

Cognitive Ecosystems and Integrated Media: Reimagining Ancient Rome Through Situated Learning

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Abstract: Contemporary pedagogical reflection has consolidated the idea that learning is not a process confined to the mind of the individual, but a distributed phenomenon, situated within contexts and deeply rooted in the body and in action. Perspectives on extended cognition, explored internationally by scholars such as Clark and taken up, with particular attention to the educational dimension, by Berthoz in his work on semplexity, have progressively shaped a new way of thinking about teaching. In Italy, the contributions of authors such as Sibilio and Rivoltella have further clarified how the interaction between the subject and the environment, whether physical, digital, or symbolic, can generate forms of knowledge that traditional transmissive lessons are no longer able to sustain. From this theoretical framework emerged an experiment carried out in a fourth-year class of the “B. Rescigno” Scientific High School in Roccapiemonte (SA), with the aim of innovating the Latin lesson and exploring how different media, intentionally interconnected, might profoundly transform the ways in which students understand and construct meaning. The experimental approach aligns naturally with the principles of Universal Design for Learning: the diversification of channels for access and representation is not a technical addition, but an intrinsic condition of learning, understood as a complex and plural process. The classroom thus becomes a cognitive ecosystem in which texts, images, sounds, and virtual environments do not merely accompany the lesson but actively transform it. Starting from the translation of a Latin passage dedicated



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to the aqueducts of ancient Rome, students were guided through an experience that gradually expanded their opportunities to encounter the content. They moved first into the analytical dimension of the text, then into the perceptual and spatial dimension provided by an exploratory video game set in a historical environment, and finally into the narrative and cultural dimension offered by a documentary. In parallel, a control group worked exclusively on the text, following a more traditional approach. The questionnaires administered at the end of the pathway showed that students involved in the multimodal setting developed a deeper and

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more integrated understanding of the content, retained information more consistently, and perceived their learning as more meaningful, motivating, and aligned with their cognitive experience. The results suggest that intelligent learning environments do not emerge from the mere introduction of technologies, but from the quality of the connections that instructional design is able to activate, transforming the study of Latin into a complex, embodied, and culturally situated experience capable of offering students a renewed form of access to the ancient heritage.

Keywords: Extended and embodied cognition, intelligent learning environments, multi-modal knowledge construction

1. Introduction

In a context increasingly shaped by hybrid technologies and practices, rethinking learning has become a priority to ensure equitable access and meaningful understanding. Latin teaching is particularly significant because it combines linguistic analysis with historical cultural interpretation and therefore requires tools that sustain both textual decoding and contextual comprehension.

Recent pedagogical research highlights learning as situated, distributed and mediated by artefacts and environments. Theories of the extended mind view tools as true cognitive extensions (Oliverio, 2017, p. 103); embodied cognition stresses the role of body and action in knowledge formation (Gallese and Lakoff, 2005); and distributed cognition (Hutchins, 2000) underlines its cooperative dimension. Tools and media thus participate in cognitive activity, considering that individuals are “joint products of our biological nature and multilayered linguistic, cultural, and technological webs” (Clark, 2003, p. 195).

These orientations have supported a pedagogical reflection that values the body, educational relationships and media as generative environments of meaning (Rivoltella, 2012; Sibilio, 2014). Corporeality becomes a cognitive resource (Sibilio, 2017; Di Tore et al., 2014), while mediation emerges as a network of practices guiding attention and fostering shared meaning (Rivoltella and Rossi, 2019). This leads to viewing teaching as the design of interconnected cognitive ecosystems in which languages and formats interact to support learning (Sibilio and Aiello, 2018; Rivoltella and Rossi, 2024). Studies on perception and multimedia learning similarly show that multisensory integration deepens representation (Berthoz, 2011) and that well designed combinations of texts, images and videos enhance processing when cognitive limits are respected (Mayer and DaPra, 2012). Critical perspectives warn, however, of risks such as overload and dispersed attention, since richly layered materials may “induce unnecessary extraneous cognitive load” (Mayer, 2009, 2014) and too many images can reduce recall (Bali et al., 2026). Ineffective multimedia design can also compromise students’ self assessment of understanding (Schnaubert and Schneider, 2022), highlighting the need for careful sequencing of media within learning environments.

To translate these insights into practice, the Universal Design for Learning framework offers an approach that supports inclusive multimodal environments and

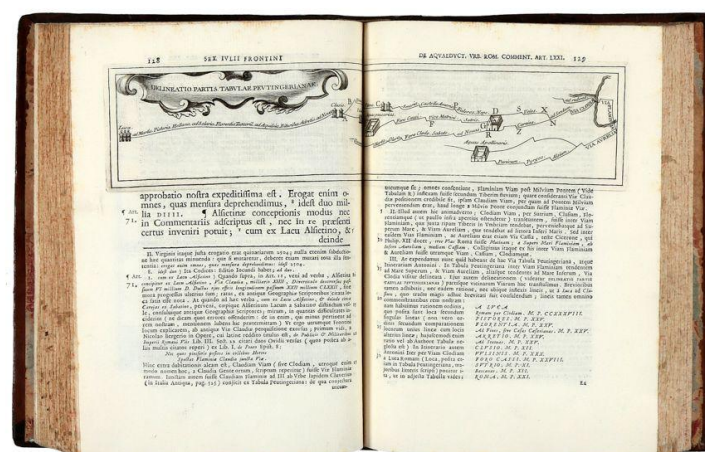
reduces barriers related to languages, media and access (Gargiulo and Metcalf, 2010). UDL reflects many principles of embodied, distributed and multimedia cognition, suggesting that learning benefits from multiple forms of representation and expression. In Latin teaching, this perspective indicates that linguistic knowledge can be strengthened when combined with visual, spatial and narrative elements in pathways where media are complementary rather than additive (King Sears, 2009).

Despite solid theoretical foundations, the literature shows a lack of empirical studies in upper secondary contexts that examine the effectiveness of integrated multimodal sequences in Latin. Given its abstraction and cultural distance, Latin is an ideal field for testing whether coordinated media support deeper comprehension, yet most research remains limited to laboratory settings or non humanistic domains.

This study addresses this gap through a field experiment at the “B. Rescigno” Scientific High School in Roccapiemonte (school year 2025–2026) on Frontinus’ *De Aquaeductu Urbis Romae*. It compares a traditional text-based approach with a sequenced multimodal pathway combining translation, exploration of a 3D reconstructed environment and viewing of documentaries, to evaluate impacts on comprehension, retention, transfer, cognitive load, motivation and engagement.

The research tests three hypotheses: that the combination of video game and documentary enhances comprehension without generating overload, improves retention compared to text only work and increases engagement while reducing translation related anxiety. The results support these hypotheses, showing that a well organised multimodal sequence fosters deeper learning and richer final elaborations where linguistic, spatial and narrative competences integrate naturally without raising perceived load. This contributes to the debate on multimodal representations in the humanities and offers operational insights for upper secondary instructional design.

Figure 1: Page showing a schematic profile of the gradient (*inclinatio*) and course of Rome’s aqueducts in Frontinus’ *De aquaeductibus Urbis Romae commentarius*, ed. Giovanni Poleni, engravings by Antonio Valentini. Patavii: Ioannem Manfrè, 1722.



2. Materials and Methods

The experimentation was conducted during the 2025–2026 academic year in a fourth-year class of the “B. Rescigno” Scientific High School in Roccapiemonte, a context characterised by strong attention to pedagogical innovation and the integration of humanistic and scientific knowledge, making it suitable for testing a multimodal pathway on the aqueducts of ancient Rome aimed at comparing an integrated approach with traditional teaching in terms of conceptual understanding, long term retention, and student engagement.

The methodological design combined textual materials, and digital resources organised to stimulate different sensory and cognitive channels. The pathway included reading, analysis, and translation of selected passages from Frontinus’ *De Aquaeductu Urbis Romae* (Figure 1), immersive exploration of a three-dimensional reconstruction of Imperial Rome through a video game (Figure 2), and the viewing of an episode of *Meraviglie* by Alberto Angela titled “Rome, the Queen of Waters”. The impact of the intervention was assessed through classroom observations and evaluation tools focused on comprehension, retention, motivation, and engagement.

The class was randomly divided into two groups to ensure comparable conditions and reduce confounding variables. The experimental group, composed of 23 students, followed a sequence structured in three phases: textual work on Frontinus with attention to the technical and engineering features of Roman aqueducts, exploration of a three-dimensional reconstruction enabling direct observation of spaces and proportions, and viewing of a documentary intended to broaden the historical and cultural perspective. The control group, composed of 22 students, carried out a traditional pathway based solely on reading, translation, and linguistic analysis without digital or multimedia tools.

To measure the effectiveness of the multimodal approach, three online questionnaires were administered. The first, addressed only to the experimental group in the pre-test and post test phases, explored perceptions, motivation, and engagement through open questions and Likert scale items on the integration of digital and traditional methods. The second, administered to all students in both groups in the same phases, assessed conceptual understanding and knowledge acquisition to allow systematic comparison of progress. The third, qualitative and addressed to the teacher, collected an overall evaluation of the pathway with attention to the coherence among tools, student participation, and critical issues emerging during implementation.

All instruments were validated by experts in pedagogy and methodology and tested in a pilot phase with external students to verify reliability and consistency with the research aims. The intervention, conducted according to ethical principles of educational research with written informed consent and full anonymity protection, lasted approximately three months and followed a sequential and integrated structure designed to allow consolidation and progressive expansion of knowledge, ensuring rigorous and reproducible implementation of the entire multimodal pathway.

3. Results

This section presents the main findings derived from the analysis of three questionnaires designed to evaluate the effectiveness of the educational programme and

students' satisfaction with the integration of 3D technologies into the teaching of classical literature

3.1. Evaluation of the learning experience

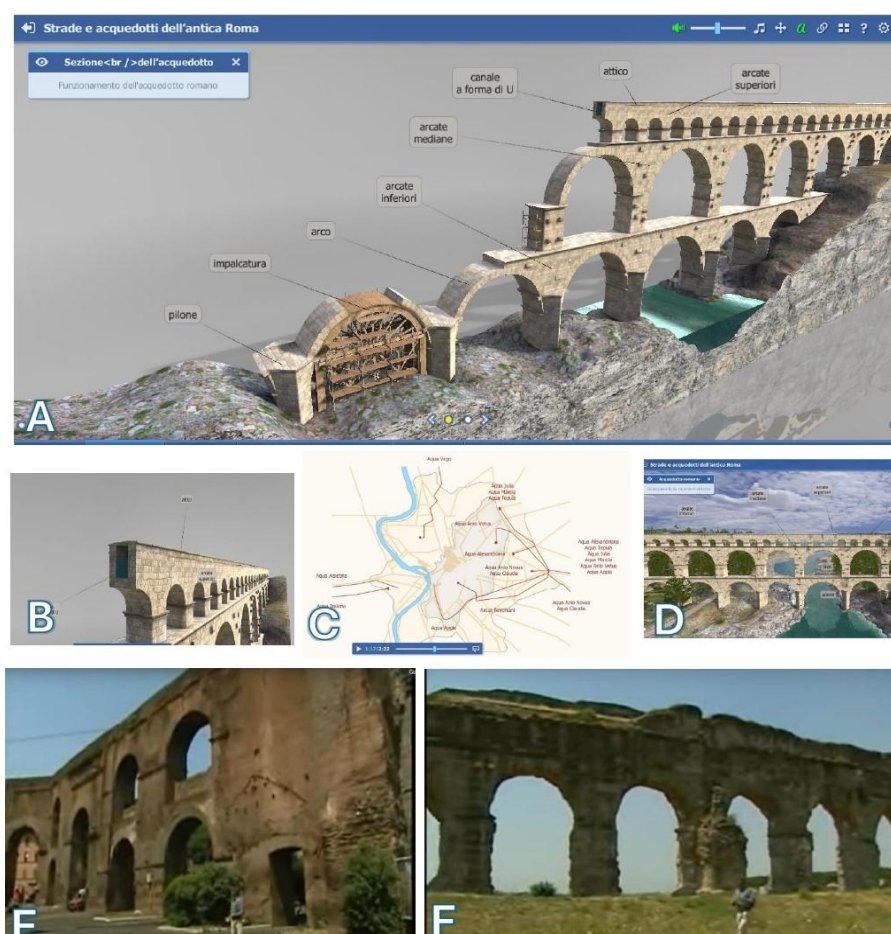
This subsection explores how the integration of 3D technologies shaped students' learning processes and perceptions, focusing on cognitive, motivational, and affective dimensions as reported in the questionnaires.

3.1.1. Questionnaire Analysis

- Questionnaire 1 – Perceived usefulness, motivation, and cognitive load (Experimental group)
The questionnaire examined how the combination of textual analysis, a 3D videogame, and a documentary supported students' understanding of Roman aqueducts. Perceived usefulness was high: 83.3% of students rated the pathway as very helpful, especially for visualising structural details. Engagement increased in 82.1% of respondents, and open-ended answers indicated that neither the videogame nor the documentary were perceived as distracting but rather as tools that clarified and facilitated understanding.
- Questionnaire 2 – Knowledge and conceptual understanding (Experimental and control groups)
This questionnaire examined factual recall, conceptual understanding, and visuospatial reasoning through pre- and post-test administration. Both groups improved, but the experimental group showed a larger overall gain. Notably, 89.9% of experimental students reported an improved ability to visualise structural relationships within the aqueduct system. Performance was higher on items requiring the integration of linguistic, technical, and historical information, supporting the hypothesis that multimodal learning promotes more coherent mental representations.
- Questionnaire 3 – Engagement, motivation and performance anxiety (Experimental group)
The third questionnaire examined affective factors, including engagement, perceived meaningfulness, and anxiety related to translation tasks. Engagement increased markedly, with 81.6% of students finding the sequence more stimulating and meaningful than traditional lessons. Several items indicated reduced performance anxiety, with students reporting greater confidence in translation after experiencing the content through multiple modalities. The immersive and narrative qualities of the videogame and documentary were frequently cited as making the learning experience clearer and more accessible.

Figure 2 : A) 3D reconstruction of a Roman aqueduct; B) detail of the upper channel; C) map of the main aqueducts of ancient Rome; D) 3D visualization of an aqueduct segment; E) urban stretch of Roman aqueducts; F) peripheral stretch of Roman aqueducts.

Source: Mozaik Education (edugame 3D) for A–D; Meraviglie by Alberto Angela, episode “Rome, the Queen of Waters”, for E–F



4. Discussion

The results show that the intentional integration of heterogeneous media makes it possible to rethink the teaching of Latin in a way that is coherent with theories of distributed, situated, and embodied cognition, largely confirming the initial hypotheses (Hutchins, 2000). The stability of factual recall in the experimental group, despite the engagement in more complex and multimodal activities, suggests that video games and documentaries do not function as distractors but as mediating tools that promote the construction of more integrated and operational mental representations of the content (Di Tore et al., 2014), in line with the idea that “meaningful learning occurs when the learner engages in appropriate cognitive processing during learning” (Mayer, 2024). This outcome addresses the identified gap, providing empirical evidence in an

authentic context in support of the effectiveness of a multimodal approach to classical languages, in which the non-redundant organization of different codes reduces extraneous load and enhances meaningful processing (Castro Alonso et al., 2021).

The responses to the questionnaires show a shift from fragmented knowledge to a more integrated understanding, where linguistic, spatial, sensory, and historical-political dimensions merge into a single mental representation. Spatial-visualization data indicate that 89.9% of students better understand complex concepts and the relationships between parts of the aqueduct, in line with perspectives highlighting bodily experience and cognitive distribution (Mayer & DaPra, 2012). Bodily involvement and exploration of simulated environments support richer cognitive schemata than verbal study alone and reduce redundancies that could overload working memory, which “is a hypothetical limited capacity system that provides the temporary storage and manipulation of information necessary for performing a wide range of cognitive activities” (Baddeley, 2012).

A salient finding is the students’ distinction between simply knowing and truly understanding, showing how bodily and spatial engagement shapes the comprehension of abstract concepts and complex historical phenomena. The high perceived usefulness of the pathway, reported by 83.3% of students, confirms that integrating different languages and environments supported meaning making rather than causing distraction. Accounts of virtually walking along the *Aqua Claudia* illustrate how emotional, sensory, and motor dimensions became part of the cognitive process, making complex content more accessible. Gestures, movements, and perceptual engagement thus acted as resources for comprehension, consistent with the view that “cognition is grounded in our embodiment (embodied action) and these histories are ‘lived’ (experiences)” (Shapiro & Stolz, 2019). Long-term retention data further show that students recalled content through spontaneous everyday associations, indicating stable and reactivatable memory traces, substantially stronger than typical outcomes of traditional instruction and fully confirming the initial hypotheses.

The richness of the learning path did not translate into an indiscriminate increase in cognitive demands, as the text, video game, documentary sequence made complexity manageable through a functional distribution of cognitive solicitations, with each environment performing a specific and complementary role. This organization progressively made the object of study accessible through different channels, fostering differentiated yet integrated modes of understanding according to an adaptive organization of cognitive resources (Berthoz, 2011).

Embodied experience plays a central role, as interaction with explorable digital environments and the need to orient oneself, act, make decisions, and interpret visual and narrative cues engaged the body as a cognitive mediator, strengthening the link between perception, action, and conceptualization. Knowledge did not remain confined to abstract comprehension but took shape as lived experience, through practices that made complex concepts tangible and fostered deeper processes of internalization—consistent with a conception of learning as a situated and embodied process (Sibilio, 2014; 2016).

The integration of codes, environments, and forms of experience therefore suggests that the effectiveness of the learning path results from a functional synergy rather than a simple accumulation of stimuli. The confirmation of the first hypothesis must be attributed to the didactic design’s ability (Todino, 2021) to connect different languages coherently, supporting cognitive integration and knowledge transfer. What

emerges is a model of learning in which complexity is not eliminated but reorganized into manageable forms, enabling students to construct stable meanings transferable beyond the immediate context of the school experience (Berthoz, 2011; Sibilio, 2017).

The affective dimension emerges as a structural component of the educational experience rather than a mere motivational support. The increase in interest, engagement, and meaningfulness, evident from questionnaires and student narratives, indicates that emotional involvement directly contributes to deep understanding of the content. The figure of 82.1% regarding increased motivation and engagement reinforces the third hypothesis and suggests that a more accessible and articulated learning environment helped to reduce the performance anxiety typically associated with translation tasks. “The body functions as a cognitive, affective, and relational device in a constant dialogue with the environment” (Sibilio, 2012), meaning that motor, sensory, and narrative engagement plays a decisive role not only in memory consolidation but also in constructing a personal sense of the content, particularly in the humanities, which students often perceive as distant from their everyday experience.

Critiques concerning the risk of spectacularization or loss of rigor appear only partially justified, as the Latin text maintained a central role, and linguistic work was neither simplified nor marginalized but embedded within a broader educational experience capable of supporting its comprehension. Digital media did not replace interpretation but made it more deliberate, prompting students to confront the interpretative nature of visual reconstructions and the inherently mediated character of any representation of the past, consistent with the idea that every digital environment constitutes “an interpretive construction” (Murray, 1997) that requires awareness and critical decoding.

Cognitive load was intentionally regulated, since the text, the video game and the documentary were presented in sequence and with different objectives, avoiding redundancy and allowing students to approach complexity progressively. This organization prevented overload (Sweller, 1988) and turned information exposure into a gradual deepening process, supporting the formation of more solid mental representations. The findings also show how the principles of Universal Design for Learning (Savia, 2016) can be applied even in a complex domain such as classical languages, demonstrating that a guided multimodal path can promote richer and more nuanced understanding than allowing students to choose only one preferred route. When carefully designed, the plurality of experiences can broaden learning rather than fragment it.

The implications for Latin pedagogy and for humanistic education more broadly suggest that it is possible to overcome the dichotomy between rigor and relevance, showing how a multimodal cognitive ecosystem can preserve the analytical depth of textual work while creating experiential, emotional and cultural connections that are meaningful for students. While acknowledging the study’s limitations, linked to its design and focus on a single context, the results open important research directions, including comparative analyses of different multimodal configurations, investigations into optimal sequencing and the creation of assessment tools that are more sensitive to metacognitive and collaborative dimensions and to the ability to apply knowledge and skills in different contexts.

5. Conclusions

The multimodal approach allowed students to engage with the content in a progressive and stimulating manner, as embodied learning, understood as the interaction between real and virtual bodies in immersive environments, enhances cognition by making the study experience concrete and grounded through active exploration (Repetto & Riva, 2024), while the combination of verbal and visual stimuli supports the construction of complex mental representations and facilitates the connection between new knowledge and pre-existing cognitive schemas (Mayer, 2005). These elements demonstrate how the integrated use of media can enrich understanding and the consolidation of concepts, transforming the study of Latin into an engaging and motivating experience for learners.

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