compared three approaches to exploring Milan's Sarpi-Chinatown multicultural neighbourhood: an on-site field visit, immersive Virtual Reality (VR) exploration with instructor-guided avatars, and webGIS-based navigation. While geospatial and Extended Reality technologies expand access to geographical information, technological mediation actively configures spatial experience, raising pedagogical questions about the capacity of digital tools to convey the multisensory richness of place. The findings reveal distinct epistemological affordances across modalities. On-site field visits fostered deeper multisensory engagement and embodied spatial understanding. VR supported spatial orientation and collaborative exploration but privileged visual perception. WebGIS proved particularly effective for analytical reasoning across scales, while tending to abstract territorial complexity. Rather than positioning these approaches as alternatives, the study conceptualizes them as complementary. Their integration – combining physical field experience, immersive virtual environments, and digital analytical tools – supports richer geographical learning and provides empirically grounded insights for epistemologically informed uses of technology in geography teacher education.

Keywords: Geographical Knowledge, Spatial Thinking, Geographical Education, Field Visit, Extended Reality, Virtual Reality, WebGIS, Multicultural Neighbourhood

1. Introduction

Direct observation of the territory has always constituted one of the foundations of the geographical method. Consequently, the field visit represents a crucial practice for the teaching of geography, as it allows students to engage directly with geographical phenomena, to develop skills of spatial observation, and to recognise the complexity and multiscalarity of territorial processes (Kent et al., 1997; Fuller et al., 2006).

Over the past two decades, the evolution of geospatial technologies and immersive virtual environments has progressively expanded and diversified the modes of geographical observation in educational contexts. WebGIS[1] (for example, OpenStreetMap, Google Maps, Google Earth, etc.) have simplified and democratised access to geographical, cartographic and remote sensing data and information, making it possible to explore territory without logistical, economic or temporal constraints. At the same time, virtual reality (VR) and augmented reality (AR) environments are gaining ground in geographical research and teaching practice, promising new forms of engagement with spatial experience and levels of immersivity that were unthinkable until a few years ago (Innocenti, 2025). This "digital turn" in geography (Ash et al., 2018) has led to questions about the ways in which technologies modify not only access to space, but also the very ontology of space itself.

Technological mediation does not, in fact, constitute a neutral process of information transmission but represents a cultural practice that actively shapes geographical experience. Digital tools – from webGIS interfaces to visualisation algorithms, from the navigation patterns of VR headsets to modes of cartographic representation – incorporate design choices, hierarchies of relevance, perceptual filters and interpretative frames that influence the gaze, select what is visible and invisible, and construct implicit narratives of territory (Walshe and Healy, 2021). In this sense, technology is never merely a "container" or "vehicle" for geographical content, but actively participates in the production of spatial meanings and in the configuration of territorial experience. In terms of learning, it becomes important to carefully assess the extent to which spatial representation technologies can capture and convey the multisensory richness of territory. Furthermore, it is relevant to understand which cognitive and emotional consequences derive from the reduction of geographical experience to the solely visual or audio-visual dimension offered by immersive technologies. This is clearly not a merely technical debate, but a profoundly pedagogical and epistemological one, which questions the very nature of geographical knowledge and the conditions of its production.

This contribution arises from the need to propose some experimental activities that can collect elements for reflection that may help to address, at least partially, these questions. It is based on a comparative study conducted with three different groups of students enrolled in the degree course in Primary Education at the Università Cattolica del Sacro Cuore, at the Milan and Brescia campuses. The research, carried out in May 2025, involved a field visit aimed at exploring the Sarpi-Chinatown district of Milan, with the objective of investigating how geographical processes such as multiculturalism, gentrification, touristification and urban regeneration are read, understood and represented by observers who access urban space through radically different modalities. Each of the three groups of students involved, in fact, employed different forms of territorial observation, namely a traditional on-site field visit, an immersive experience in a virtual environment with a teacher avatar acting as a shared guide, and a non-immersive experience through interactive digital content of a webGIS type.

This article presents empirical evidence on the cognitive processes and geographical competences involved in exploring a multicultural neighbourhood. It examines which of these can be most effectively investigated and developed through digital technologies for the visualization of and interaction with geographic information, which of these necessarily require the sensory and embodied experience of physical presence in the field, and how these different modes of knowing the territory can mutually enrich one another within a framework of pedagogical complementarity. From this point of view, the project idea underpinning the research is not simply to "replace" a traditional guided visit with a virtual immersive tour, following a logic of mere technological substitution, but rather to provide conditions for a collaborative experience in a VR environment capable of simulating a field visit. This should

[1] WebGIS are GIS applications that allows users to navigate and query a map through a standard web browser.

lay the foundations for a genuine epistemological and pedagogical redefinition of geographical learning in the digital era, contributing to the debate on the "hybridisation" of geographical education (blended learning, hybrid geographies, multimodal geography education: Bednarz et al., 2013; Rhys et al., 2020; Walshe and Healy, 2021) and providing guidance for teacher education, particularly with regard to the conscious and epistemologically grounded use of technologies in the teaching of geography.

The article is structured as follows: the next paragraph defines the theoretical framework of the study; the following section explains the methodological approach, the working hypotheses and the research conducted. The article concludes by discussing the results and reflecting on the potential of a didactic perspective that combines, in a complementary manner, on-site territorial study and Extended Reality technologies.

2. Theoretical framework

2.1. Spatial thinking and embodied cognition

From a disciplinary perspective, the theoretical framework of this research draws on developments in contemporary human geography, which conceives space not as a neutral container or a surface to be mapped, but as a social construction continuously renegotiated through corporeal, narrative and technological practices (Minca, 2022). According to this theoretical approach, geographical perception, far from being a mere passive registration of external stimuli, constitutes an active process of meaning-making in which body, memory, emotions, social relations and technological devices intertwine in complex and situated configurations (Rodaway, 1994). In fact, the paradigm of embodied cognition argues that cognition is not an abstract and disembodied process, but is fundamentally rooted in bodily experience and in sensory-motor interaction with territory (Butcher, 2012). Applied to geography, this theoretical framework suggests that spatial knowledge emerges from the multisensory integration of visual, auditory, olfactory, tactile and kinaesthetic information, all of which are fundamental to the construction of a *sense of place and belonging* (Tuan, 1977; Minca, 2022). Within a perspective of active citizenship, this aspect is particularly relevant in multicultural spaces, where sensory markers contribute to the construction of *place identity* and to the perception of the "invisible boundaries" that structure urban life.

From a pedagogical perspective, the didactic experimentation carried out in this study is situated within the tradition of some of the main learning paradigms. First, *cognitivism*, which conceives the acquisition of knowledge as an active, situated and goal-oriented process, giving centrality to complex cognitive processes such as critical thinking and problem-solving (Anderson, 1983). Second, *constructivism*, according to which students must be actively involved in the construction of subjective representations of reality (Vygotsky, 1978). Third, *experiential learning*, in which practical (hands-on) experience and use of analytical skills serve to foster reflection and to bring about changes in judgement, feelings or competences (Kolb, 1984).

Having established these necessary premises with regard to the present research, the development of spatial thinking (Bednarz et al., 2013) is inevitably shaped by the affordances and constraints of the technological tools employed, which do not merely "show" territory but actively construct specific versions of it, emphasising certain dimensions (typically visual and metric ones) at the expense of others (olfactory, tactile, relational). In the literature, the qualitative impact of these technological mediations on the geographical knowledge remains largely unexplored, particularly in its multisensory, emotional, and relational dimensions. For this reason, it becomes crucial to question how Extended Reality technologies may mediate, integrate or transform the embodied and multisensory experience of geographical knowledge.

2.2. Spatial thinking Extended Reality and immersive modalities in geographical education

Within the landscape of new technologies applied to geographical education, Extended Reality (XR) encompasses a broad range of immersive modalities: Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR). All these modalities share the aim of enriching the learning experience through advanced forms of digital mediation and are positioned along the so-called reality–virtuality *continuum* proposed by Milgram and Kishino (1994). Along this *continuum*, it is possible to distinguish different degrees of integration between the physical world and digital content, and the boundaries between these categories are increasingly blurred today, due to the continuous evolution of applications and devices.

With VR, the user is fully immersed in a three-dimensional digital environment and experiences a strong sense of "presence" within the simulated world (Radianti et al., 2020). Research in human geography has highlighted the potential of VR for developing spatial competences and *geographic literacy* through immersive experiences. Recent studies (Stainfield et al., 2000; Cöltekin et al., 2020) have shown how virtual field visits can effectively complement traditional field visits, particularly when these are not feasible due to logistical or economic constraints. VR fosters experiential learning and conceptual understanding of geographical processes through active interaction via controllers or haptic devices, making environments dynamic and manipulable. Research conducted in educational contexts (Daniele, 2022; Freina and Ott, 2015; Radianti et al., 2020) has also emphasised how VR can enhance student motivation and facilitate processes of simulated inquiry, allowing the observation of geographical phenomena at spatial and temporal scales that would otherwise be difficult to access. However, the geographical literature has also raised concerns about the epistemic quality of virtual experience: some scholars have pointed out that reducing geographical experience to a visual–auditory dimension entails a significant loss of multisensory information that is crucial for a holistic understanding of territory. Therefore, the debate centres on the extent to which VR can replicate or integrate the *embodied knowledge* that characterises direct experience of place (Bos, 2024; Paterson, 2009).

At the opposite end of the *continuum* lies AR, which does not replace the real world but enriches it by overlaying georeferenced digital elements onto the perceived physical environment. AR enables new modes of critical reading of the landscape, transforming it into a kind of "augmented map" that allows invisible informational layers to be superimposed (geographical processes not directly observable, historical reconstructions, etc.). Geographical research has highlighted how AR can support the development of *spatial thinking skills* by anchoring abstract content to concrete physical elements (Chang et al., 2015; Dunleavy et al., 2009). However, the educational implementation of AR requires great care with regard to technical aspects.

Mixed Reality (MR) occupies an intermediate position along the *continuum*, combining distinctive aspects of VR and AR. Contemporary implementations include both advanced AR and "augmented virtuality" in which virtual worlds integrate elements and data from the real world in real time. MR privileges a deeper and bidirectional interaction between the physical and digital dimensions, proving particularly effective for the collaborative manipulation of complex geographical models or for participatory territorial planning activities and scenario simulation.

Taken together, XR technologies act as powerful, far from neutral, mediators of the educational spatial experience. They make it possible to overcome structural limitations related to geographical distance, safety, physical accessibility and resource constraints, by creating controlled environments in which students and teachers can explore, experiment and collaboratively design. Recent research shows that, while requiring significant technological and pedagogical investment, shared spatial experiences in XR environments strengthen the sense of social presence and foster forms of collaborative participation even at a distance, redefining the possibilities of

synchronous but non-co-present geographical education (Priestnall, 2021; Rhys et al., 2020). The current challenge concerns the definition of pedagogical and epistemological frameworks capable of guiding a conscious use of XR, avoiding merely technocentric approaches and enhancing its capacity to support processes of critical and participatory inquiry in the study of the spatial dimension.

3. Methodology

The use of XR in education is still at an experimental stage and often lacks a clear theoretical foundation or an evaluation of learning outcomes (di Natale et al., 2020). At present, it is widely acknowledged that limited knowledge has been accumulated on how to assess learning outcomes using VR in educational activities, and most research in this field remains at an experimental level, focusing on prototyping and usability testing (Radianti et al., 2020).

Therefore, the main aim of this study is not to focus on the user experience of VR applications, but rather on actual learning outcomes, using both quantitative and qualitative research methods to assess increases in students' knowledge and competences as well as their learning experience.

The study adopts a comparative quasi-experimental approach to examine whether different modes of urban exploration configure qualitatively distinct experiences of geographical knowledge construction (Bos, 2024; Roelofsen and Carter-White, 2022).

First, the study asks whether the direct and bodily experience of place fosters broader and more integrated multisensory activation compared to technologically mediated forms of exploration, which generally tend to privilege the visual dimension.

Second, it seeks to verify whether different modes of exploration produce differentiated emotional profiles, thereby selectively influencing affective engagement, sense of safety and curiosity, elements that are widely recognized as central to spatial learning processes.

The third hypothesis concerns spatio-temporal cognition: does bodily interaction with the urban environment produce a more coherent and accurate representation of spatial and temporal relations compared to virtual or digital experiences, characterised by discontinuous and mediated engagement? Furthermore, are experiential differences reflected in the modes of narrative re-elaboration of the experience, generating different linguistic forms?

Finally, the study aims to ascertain whether the differences among the three modes of exploration employed are not only of theoretical relevance, but also of practical applicability, as they significantly affect the didactic design and quality of geographical learning processes.

In order to address these questions, three different modes of experiencing the same urban context were compared: an on-site field visit, immersive exploration through VR, and non-immersive navigation via Google Street View. Participants were not assigned to the three groups through randomization; rather, group allocation was determined by organizational and logistical constraints related to the different university sites involved.

The sample consisted of university students, who were offered a standardised urban itinerary in Milan's Chinatown district. At the end of the experience, all participants completed a structured questionnaire administered as a post-test, designed to systematically capture the sensory, linguistic–expressive, emotional, cognitive, spatio-temporal and "presence" dimensions of the proposed exploration. The questionnaire comprised closed-ended Likert-scale items used to measure the degree of sensory activation and emotional engagement (well-being, curiosity, disorientation, discomfort, sense of safety), together with spatial cognition tasks relating to orientation and estimation of travel times. The questionnaire also included open-ended questions aimed at collecting qualitative descriptions of the experience and exploring subjective representations of place, as well as multiple-choice and open-ended questions on the observed territorial processes.

Data analysis was conducted following a mixed-methods approach, integrating

quantitative and qualitative methods (Gurr, Parr and Hardt, 2022). On the quantitative level, descriptive statistics were calculated and inferential analyses were conducted to compare groups, using parametric and non-parametric tests depending on the characteristics of the variables. To assess not only statistical significance but also the practical relevance of the observed differences, *effect sizes* (Cohen's d) were calculated. To explore the internal structure of experiences and identify recurring patterns, a *cluster analysis* was also applied to standardised sensory and emotional variables, allowing the identification of distinct experiential profiles[2].

On the qualitative level, open-ended responses were subjected to semantic and thematic analysis, including the identification of recurring terms, assessment of emotional valence and analysis of the linguistic structures employed by participants.

Before describing the experimentation in detail, it is useful to outline the main features of the study area. The Sarpi–Chinatown district is located in north-western Milan, approximately 1.5 kilometres from the Duomo, within a compact grid of late-nineteenth-century residential blocks with internal courtyards (*case di ringhiera*). The Chinese presence dates back to the 1920s, when migrants from Zhejiang province settled in via Canonica, establishing workshops for silk ties and leather goods. Over the following decades, the community developed a dense wholesale and retail network along via Paolo Sarpi, generating recurring tensions with Italian residents. The pedestrianisation of the street in 2011 encouraged a shift from wholesale to retail and a progressive gentrification and touristification of the area. Unlike many North American Chinatowns, which developed in marginal areas and are typically marked by a ceremonial gateway separating the ethnic quarter from the surrounding city, Milan's Chinese district grew within an historical neighbourhood, with no visible boundary or threshold: the result is a pattern of "interspersion" rather than enclave formation, generating the sensory density and cultural complexity the research sought to capture.

4. The experimentation

The research was conducted within the framework of the project 'Metaversity' between the 5th and the 8th of May 2025, involving 143 students enrolled in the degree in Primary Education at the Milan and Brescia campuses of the Università Cattolica del Sacro Cuore, as part of the Geography course (with workshop)[3].

Based on the research protocol developed within an interdisciplinary team, each group began the planned activities by watching a short introductory video about the "Metaversity" project, intended to inform all students about the project they were participating in.

All participants followed the same itinerary, articulated into seven significant stops within the neighbourhood. The itinerary begins at the historic residential courtyard in via Canonica, which represents the first nucleus of settlement of the Chinese community in Milan in the 1920s; it then continues with the observations of the Kathay supermarket and the Gran Commercial wholesale warehouse, as emblematic examples of an ethnic economy specialised in consumer goods; then it reaches the Mare d'Oro restaurant, which constitutes a particularly dense concentration of sensory elements, with its bilingual signage and intense cooking smells; it passes through Bar Felice as a place imbued with historical memory linked to conflicts between the Italian and Chinese communities; it pauses at the primary school in via Giusti, with the adjacent pedestrianised area of via Giovanni Verga, a recent example of urban regeneration that has significantly

[2] For statistical details, see Ercolani A.P., Areni A., Leone L., *Statistica per la psicologia*, Bologna, il Mulino, 2002.

[3] Metaversity is an institutional research project developed at the Università Cattolica del Sacro Cuore, coordinated by the Research Center in Communication Psychology (PsiCom) and directed by Prof. Andrea Gaggioli, aiming at exploring the pedagogical, experiential, and inclusive potential of extended reality (XR) technologies in higher education. Info: https://organismi.unicatt.it/telelab-i-nostri-progetti-metaversity-24432

transformed the use of public space. The visit concludes in via Paolo Sarpi, first to analyse the pedestrianisation of the street and its consequent touristification, and then to observe the Chinese Cultural Centre, a key institution for the transmission of Chinese cultural identity. It is important to emphasise that each participant carried out the proposed activity only once, in one of the three different groups.

4.1. On-site field visit

The first group, consisting of 74 students (69 females, 5 males), carried out the physical visit on the 5th of May 2025. The visit was organised into three parallel groups of approximately 25 students each. The standardised procedure included: a briefing on the educational nature of the experience, the distribution of a worksheet for note-taking, and specific instructions on multisensory observation with attention to sounds, smells and textures.

The walk lasted approximately 30 minutes. Each stop followed a precise sequence: a brief individual multisensory observation; two to three minutes of geographical contextualisation, with guiding questions to direct attention towards significant aspects and details revealing ongoing transformations; and one minute for spontaneous questions. After the field visit, students completed a survey that took an average of 15 minutes, including the creation of a mental map of the route taken.

4.2. Virtual field visit with avatar

The second group, consisting of 10 students (9 females and 1 male), experienced the neighbourhood on the 6th of May 2025 through VR technology[4].

[4] For what concerns the technical specifications, the VR experience employed Meta Quest 3 headsets with inside-out tracking and handheld controllers. The Wander software was used as an immersive exploration application based on geolocated environments (derived from Google Street View), allowing for free or guided navigation of the geographical spaces involved in the experience.

None of the participants had prior experience with VR, and specifically with VR applied to geography. This made a particularly careful preparatory phase necessary. Before the session, participating students were therefore asked to complete an initial questionnaire to identify any needs or difficulties they might encounter during the virtual field visit, thus ensuring a comfortable and inclusive experience. Similarly to the procedures adopted for the other two groups, prior to the actual virtual immersion, participants viewed a short introductory "Metaversity" video. At the same time, a brief explanation was provided of concepts such as the metaverse, virtual reality and artificial intelligence.

Following the synchronisation of the devices between students and the instructor who guided the group, a detailed explanation of the operation of the equipment was provided, with particular attention to the controllers. This included instructions on how to use the analogue stick for virtual movement through space and the trigger for selection and interaction with spatial elements, as well as on head rotation to modify the visual perspective (Figure 1). A practical tutorial allowed participants to become familiar with the controls before engaging in the actual exploration through their avatars. At the same time, specific instructions were also given on how to manage potential symptoms of cyber-sickness, preparing participants to recognise signs such as nausea, dizziness or general discomfort, with the indication to immediately remove the headset and notify the assistant if necessary.

At the end of the virtual experience, after a short reorientation break of a few minutes, necessary to facilitate the return to physical reality, the same questionnaire administered to the previous group was distributed. This transition phase proved to be important, as some participants reported mild spatial disorientation or a sense of instability.

Figure 1. A moment from the immersive VR experience through the use of headsets. Source: Authors' photo.

4.3. Exploration through Google Street View

The third group, consisting of 59 students (55 females, 4 males), explored the neighbourhood on the 8th of May 2025 using Google Street View on laptop computers.

Again, detailed technical instructions were provided for navigation within the two-dimensional Street View interface, including the use of directional arrows, 360° rotation with the mouse, and the use of the timeline function for temporal comparisons. The didactic briefing, while sharing the same objectives as those of the other groups, emphasised the ability to "imagine" the physical experience from static images, encouraging students to mentally visualise sounds, smells and tactile sensations to compensate for the purely visual representation offered by Street View.

The experience lasted approximately 30 minutes: the instructor coordinated the synchronised navigation by projecting the route to be followed onto the classroom screen, while students followed along on their own devices. Starting from the historic courtyard in via Canonica, the group moved virtually with stops of approximately four minutes at each location, during which the instructor provided the same contextualisations illustrated to the other groups.

Students used the timeline function for temporal comparisons (2008–present) and zoomed in on specific details (signage, photographic menus, decorative elements). At the end of the experience, students completed the questionnaire administered to the previous groups in approximately 15 minutes, including the creation of a mental map of the route taken.

5. Findings

The results of the empirical research conducted with 143 university students offer a nuanced picture rich in theoretical and practical implications concerning the qualitative differences between physical, virtual and digital modes of urban exploration. The multidimensional analysis – integrating sensory, emotional, cognitive, linguistic, spatio-temporal and "presence" metrics – produced evidence that made it possible to respond, at least partially, to the initial hypotheses, while suggesting meaningful perspectives for geographical education.

The first particularly salient result concerns the different sensory activation across the three modes of engagement. Statistical analysis revealed exceptionally large *effect sizes* for hearing (d = 2.14) and smell (d = 1.97) in the comparison between physical experience and digital navigation, values that significantly exceed the conventional thresholds used in educational research. These data do not simply indicate a quantitative difference in perceptual intensity, but rather configure experiences that are qualitatively different in their phenomenological essence. While visual remains the dominant sense across all modalities, with nevertheless significantly higher levels in the on-site condition (M = 4.78 vs M = 4.12 using Street View), it is access to the auditory and olfactory dimensions that radically distinguishes embodied experiences from technologically mediated ones.

The particularly strong correlation between multisensory activation and emotional well-being in the on-site group (r = .71 for hearing, r = .64 for smell) further suggests that sensory richness does not represent a mere experiential "surplus", but constitutes a fundamental element for deep affective engagement. In the specific context of Milan's Chinatown district, auditory markers (voices in Mandarin, intense traffic noise, street conversations, and sounds coming from shops) and olfactory markers (smells of Chinese cuisine, spices, incense) emerge as more powerful identity elements than bilingual signage or visual decorations alone. Therefore, their absence in virtual modalities entails a significant reduction in the ability to grasp the cultural specificity of the neighbourhood, reducing multiculturalism to easily recognisable but emotionally less engaging visual stereotypes. The analysis of emotional dimensions revealed differentiated patterns reflecting the specific affordances of each modality. The on-site experience generates higher levels of well-being (M = 3.79) and curiosity (M = 4.51), emotions that pedagogical literature associates with optimal conditions for meaningful learning (Immordino-Yang and Damasio, 2007). Particularly interesting is what might be termed the "safety paradox": virtual reality produces the highest perceived sense of safety (M = 4.50) precisely because it removes the real risks of the urban environment (vehicular traffic, dangerous crossings, potential obstacles, etc.). However, this "sterilisation" of experience raises important pedagogical questions: to what extent does the systematic removal of uncertainty and risk undermine educational objectives related to managing unpredictability, adapting to complex contexts, and negotiating urban space?

The moderate discomfort reported by the on-site group (mainly due to intense traffic and the narrow spaces of via Paolo Sarpi) should not be interpreted solely as a negative element, but rather as an authentic component of urban experience.

The ability to move through crowded spaces, manage intense sensory stimuli, and negotiate one's presence in culturally diverse contexts represents a geographical and civic competence that excessive technological "protection" risks atrophying. By contrast, the disorientation reported in VR (M = 3.50) and Street View (M = 3.42) groups is of a different nature: it does not derive from concrete characteristics of places, but from difficulties in technological orientation and from the fragmentation of spatial experience.

Data relating to spatial orientation provide particularly eloquent evidence of the qualitative differences between the three modalities. Only 24% of students in the on-site group reported complete disorientation with respect to the cardinal orientation of the school, compared to 73% in the Street View group. This difference stems from the absence, in digital technologies, of what the literature defines as "embodied

wayfinding" (Chrastil and Warren, 2012): the integration of vestibular, proprioceptive and visual information that enables the construction of more robust and spatially coherent cognitive maps. Street View, in particular, provides fragmented "views" rather than "experiences of continuous movement", producing an atomised geographical knowledge that struggles to be cognitively recomposed into coherent spatial representations.

Especially significant is the accuracy in estimating travel times: 78% of the on-site group provided correct estimates, compared to 31% in the Street View group. The body "measures" space through movement, physical effort and travel time, generating what could be defined as a "proprioceptive knowledge" of space. VR, while offering visual immersivity, tends towards temporal underestimation (42% of participants), probably due to the absence of kinaesthetic feedback and to "teleportation" mechanisms that artificially compress distances. Street View, by contrast, shows high variability with a tendency towards overestimation (42%), likely correlated with the number of clicks and images required to complete the virtual route (Table 1).

The identification of four distinct experiential profiles through *cluster analysis* represents a further significant contribution of the study. The "Engaged Explorers" cluster (46% of the total sample, but 65% of the on-site group) represents the didactically optimal profile, as it exhibits high intrinsic motivation, multisensory activation, positive emotional integration and a critical approach to observation. By contrast, the "Detached Observers" cluster (31% of the sample, but 59% in Street View) configures a superficial "touristic" experience characterised by reduced emotional engagement and almost exclusively visual activation. This non-random distribution of profiles across the three groups suggests that the medium is not neutral, but actively predisposes towards specific experiential configurations. Physical experience appears to naturally foster deep engagement, whereas digital navigation requires compensatory didactic mediation to avoid a drift towards passive observation. The "Anxious Navigators" cluster (15%), distributed across all conditions, highlights how discomfort may emerge in all modalities for different reasons – real urban traffic, cyber-sickness in VR, technological frustration in Street View – suggesting the need for differentiated pathways and attention to individual vulnerabilities.

Qualitative analysis of open-ended responses reveals profound structural differences in how the various modalities are processed and remembered. The average length of answers (18.4 words on-site, 12.1 in VR, 6.8 in Street View) is not merely a quantitative indicator, but reflects the depth of cognitive processing. Answers from the on-site group construct integrated narratives that causally connect multiple elements ("a strong smell of Chinese food, intense traffic noise and voices coming from inside the shops"), whereas Street View generates telegraphic, unconnected lists ("hairdresser, yellow building, parked cars").

The prevalence of perceptual verbs in the on-site group's narratives ("I heard", "I smelled", "I saw") indicates an embodied memory of the experience, anchored to concrete sensory traces. The prevalence of concrete nouns and exclusively visual adjectives in VR ("red", "large", "colourful"), and the almost total absence of emotional markers in Street View, reveal qualitatively different modes of mnemonic encoding. Research on long-term memory suggests that multisensory and emotionally charged encodings are significantly more resistant to forgetting than purely semantic ones (Immordino-Yang and Damasio, 2007), with direct implications for the retention of geographical content. Analysis of the emotional valence of language confirms these patterns: 41% of responses in the on-site group contain terms with positive or negative valence (i.e. emotionally charged), compared to only 8% positive and 12% negative in Street View, where affective neutrality dominates (80%), signalling emotional detachment. Thus, language becomes a revealing trace of the quality of experience: rich, integrated, and personal in embodied experience; descriptive and static in the virtual one; inventory-like and depersonalised in the digital one (Table 2).

Spatial cognition indicator	On-site	VR	Street View
Complete disorientation (cardinal orientation)	24%	10%	73%
Correct travel time estimation	78%	45%	31%
Temporal underestimation	15%	42%	27%
Temporal overestimation	7%	13%	42%

Table 1. Spatial orientation and travel time estimation accuracy (%). Source: Authors' elaboration.

Linguistic indicator	On-site	VR	Street View
Average response length (words)	18.4	12.1	6.8
Dominant linguistic features	Perceptual verbs, integrated narratives	Concrete nouns, visual adjectives	Telegraphic lists, unconnected items
Positive/negative emotional valence	41% pos. / 34% neg.	28% pos. / 22% neg.	8% pos. / 12% neg.
Affective neutrality	25%	50%	80%

Table 2. Qualitative and linguistic indicators of experiential processing. Source: Authors' elaboration.

Indicator	On-site	VR	Street View
Urban characterisation (% agreement)			
Multicultural	96%	90%	88%
Commercial	97%	100%	93%
Peripheral	12%	30%	25%
Proposed urban improvements (% of respondents)			
Traffic reduction	89%	50%	41%
Road safety	46%	10%	8%
Aesthetic improvements	27%	50%	15%
Increasing services	19%	10%	34%
Spaces for children	32%	20%	44%

Table 3. Urban characterisation and proposed improvements by exploration modality (%). Source: Authors' elaboration.

Results concerning the urban characterisation of the neighbourhood show cross-cutting consensus in identifying Chinatown as a multicultural (91% mean) and commercial (97% mean) space, suggesting that these characteristics are sufficiently evident even mediated through technology. However, subtle but significant divergences emerge: the VR group tends to perceive the neighbourhood as more "peripheral" (30% vs 12% on-site), probably due to the absence of an urban contextualisation allowing Chinatown to be situated within the broader context of Milan.

Particularly relevant is the analysis of proposals for urban improvement, which reveals how the mode of exploration influences not only perception but also planning priorities. In terms of desirable improvements to the neighbourhood, the on-site group strongly emphasizes traffic reduction (89%) and road safety (46%), reflecting the direct experience of congested streets.

The VR group more frequently proposes aesthetic improvements (50%), consistent with the visual dominance of the experience. The Street View group more often suggests increasing services (34%) and spaces for children (44%), perhaps reflecting a more functionalist and abstract perception of urban space, more closely anchored to the specific analytical prompts provided and less to the "atmosphere" and *sense of place* (Table 3). These differences have significant implications for the training of future teachers and territorial planning professionals: the mode of access to places shapes not only what is perceived, but also what is imagined as desirable and prioritised in urban intervention.

6. Discussion

The data collected through three different modes of exploration of Milan's Chinatown district provide a nuanced and meaningful picture of the spatiotemporal, perceptual, cognitive, emotional, and 'presence'-related differences that characterise technologically mediated geographical experiences as compared to direct physical ones. The comparative analysis highlights how the choice of mode of engagement with urban space does not constitute a merely technical variable, but rather configures qualitatively different forms of geographical knowledge construction, with significant pedagogical implications for the design of effective educational pathways (Bos, 2024; Roelofsen and Carter-White, 2022).

The greater accuracy in temporal estimations observed in the on-site group (78% vs 31% in Street View) demonstrates that the body constitutes the primary instrument of spatial understanding. Fatigue, proprioception, and vestibular integration contribute to the construction of what Butcher (2012) defines as an "embodied geography", in which distance ceases to be an abstract value and becomes lived experience. The elimination of these components in virtual technologies radically transforms the way space is conceived.

The difficulty in cardinal orientation reported by the Street View group (73% declares "I don't know") reveals how fragmentation into discontinuous views produces an equally fragmented form of knowledge. This confirms the importance of integrating vestibular, proprioceptive, and visual information during continuous movement in order to enable the construction of robust cognitive maps, which technologies based on static images cannot replicate.

The significantly large auditory and olfactory differences prompt a disciplinary reflection on the representation of cultural diversity in urban space: urban multiculturalism cannot be reduced to visual markers alone; the soundscape and smellscape constitute identity dimensions that are equally, if not more, powerful than bilingual signage, and their absence in virtual modalities entails qualitative transformations that risk reducing multiculturalism to visual stereotypes, turning difference into folklore rather than lived experience.

The strong correlation between multisensory activation and emotional well-being in the on-site group further suggests that sensory richness generates deep affective engagement, a necessary condition for transformative learning (Immordino-Yang and Damasio, 2007).

The higher perceived sense of safety in VR compared to physical presence raises relevant pedagogical questions. Virtual environments generate a psychologically real sense of "presence" that is nevertheless ontologically separated from physical reality. This separation simultaneously produces opportunities and limitations: it removes barriers, but risks atrophying essential competences related to managing uncertainty and negotiating real urban space.

The four profiles identified through cluster analysis demonstrate that the medium actively predisposes learners towards specific experiential configurations. Simply replacing physical visits with virtual alternatives, without compensatory pedagogical redesign, systematically shifts students towards profiles that are less favourable to deep learning.

Semantic analysis also reveals radical qualitative differences, with a marked transition from integrated multisensory narratives (on-site) to static visual descriptions (VR), to simple lists (Street View). On-site experiences enable the construction of narratives that causally integrate multiple elements, revealing an embodied memory anchored to concrete sensory traces. The prevalence of perceptual verbs indicates an experience that is actively reprocessed, with implications for the construction and consolidation of long-term meanings (Immordino-Yang and Damasio, 2007).

Overall, VR emerges as an intermediate solution that offers a compromise between immersivity and practicality, proving particularly inclusive. Moreover, the possibility of integrating informational content, enabling personalised explorations, and offering diachronic comparisons opens innovative pedagogical perspectives (Czimre et al., 2024; Roelofsen and Carter-White, 2022). However, current sensory limitations – the absence of olfactory, thermal and haptic stimuli – significantly impoverish the experience. Google Street View, by contrast, emerges as the most accessible modality, but also the one that generates the most fragmented experience. The possibility of virtually exploring any place represents an extraordinary opportunity (De Vecchis and Pesaresi, 2024), yet the data reveal an emotionally flat and cognitively problematic experience, although it may serve useful functions in preparatory or consolidation phases.

Findings therefore encourage moving beyond the sterile dichotomy between uncritical technological enthusiasm and conservative nostalgia in the teaching of geography, particularly in relation to direct observation. Assuming an equivalence between virtual and physical modalities is unrealistic: different modalities configure qualitatively distinct experiences that generate different forms of geographical knowledge. Based on the evidence obtained, a didactic model capable of fostering robust geographical understanding should valorise specific affordances. From this perspective, Street View could be productively employed for preliminary orientation; VR for safe territorial exploration; physical presence for authentic multisensory experience, followed by a final digital synthesis. Such strategic complementarity, however, requires a profound rethinking of the educational experience, considering the epistemological specificities of each medium.

7. Conclusion

This study has empirically documented how different modes of exploration generate qualitatively distinct forms of geographical experience, contributing to the current debate on geography education (Bednarz et al., 2013; Walshe and Healy, 2021).

Although many questions remain open regarding the long-term effectiveness of immersive technologies and their potential effects on students' cognitive and emotional development, the potential of immersive pedagogy to enrich geographical learning remains evident. Given the low maturity of the research field on immersive experiences in education, the objective must remain the conscious and targeted integration of these technologies, in order to create experiences that are not only technologically advanced, but above all, pedagogically effective.

The methodological approach adopted – rooted in theoretical principles of human

geography and embodied cognition, and supported by a research design integrating quantitative metrics and qualitative analyses – responds to the need to move beyond technological fascination and to ground reflection on the construction of geographical knowledge in empirically robust evidence.

For immersive technologies to genuinely enrich educational experience, it is essential to develop pedagogical frameworks and didactic guidelines that can orient their epistemologically grounded use.

Translating these findings into sustainable teaching practice, however, requires acknowledging significant constraints. VR equipment remains costly, demands dedicated spaces and technical supervision, and raises inclusivity concerns related to cybersickness; the small VR group in this study reflects precisely these material limitations. Teachers, moreover, need not only technical competence but epistemological awareness of how each medium shapes spatial experience. The complementarity documented in this study should thus be understood not as a requirement to deploy all three modalities simultaneously, but as a pedagogical principle guiding the conscious selection of tools according to available resources, learning objectives and curricular constraints.

This reflection is particularly relevant for teacher education, as educators are now called upon to adopt a conscious and theoretically informed use of technology in the teaching of geography. Teachers require conceptual and operational tools to promote educational practices capable of combining direct territorial exploration, strategic digital mediation and students' critical participation, while recognising the epistemological specificities of each experiential modality and enhancing their complementary affordances.

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