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DIGITAL NARRATIVES FOR THE ENHANCEMENT OF MINOR HISTORICAL HERITAGE

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Abstract

This research analyses an interdisciplinary model to enhance Minor Historical Heritage by integrating historical, architectural and digital skills. Through archival analysis, the study shows how participatory methodologies and immersive technologies can promote the protection of marginalised cultural heritage. The adoption of interactive strategies, including gamification, reveals significant potential in community engagement and dialogue between past and present, especially in contexts such as Pavia's historical heritage, which would benefit from this approach. The results highlight an approach that can be replicated in other urban contexts, outlining a path of preservation and interpretation that consolidates the relationship between research, innovation and cultural awareness.

Keywords

Minor Cultural Heritage, Digital Cultural Heritage, 3D Modeling, Serious Game, Pavia

1. *Introduction*

Minor Historical Heritage refers to those cultural assets which, despite not belonging to the circuit of major monuments and sites of national or international renown, represent significant elements for understanding a territory's history and cultural identity[1], serving as tangible symbols of a community's social and architectural traditions (Bruno Jr. & Spallone, 2015; Salerno, 2017; Galeazzo, 2024). Despite their value, these minor assets face various challenges in terms of conservation and enhancement: the absence of systematic development plans leads to clear instances of neglect and abandonment, resulting in the irreversible loss of the signs and symbols embodied in the elements of Cultural Heritage. The lack of awareness of their value on the part of the local population and institutions contributes to a vicious cycle in which minor heritage is neglected or even forgotten (Picchio et al., 2022; Palestini & Rasetti, 2024).

Education plays a fundamental role in enhancing minor historical heritage. Raising awareness among the entire community about the importance of these assets becomes crucial to ensure their conservation and the transmission of their value to future generations (Piscitelli, 2022). Through experimental research initiatives, this heritage can offer academics both the opportunity to test new forms of documentation, analysis, and understanding, and to promote greater awareness of the importance of this Heritage within the academic community.

The central goal of this article is to explore an approach aimed at raising university students' awareness of the crucial role that the minor historical heritage of the city of Pavia can play, as well as to propose contemporary solutions to the community's need to rediscover minor heritage. The research project "Unknown Pavia" included the integration of theoretical and practical notions on the use of digital tools within the educational program[2], with the intention of transforming

[1] The definition of 'minor historical heritage' is not officially established as a specific category in Italian legislation. It therefore refers to those assets that are significant for the local identity of a community (Fanzini, Zreika, 2023).

[2] The "Unknown Pavia" research project involved lecturers, researchers, research fellows, PhD students and students of the course Models and Representation of Architecture, Master's Degree in Building Engineering and Architecture, Department of Civil Engineering and Architecture, University of Pavia (responsible professors: Prof. Francesca Picchio, Dr. Francesca Galasso).

students into active protagonists in the enhancement of local minor heritage and of increasing their awareness of its historical and cultural value. In this context, interactive video game-based applications, which are emerging as powerful means of cultural dissemination (Luigini et al., 2020; Avella et al., 2024), were chosen as the project's final output, conceived as a beneficial educational and awareness-raising experience. In the first instance, the project made it possible to deepen knowledge of Pavia's minor historical heritage through a process of research, analysis, and the development of cultural content, drawing on game design concepts and harnessing computational potential in a three-dimensional digital space. Aiming to enrich students' knowledge base, the project served as a mid-term trial for future professional challenges as digital curators (Borucka & Parrinello, 2023; Kowalski et al., 2024) in fields such as digital heritage, game design, and education. By documenting the entire process, from the project's conception to its realization and analyzing the results achieved, this academic experience becomes a concrete example of how teaching can be innovative while remaining closely tied to the enhancement of local heritage.

2. *Cultural memory of Minor Historical Heritage*

Cultural memory constitutes one of the fundamental cornerstones around which human and collective identity is structured. Always, human beings have felt the need to leave tangible traces of their existence, a need that has manifested itself in the most varied material and immaterial forms. The transmission of memory has never been just secondary act, it has been a constitutive principle of the human condition, an impulse intended to preserve what has been and to connect the fragments of individual and collective experience within the historical *continuum*. From prehistoric rock inscriptions to celebratory monuments, including oral traditions and written narratives, every cultural expression can be regarded as a mnemonic repository that transcends the temporal dimension (Assmann, 2011). In this perspective, memory unfolds through what theoretical reflection describes as the "materials of memory". Monuments and documents are the two main vehicles of this transmission[3]. The first, with their tangible presence in space, represent symbols capable of evoking shared values and collective meanings; the latter, by virtue of their interpretive and narrative nature, crystallize the past into textual forms that inform and shape the identity structures of a community (Parrinello et al, 2024). Both, however, do not merely preserve remembrance but rather shape it, attributing meanings that change based on cultural and social context (Assmann, 2011; Nora, 1984). The value of these memory materials lies not only in their material persistence, but also in their ability to articulate complex relationships between mind, memory and remembrance Such relationships acquire a paradigmatic significance in ruins, fragments of the past that gain meaning only through the temporal awareness of those who observe them[4] (Lévi-Strauss, 1962). This awareness, far from being a static dimension, forms the fulcrum of an ongoing dialogue among the past, the present, and the future. In consideration of these reflections, cultural heritage takes shape as a vast shared archive, a symbolic place in which tangible and intangible memories are deposited and layered, a heap of broken images (Eliot, 1982). It is not just a matter of preserving monuments or documents of major significance, but of recognising the value of every trace of the past as an integral part of a complex cultural system. In this context, there is the minor historical heritage a set of cultural assets that, while often excluded from institutional narratives and official valorisation circuits, possess intrinsic importance for local communities and the cultural fabric they represent. Minor historical heritage consists of places, buildings, objects, and practices that are not always conspicuous or celebrated, yet they safeguard the genius loci of a territory, namely the distinctive spirit linking a place to its history and identity (Norberg-Schulz, 1980). However, the marginalization to which they are often subject raises critical questions. This phenomenon is further increased by the difficulty of systematically mapping and documenting such assets, which frequently remain fragmentary or confined to local archives that are hard to access.

[3] The distinction between 'documents' and 'monuments' reflects two complementary dimensions of cultural memory: historical narrative and visual symbolism. For a more in-depth discussion, see Assmann, 2011.

[4] Lévi-Strauss (1962) identifies ruins as an example of "ambiguous cultural objects", capable of evoking the past through a present-day reinterpretation, integrating themselves into identity-building processes.

Within this complex dynamic, the *sense of past*[5] emerges as an essential element in enhancing minor historical heritage. Recognizing traces of the past requires a hermeneutical operation that goes beyond mere observation: it implies an act of interpretation that positions material and immaterial signs within a broader historical and cultural perspective. This operation is based on "temporal awareness", the ability to grasp the significance of the temporal layers that a place or object holds (Augé, 1992). The sense of the past is not simply a recording of events, but a dynamic process that engages collective memory and reworks it according to the present. The minor historical heritage represents, in this sense, a unique opportunity to develop this awareness. Its valorisation must not be limited to material conservation but must involve local communities in a participative process that makes them protagonists of their own heritage. Far from being a static remnant of the past, minor historical heritage constitutes a living and dynamic element, capable of adapting to social and cultural transformations and generating new meanings. Managing such assets requires a holistic, interdisciplinary approach that unites expertise in history, architecture, and urban planning with the possibilities offered by new digital technologies. The use of innovative tools can make minor historical heritage more accessible and usable, helping to surmount the barriers that hinder its appreciation (Parrinello & Picchio, 2023). Nevertheless, any intervention must be guided by a critical awareness that balances the demands of conservation with those of sustainability and innovation. Finally, the minor historical heritage presents itself as a crucial node in the relationship between cultural memory and collective identity. Its valorisation is not only an act of protection, but a process of cultural regeneration that invites reflection on the meaning of the past and its role in shaping the future. It represents a bridge between generations, a link between times and spaces that deserves to be preserved not only for its historical relevance, but for its ability to enhance the understanding of what it means to be part of a community.

3. Pavia's Minor Heritage: contexts and perspectives

Although a city's historical heritage can often be reduced to its most visible or immediately recognizable elements, it frequently finds a fundamental part of its essence in those lesser known, sometimes forgotten places that contain profound memories and meanings (Tozzi, 2017). In Pavia, a city with a complex historical and cultural stratification, the minor heritage emerges as an essential element to understand the identity dynamics that have followed one another over the centuries, creating a unique urban fabric. It is not only evidence of a distant past, but also a mirror of the relations that contemporary generations have been able to establish with the city's architectural, urban and infrastructural heritage.

Pavia's minor heritage presents itself as a heterogeneous set of spaces, buildings, and infrastructures that, although often marginalized compared to the city's major monuments, tell stories that are just as significant. These invisible spaces and architectures embody that ancient, "daily" memory which does not seek monumental celebration, but which silently safeguards the genius loci of a city and its connection to the rhythms of community life and its territory[6]. Reading and enhancing these elements require a critical, interdisciplinary approach, since their meaning is never univocal and their value is rooted in the dialogue between past and present.

In the Pavia context, the cultural value of heritage lies in its capacity to convey alternative narratives, to reveal the relationships between inhabitants and their territory, and the social transformations that have shaped the city. Recognizing and promoting heritage therefore involves constructing a more inclusive dialogue with the past, giving voice to those traces which, even if lacking universal resonance, represent the foundations of local belonging and identity. Managing minor assets in the city poses complex challenges, partly linked to their fragmentary nature and symbolic isolation: historical cloisters are often incorporated into private contexts, making public access difficult; monumental gates, now disconnected from the original urban walls,

[5] The "sense of the past" is a concept that is also reflected in the work of Marc Augé, who analyses the role of temporal dimensions in the perception of spaces and ruins as repositories of memory. See Augé, 1992.

[6] For example, the medieval towers, once a symbol of power and prestige of the great city families, now stand completely incorporated into the urban fabric and have lost their original function as a landmark in the urban landscape and their link with the social fabric that once surrounded them.

appear as silent ruins; Naviglio canal, in disrepair and abandonment, has lost its primary function; and the Monumental Cemetery is perceived more as a site of mourning than as a repository of artistic memory. One of the main difficulties lies in overcoming this fragmentation, restoring coherence and meaning to minor heritage through enhancement strategies that go beyond mere material conservation and instead integrate the history of these places into contemporary experience.

3.1. Historical cloisters, suspended places

Pavia's historical cloisters represent one of the most emblematic examples of spaces suspended between memory and oblivion. Among the most significant is the Cloister of the Monastery of San Felice, an example of medieval architecture that preserves traces of its original monastic function, now integrated into the university complex. Differently, the cloister of the Palazzo del Broletto in Pavia, located in the historical centre, is an example of medieval civil architecture (Fig. 1). Originally part of the municipal seat, the cloister, with its porticoes and arcades, served as a place of public meeting and exchange. These places, designed as centres of religious, social and cultural life, have always symbolised an architectural model of balance and contemplation. In this sense, the cloister is not only an architectural element, but also a symbol of connection between man and the transcendent, between the city, nature and spirituality. Their geometric organisation, the rhythm of the columns and the harmony of proportions reflect a symbolic order that invited meditation and the search for inner balance. Over time, many of them have lost their original function, turning into silent, sometimes forgotten spaces that seem to exist outside the flow of time[7]. This fate raises questions about their management and possible reintegration into the cultural life of the city, as spaces for meeting and reflection.

Fig. 1: Undergoing extensive restoration and conservation work, the historical cloisters in the urban landscape of Pavia preserve an architectural elegance that survives the passage of time.

3.2. Monumental Gates, fragmented heritage

Pavia's monumental gates, ancient entrances that marked the perimeter of the city walls, represent an emblematic example of fragmented heritage. These imposing gates were not merely defensive elements, but authentic symbols of the city, tangible signs of a civic culture that manifested itself through architecture. Gates not only defined the urban border but also expressed a collective identity and a sense of belonging to the territory. Today, many of these structures appear as disconnected fragments that have survived urban transformations and the modernisation of the city. Despite their monumental value, the major urban renewal interventions in the historic centre and the construction of the road system led to the demolition of most of the ancient city gates between 1920 and 1950. Only Porta Calcinara, Porta Nuova, belonging to the Gothic period, and the renovated Porta Milano were preserved, due to their position along the original medieval perimeter of the city, outside the layout of the external road. The physical and symbolic isolation of the gates raises the question of their reinterpretation and enhancement in the contemporary context.

A possible perspective could consist in reconstructing, at least ideally, the ancient relations that existed between these structures

[7] There are many cloisters in the urban fabric that have been privatised or of which little is known about their construction. The cloister of the Monastery of San Maiolo is a key example. Founded in 967 by Abbot Maiolo and now housing the Pavia State Archives, the former monastery is built around the main cloister, which was constructed in the second half of the 15th century by members of the Corte family, presenting the archetypes of the architecture of the time. For further information, see Archivio di Stato di Pavia. The Cloister of the Monastery of Santa Maria Teodote, also known as Santa Maria della Pusterla, represents another important fulcrum of Pavia's religious history, with its structure recalling the city's first female monastic communities. For a more in-depth study, see Peroni, 1972.

(De Marco, Galasso, 2023), the urban context and the community of Pavia, to revive a heritage in danger of disappearing.

3.3. Naviglio Pavese, doomed infrastructure

Naviglio Pavese represents one of the city's most significant historical infrastructures, not only for its economic and functional role, but also for its symbolic value (Chierico, 2019). Built to connect Pavia to Milan and the Lombard canal system, the canal was a vital artery connecting the city to the wider regional context. Its function, ensured by the engineering system of the locks and hydraulic artefacts[8], was not limited to transport: it also constituted a space of sociality and exchange, around which settlements, economic activities and cultural practices developed (Cremonesi, 2001). However, the progressive abandonment of navigation and the lack of adequate structural interventions have relegated the Naviglio to a condition of marginality. Today, these infrastructures, although still full of potential, appear condemned to oblivion (Fig. 2). Their documentation and redevelopment is based on an integrated approach, capable of combining historical memory with contemporary needs, transforming it into a central element of Pavia's urban landscape and tourist system (La Placa & Picchio, 2022).

3.4. Monumental Cemetery, veiled memory

The Monumental Cemetery of Pavia is a space where collective memory takes tangible form through architecture and funerary sculpture. This place, conceived as a garden of memory, contains within it an artistic and cultural heritage of extraordinary value, which is manifested in the tombs, monuments and mausoleums dedicated to important figures and families from Pavia's history[9].

The monumental chapels within it not only celebrate the dead but also recount the events and ambitions of Pavia's great dynasties, offering a cross-section of different historical periods (Fig.3).

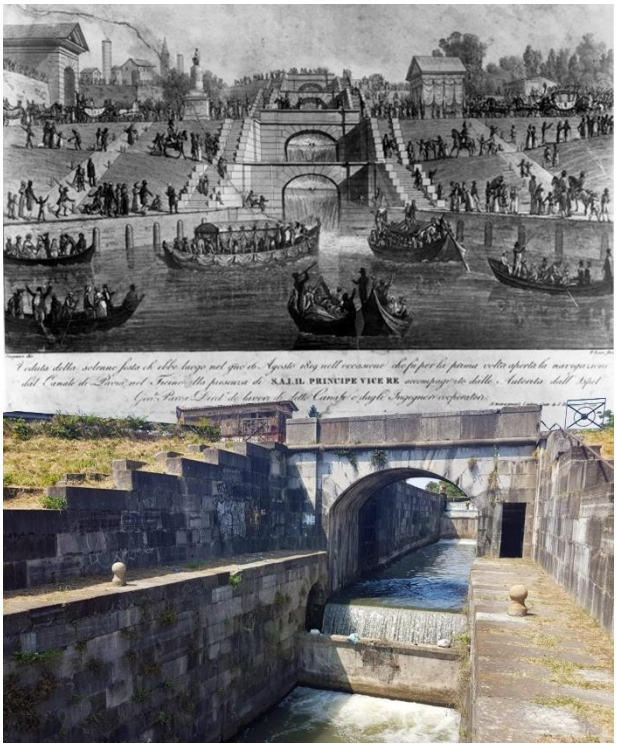

Fig. 2: Naviglio was an important route of trade and communication. Today, it has lost its original role, no longer playing the strategic function for the local economy.

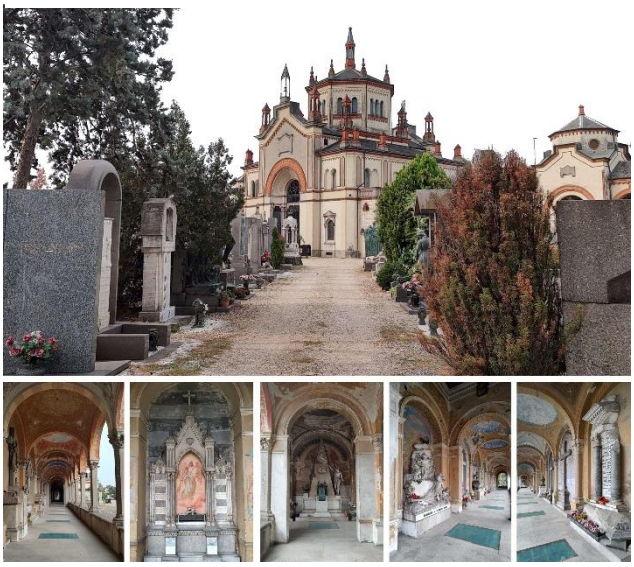

Fig. 3: The Monumental Cemetery of Pavia hosts numerous monuments of historical and artistic value. The chapels within it reflect the evolution of funerary taste and offer a insight into the city's history.

[8] The main ones include Conca Cairoli, located close to the square of the same name, once fundamental for regulating the water level; Conca Botanica, adjacent to the Botanical Garden, stands out for its strategic position, connecting the Naviglio to the scientific and cultural heart of the city; Conca Garibaldi, close to one of the city's main thoroughfares, and Conca del Confluente, located at the point where the Naviglio meets the Ticino, testify to the essential role of these structures for commercial water control.

[9] The central boulevard of Pavia's Monumental Cemetery contains burials of famous figures, such as Camillo Golgi, the first Italian to receive the Nobel Prize for Medicine. In the perimeter galleries, chapels tell the stories of city families that marked different eras, including Risorgimento battles, world wars and successful employers, some of whom now have no heirs.

Despite its value, the Monumental Cemetery suffers from an ambivalent perception: on the one hand, it represents a space of veiled memory, intimately linked to the private dimension of mourning; on the other, its public function as a place of historical and artistic reflection often appears undervalued. The low valorisation of the funerary heritage, coupled with reduced public awareness, risks depriving the community of an important tool to connect with its past. Promoting a new narrative of the Monumental Cemetery that enhances its symbolic and cultural dimension could be a way to give it back the centrality it deserves[10].

4. *Educating Pavia's Minor Heritage through digital innovation*

The safeguarding of the minor historical heritage cannot be separated from an education that is able to inspire an emotional and personal involvement with cultural heritage. The only way to emphasise the importance of these places and objects is to promote a 'sentimental' education that focuses on the ability to 'see' heritage not only as a collection of objects to be preserved, but as living witnesses of shared histories, identities and values (Montanari, 2023). This approach starts from the awareness that to appreciate and protect cultural heritage, it needs to become part of the affective and cognitive experience of the community. Minor heritage education, in this sense, represents a challenge and an opportunity[11]: In the first case, it requires a paradigm change, shifting the focus from material conservation to the construction of a meaningful link between people and places of memory; in the second case, it offers the possibility of rediscovering the value of often forgotten assets, giving back to the community living resources for the present and the future[12]. Promoting education on minor historical heritage therefore means adopting an interdisciplinary and flexible approach, capable of integrating innovative methodologies and traditional tools (Borucka et al., 2024). It is necessary to develop training paths that stimulate not only the acquisition of technical and operational skills, but also the ability to interpret heritage as an open narrative, in which everyone can find his or her own space of meaning (Kowalski et al, 2024). Within this perspective, education becomes a fundamental tool to create an aware cultural citizenship, able to recognise the value of assets that, although not monumental, represent the living network of communities and the shared memory of places and people. Education, however, cannot be limited to the acquisition of practical skills. It must stimulate deep reflection on the cultural and social value of these assets, encouraging active and conscious participation. Students need to be enabled to see heritage not as a collection of fragments of the past, but as a living and dynamic resource that contributes to the construction of collective identity and requires a shared commitment to be preserved and enhanced. In the context of disciplines related to the representation and digitisation of historical heritage, teaching methods of knowledge and safeguarding historical artefacts represents a crucial challenge in contemporary education. Integrating the theoretical dimension with practical tools and advanced technologies allows students to develop not only technical, but also critical skills, which are fundamental for dealing with the complexities of cultural heritage (Ippoliti & Parrinello, 2023; Condorelli et al, 2024).

These approaches have not only shown to provide an opportunity to improve educational processes but have also made it possible to link practices such as drawing, documentation and digital modelling. Through the integration of technological tools and traditional methodologies (D'Agostino & Antuono, 2022; Giovannini, 2024), it is possible to build itineraries that connect education and research, theory and practice, ensuring a more complete and articulated understanding of heritage. While didactics has identified contents and methods, research has

[10] Since 2019, there have been many territorial initiatives that attempt to bring citizenship closer to the funerary heritage of the monumental cemetery, confirming the institutions' intention to enhance local cultural assets. For an approach, see Un Museo a Cielo Aperto. Una visita guidata allo storico Cimitero Monumentale di Pavia

[11] Heritage protection is closely linked to the achievement of Target 11.4 of Goal 11 of the 2030 Agenda for Sustainable Development, which aims to intensify efforts to protect and preserve the global cultural and natural heritage. Furthermore, heritage-oriented education contributes significantly to the achievement of Goal 4 (Quality Education) and indirectly to Goal 8 (Decent Work and Economic Growth) by promoting educational pathways that can foster the creation of new job opportunities and the development of innovative skills. For more on this, see The 17 GOALS of the 2030 Agenda for Sustainable Development

[12] See the National Plan for Heritage Education.

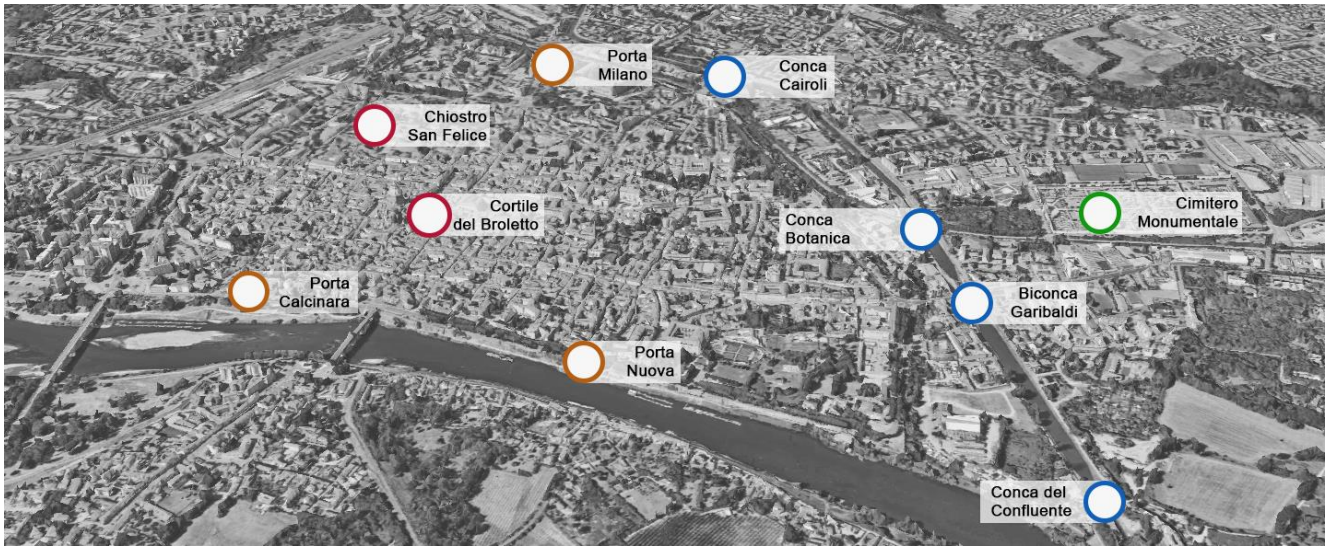

Fig. 4: The Unknown Pavia research project considered some examples of minor historical heritage, fragmented within the city, allowing to observe their specificities and to reflect on their value within the urban narrative

proposed to provide effective solutions for the understanding of Cultural Heritage.

Structuring an educational method useful to stimulate in students a change in the perception of the historical, cultural and social value of Pavia's minor heritage, an interdisciplinary research project was devised for the digitisation of historical artefacts in the urban fabric of the city. The "Unknown Pavia" project involved teachers, researchers and students along a path structured in different modules, each aimed at providing specific skills, developing a critical sense of digitisation principles and fostering a deep understanding of the theoretical principles and practical techniques related to digital modelling and representation. In planning the activities, theoretical lectures were alternated with practical research actions to directly link the concepts acquired in the former with the techniques of the latter.

The first phase of the project involved the selection of representative case studies of Pavia's Minor Historical Heritage, chosen for their historical, architectural and identity relevance. The students worked on four categories of assets: the cloisters of San Felice del Broletto, some historical chapels in the oldest part of the Monumental Cemetery, the Naviglio Pavese canal with some historical locks, and the three monumental city gates (Fig. 4).

4.1. Historical research for understanding case studies

The initial phase of the project emphasized the value of historical and archival research, essential elements for a thorough and informed knowledge of the assigned case studies. Through the analysis of documents, technical drawings, historical maps and bibliographic sources, the activities were aimed at learning about the historical, architectural and cultural context of the minor heritage asset. This preliminary work allowed students to understand not only the physical and stylistic features of the buildings and structures analyzed, but also the social and cultural dynamics that shaped their material existence. The students, guided by professors and researchers, explored local archives in the city of Pavia and consulted primary and secondary sources. These materials represented an essential first support for the subsequent design phases, but also a tool to encourage critical reflection on the historical stratification and symbolic meaning of the studied heritage (Santagati et al, 2020). Thus, understanding the historical context proved to be fundamental to interpret the value of these minor assets and to guide the process of representation and valorization.

4.2. Digital representation actions and virtual reconstruction

After obtaining preliminary knowledge through historical research, activities were oriented toward the digital representation of the heritage. Before the archival drawings could be transferred to the CAD environment, it was necessary to carry out a thorough analysis of their geometries, architectural details and technical features. As many of these graphic sources are

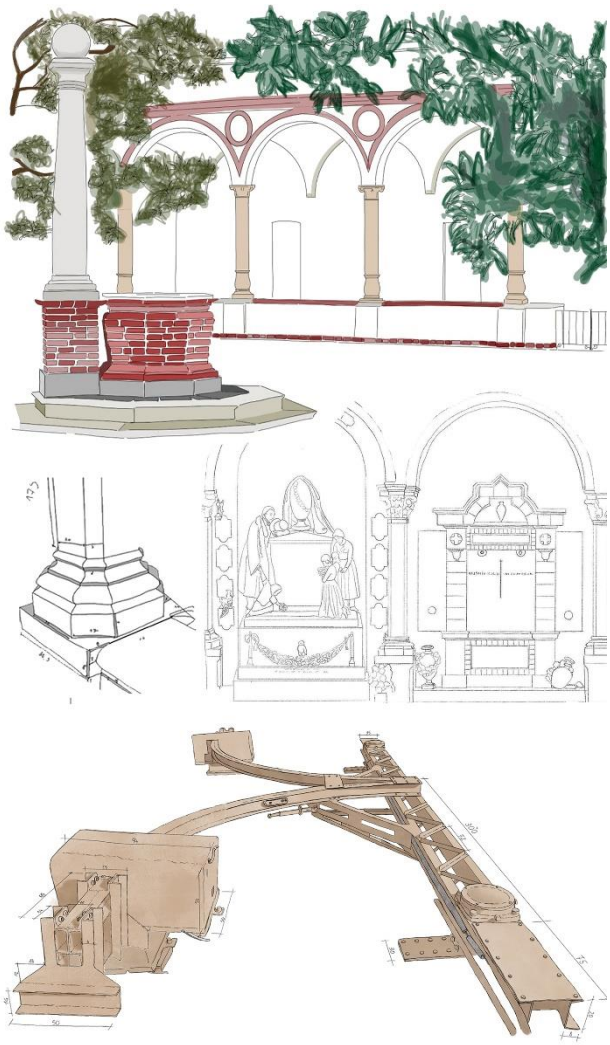

Fig. 5: Eidotypes and sketches made it possible to understand the spatial qualities of the sites and the composition of their elements, providing a foundation for the subsequent stages of digital representation and interactive design.

dated, incomplete or distorted, a critical reading was required to reconstruct plausible morphologies and proportions. Based on this preliminary analysis, a staged survey strategy was devised to reconcile historical evidence with an up-to-date metric description of the objects. The first operational step was a direct *in situ* survey. Working within a provisional Cartesian grid fixed to well-preserved orthogonal wall lines[13], students recorded absolute distances (wall thicknesses, bay spans, column heights) using calibrated tapes and handheld laser distance meters. In order to provide the maximum reliability of the digital representations, surveys were conducted on the sites under study, verifying directly in the field what was reported in the historical documents, supplementing missing information, and clarifying details that were barely legible or incomplete in the archival drawings. During the visits, special attention was paid to reading construction details, such as connections between different architectural components, materials used and construction techniques. In the case of the locks of the Naviglio, the surveys proved essential to also analyse the mechanical aspects of the hydraulic elements, supporting structures, and to understand how the water flow was regulated (Fig. 5). Although the campaign was intentionally elementary, it supplied two critical assets: (i) a minimum set of control baselines against which the historical drawings could be verified, and (ii) the dimensional ground truth needed to scale subsequent photogrammetric models. For many participants, the exercise also provided an initial introduction to metric surveying protocols.

Information collected were discretized into digital representations useful for subsequent three-dimensional modelling, highlighting the importance of an integrated approach that combines archival analysis, field verification and technical representation skills in a CAD environment. Following the subdivision into teaching modules useful for pursuing the specific training objectives of the course[14], activities of digital 3D modelling of historical artifacts was divided into two specific activities: the first one dedicated to geometric modelling from two-dimensional drawings, the second one dedicated to photogrammetric acquisition and processing activities. Starting from the vectorised orthographic views obtained by redrawing the

[13] The grid origin was fixed to the most rectilinear available stone corner on site. Two orthogonal axes were projected onto the adjacent wall faces and a vertical axis was set using a plumb line. All direct distances were recorded in the XYZ frame and the same control baselines were used to scale and rigidly align the SfM point cloud. This meant that archival drawings, direct surveys and photogrammetry all shared identical coordinates.

[14] The aim of the course is to provide a range of operational possibilities to produce three-dimensional, geometric and parametric digital models, highlighting the iterative potential of the different representations. The course analyses the problems related to the production of renderings, flanking the learning of the themes related to the production of 3D digital works with a process of knowledge construction related to the development of media languages for the virtual narration of architecture. In this way, the student acquires a solid grounding in the fundamentals of 3D modelling, the integration of digital media and the development of realistic representations.

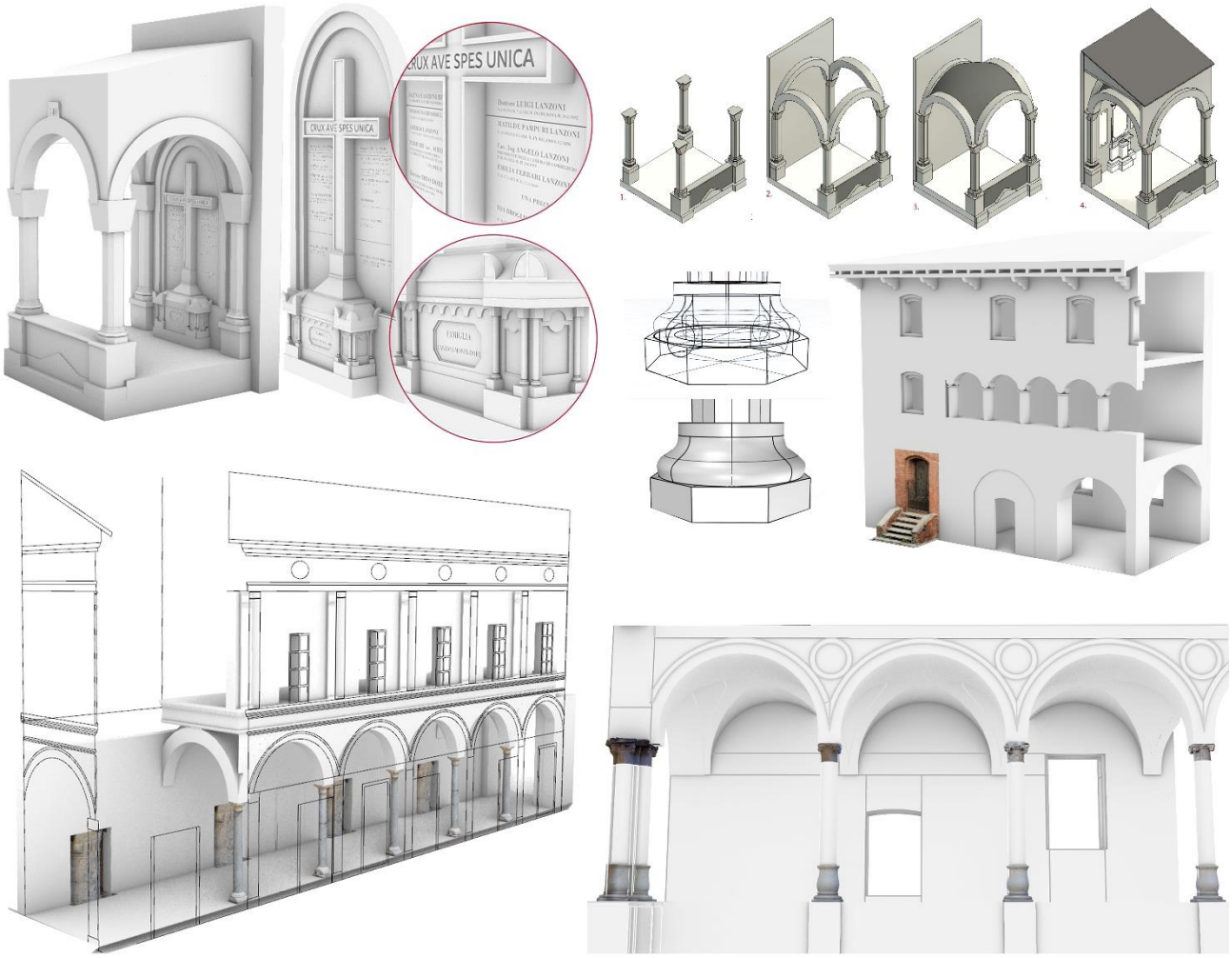

Fig. 6: Hybrid NURBS-mesh modeling applied to the case studies. Using a NURBS model makes it possible to describe the shape of the architectural object with simple polysurfaces, while mesh models, derived from photogrammetric processing, enable a deeper level of detail for more complex elements

archival sheets, each regular architectural component (walls, cornices, barrel vaults) was rebuilt as a parametrically controlled NURBS surface whose control vertices were constrained by the verified dimensions collected on site, ensuring metric rigour and facilitating later semantic segmentation of the model. For Structure-from-Motion (SfM) photogrammetry, photographic set was acquired[15] and processed through the standard SfM pipeline (image alignment, sparse and dense point-cloud generation, triangular mesh reconstruction and texture mapping), yielding dense clouds characterised by a mean point spacing of 2–3 mm. Absolute dimensions were imposed *a posteriori* by constraining the model to the control measures collected during the direct survey, with a residual scaling error below 5mm; this ex-post scaling justifies the definition of the procedure as semi-automatic rather than fully automated.

The two modules allowed testing two different types of modeling (manual and semi-automatic), acquiring advanced skills in handling digital tools. The digital modelling process included the use of hybrid techniques (Parrinello et al, 2021; Picchio & Pettineo, 2023), combining NURBS for regular surfaces and mesh modelling, derived from photogrammetric processing, useful for handling more organic and irregular elements (capitals, sculpted pedestals and statuary). The integration of these two techniques allowed for three-dimensional models capable of integrating both the technical accuracy required for geometrically complex architectural components (Fig. 6) and the

[15] During the acquisition, students used digital camera was employed following a convergent shooting scheme that guaranteed > 70 % image overlap and an average base-to-distance ratio of 0.4.

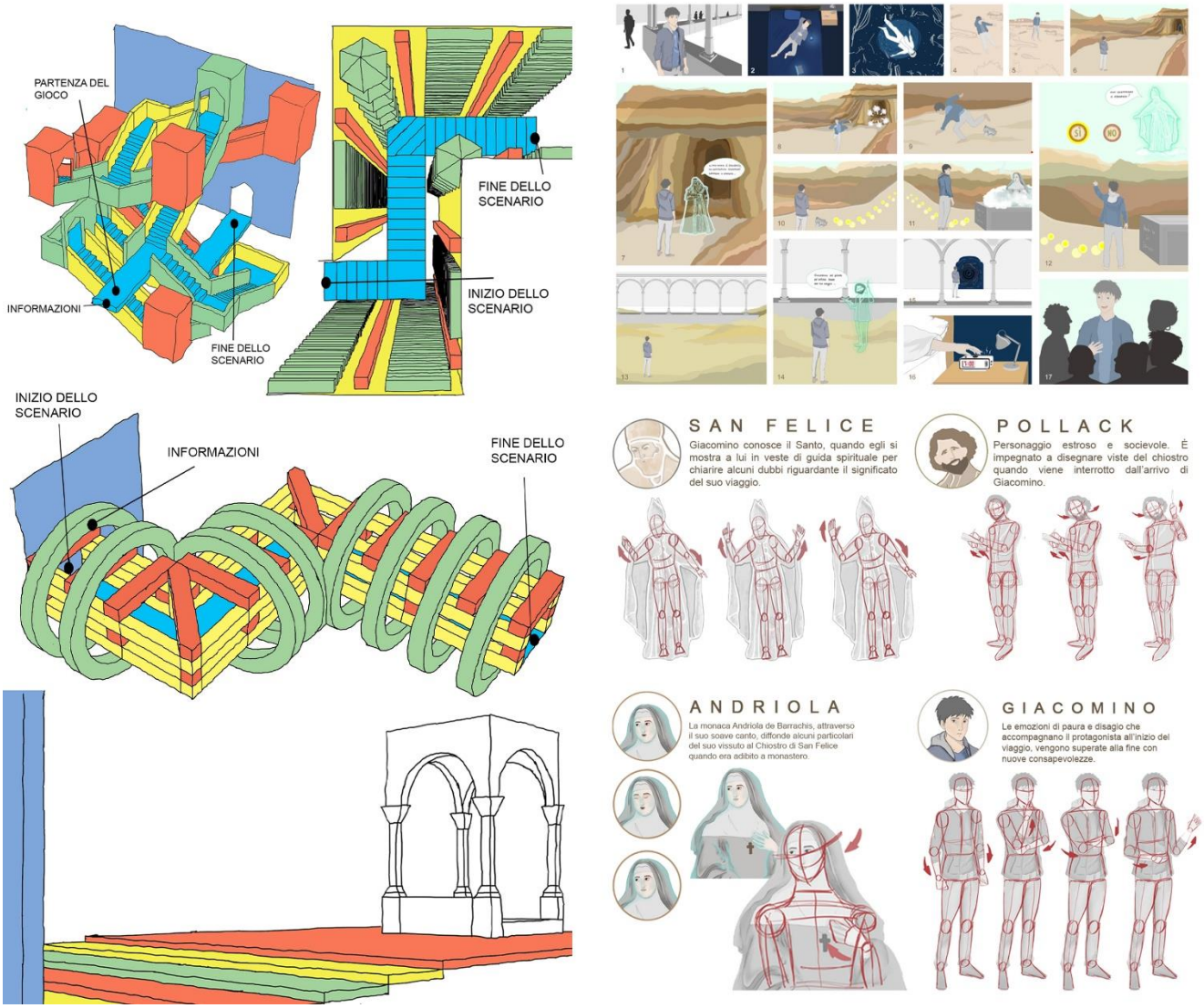

Fig. 7: On the left, multi-level visual storyboard shows the paths the user must follow to reach the final objective, forming a labyrinthine structure. Graphic layout, inspired by narrative of Squid Game saga, highlights the relationship between spatial constraints and game progression, suggesting a strategic interaction with the digital environment. On the right, graphic storyboard based on an original narrative. Digital characters were integrated into the game interface to handle dialogues with the user. Each character was designed with specific animations for facial expressions

authenticity needed for the unique features of the artifact.

4.3. The use of gamification to enhance Heritage

The final phase of the research involved the use of gamification as a tool for cultural heritage enhancement, transforming 3D models into interactive environments. As part of this research, it was crucial to analyse the role of video games as a medium for cultural mediation, identifying innovative methodologies to make the experience of minor historical heritage accessible and immersive. To explore these aspects in more depth, study days were organized dedicated to the scientific analysis of video game dynamics, where key concepts such as interaction and interactivity (Maietti, 2017, pp. 68-69), the impact of the graphical interface and the construction of a sense of immersion, as well as the differences between traditional video games and serious games (Pescarin, 2020) were examined.

The research explored how the principles of interactive storytelling can be applied to the transmission of historical-architectural knowledge, making serious gaming an experimental model of learning and dissemination (Fig. 7). One of the central aspects of the research was the study of narrative structures and ways of representing heritage in virtual contexts. Story construction and choice of viewpoints were

critically analysed, highlighting the differences between linear and nonlinear storytelling and the most effective strategies to stimulate user engagement. In particular, the concept of interactivity as an element capable of amplifying communicative effectiveness was explored, transforming heritage enjoyment into an active exploratory process rather than a mere transmission of content (Maietti, 2017).

The role of virtual environment design was also investigated, with a focus on methods of transposing architectural heritage within digital scenarios and visualization and interaction techniques that enable greater accessibility and understanding of content (Fig. 8).

The construction of the visual storyboard (Cajelli & Toniolo, 2018) was addressed as a crucial phase of the development process, not only for the definition of the plot and characters, but also to determine how the heritage could be narrated effectively and consistently with the interactive dynamics.

Fig. 8: Definition of immersive atmosphere of the virtual environment. Lighting and material settings are a decisive element for user involvement.

The implementation process included an initial optimisation phase of the game environments. The digital architectures were placed within digital maps and subsequently enriched with scenic elements, textures consistent with real materials and volumetric assets to ensure an immersive and realistic atmosphere. Particular attention was paid to lighting, shadow definition and environmental effects, such Particular attention was paid to lighting, shadow definition and environmental effects, such as ambient sounds or atmospheric conditions, in order to increase the user's spatial perception and stimulate his cognitive and emotional involvement (Gatto & Semeraro, 2024).

The most relevant element was the transition from conception to implementation of the virtual environments (Fig. 9), a phase that required the development of strategies to integrate the 3D models with the interactive game dynamics.

The various prototypes developed as part of the experimentation demonstrated the versatility

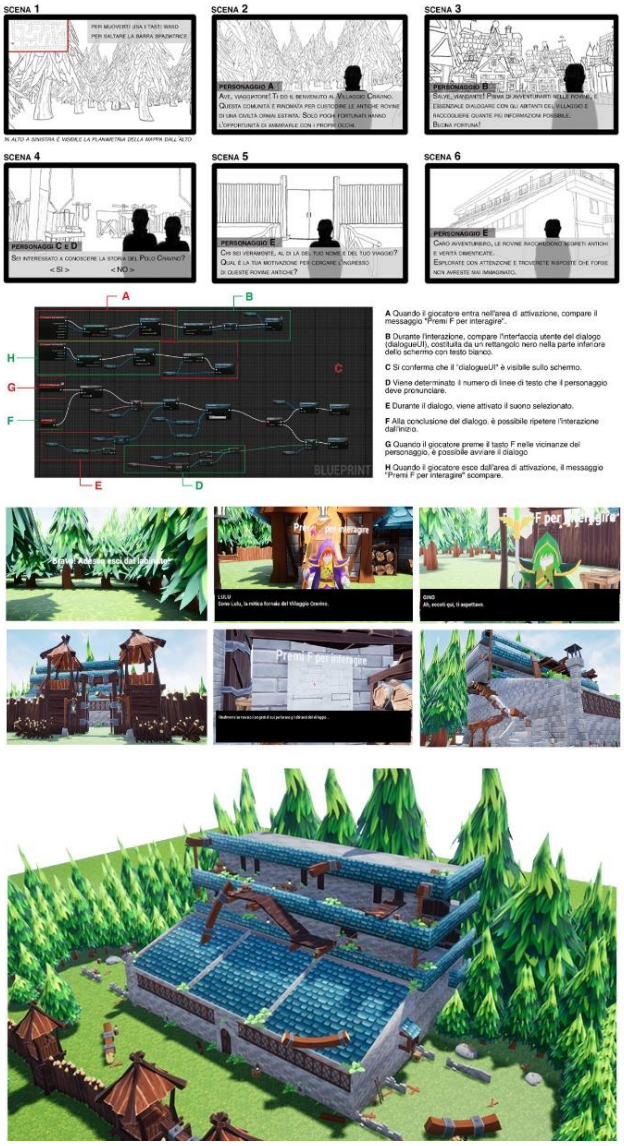

Fig. 9: To practical implementation in Unreal Engine. Thanks to visual programming, it was possible to transform the graphic concept into an interactive experience, streamlining the development process and enabling experimentation with creative solutions

of visual programming technologies in creating immersive experiences[16].

For interactive programming, a visual programming system was used that allows the construction of complex dynamics without the need to write code. Within this environment, specific game mechanics were created, including interactions with objects, dialogues with virtual characters, guided exploration paths and mini-games designed to incentivise the user to complete certain tasks or solve puzzles (Figg. 10, 11). These elements required a detailed mapping of the game's behavioural logic and the design of conditional events capable of generating dynamic reactions according to the user's actions. Programming proved to be a key field of inquiry in understanding the ways of interacting with digital heritage, highlighting the potential for both guided and exploratory experiences. The results revealed two main types of digital fruition: structured virtual tours and open-site explorations.

The first were designed as guided tours through digitally reconstructed architecture, enhanced by interactive points of interest

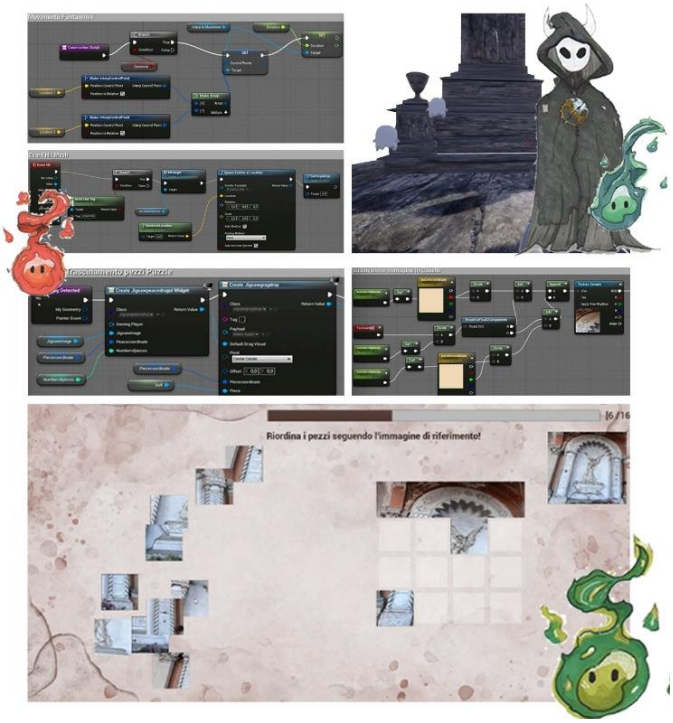

Fig. 11: Use of Blueprints for the design of mini-games integrated into the serious game, which can be activated as narrative challenges to be overcome in order to achieve the final objectives of the interactive experience

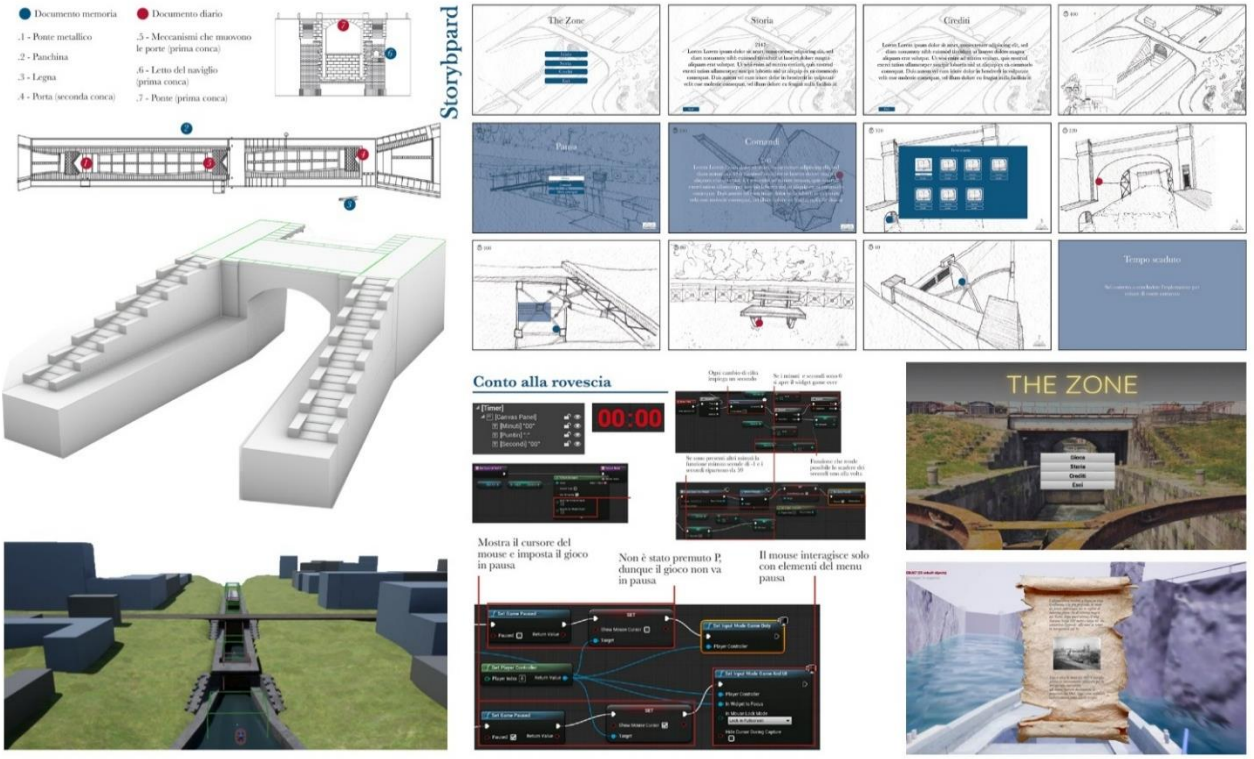

Fig. 10: Project development sequence: from the initial narrative concept to the storyboard, three-dimensional modelling, setting with materials and lighting in Unreal Engine, visual programming and the final version of the video game.

[16] In the context of the teaching project, students were taught the use of game engine software, with a particular focus on Unreal Engine 4.27. This platform was chosen for its combination of advanced functionality and relative ease of use, thanks to its visual scripting tools, which made the interactive design process more accessible even for those with limited technical skills.

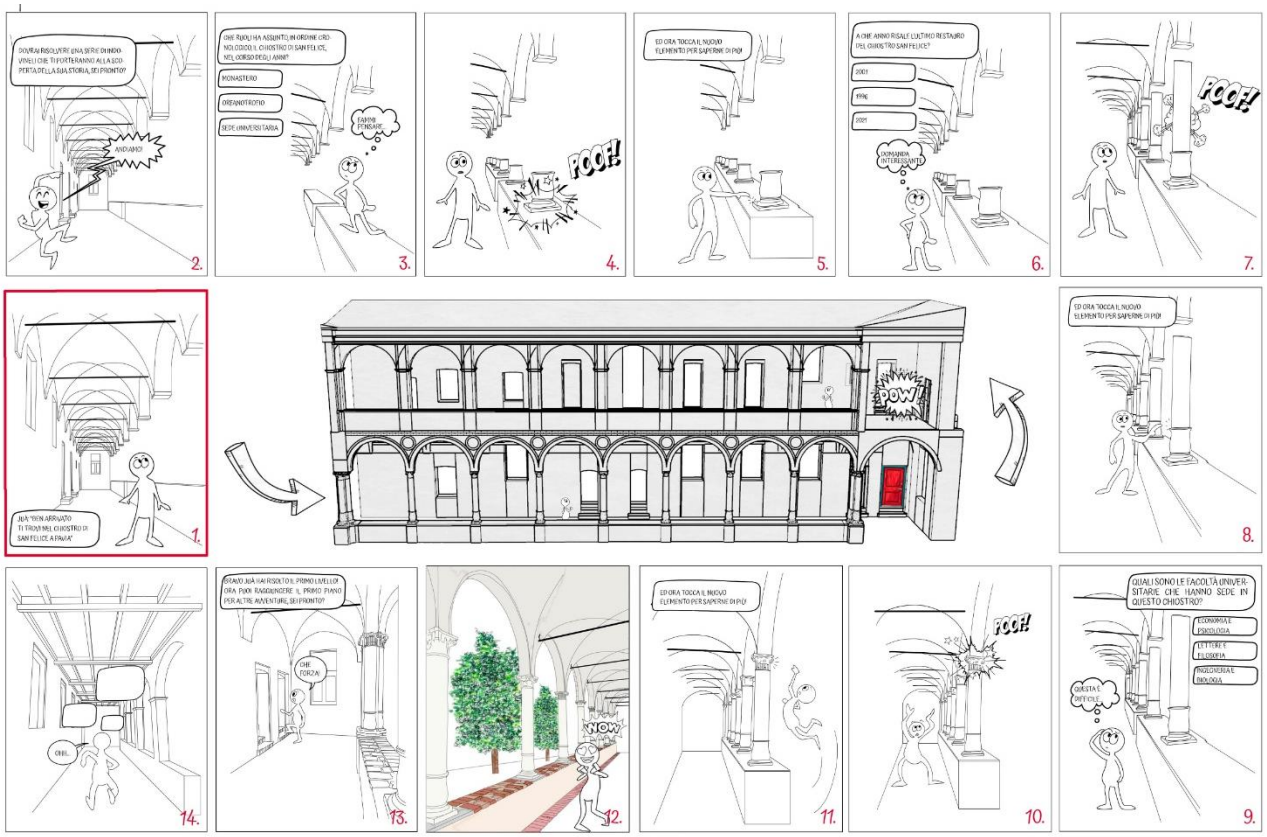

Fig. 12: Graphic structuring of the video game storyboard. The diagram illustrates the sequence of scenes, outlining the narrative path and the presence of the character who accompanies the user throughout the story.

containing historical, artistic and stylistic information presented through text, images and multimedia content. In contrast, open environments offered a more dynamic and free experience, promoting direct and non-prescriptive interaction, with the use of visual and sound elements to guide the player in the exploration of heritage.

5. *Heritage Level Up, experimental outcomes*

This research contributed to extending the debate on the potential of serious gaming in the communication of cultural heritage, demonstrating how digital interaction can represent a concrete opportunity to experiment with new languages of enhancement and dissemination (Parrinello, 2024). The results obtained suggest further developments in the field of academic research, exploring the role of gamification not only as an educational tool, but also as a means of critical interpretation of heritage.

In addition to classifying the two main interaction models, qualitative feedback was collected during final presentations and internal peer review sessions involving students and tutors. Many students reported a high level of engagement, particularly in tasks involving environmental customisation and interactive scripting. They perceived these tasks as opportunities to experiment with creative autonomy and technical problem solving. However, difficulties in managing the logical consistency of the game flows emerged, particularly in the design of conditional behaviours and adaptive responses. These limitations were primarily caused by the students' varied digital skills and the limited time available for full development (Figg. 12, 13). Despite these constraints, the testing phase demonstrated that even prototype-level applications could effectively support educational objectives and foster a renewed perception of heritage spaces. These results suggest interesting possibilities for future developments, such as integrating user analytics to monitor real-time interaction patterns and implementing cross-platform distribution to reach a wider audience beyond the academic context.

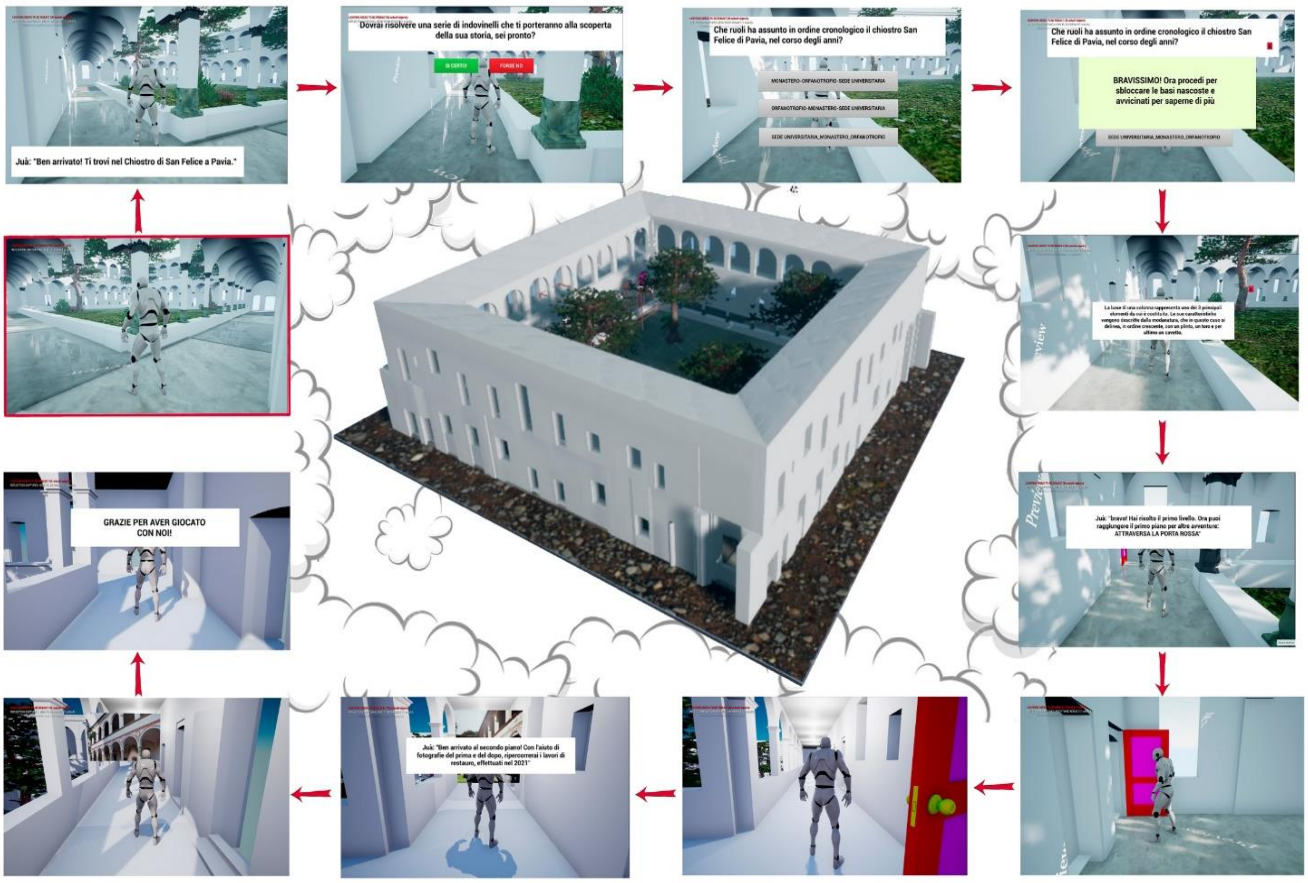

Fig. 13: Graphic structuring of the video game interactive 3D transposition. The 3D representation graphically and spatially translates the storyboard, turning the narrative into an interactive environment that fosters an immersive and participatory experience.

6. *Analysis and future perspectives*

The research demonstrated the potential of interdisciplinary methodologies applied to the enhancement of minor historical heritage, outlining replicable strategies for the documentation, interpretation and dissemination of cultural content in academic and professional settings. The integration of historical research, architecture and digital tools allowed the exploration of new ways of heritage representation and fruition, fostering an innovative approach to cultural preservation and communication.

Analysis of the results[17] showed how this experimentation can contribute to the development of advanced training models, laying the basis for research paths that cross disciplines. The use of digital tools was not only an operational support, but a means to rethink the relationship between heritage and society, stimulating a dialogue between tradition and innovation. The approach taken can provide a methodological reference for future studies in the field of heritage education and science dissemination. From an academic aspect, the research has provided useful data for the refinement of learning strategies based on the interaction between theoretical skills and practical applications. The combination of historical documentation, digital tools and interactive design has made possible a better understanding of the processes of heritage transformation and its communicative potential. This model, applicable to different contexts, suggests new perspectives for the training of specialists in the field of preservation, cultural

[17]In total, the project resulted in 21 digital products, equally divided between interactive applications and serious games. The balanced distribution between the two types of products allowed the theme of cultural enhancement to be approached from complementary perspectives, providing both informative and experiential tools, capable of meeting the needs of a heterogeneous audience.

communication and design of digital heritage environments. At the societal level, research findings point to a possible evolution of accessibility to minor heritage, exploiting digital solutions to broaden fruition and engage new audiences. Pavia's minor historical heritage, which is currently undervalued, could be rediscovered and reinterpreted through innovative tools that promote its integration into the daily life of the community. Although the implementation of digital applications is still being evaluated, their potential impact suggests new scenarios for public awareness and participation. Interaction with cultural content, made possible by immersive and interactive experiences, could strengthen the link between the community and heritage, stimulating an active and conscious perception of local assets. This perspective opens new possibilities for the application of research, laying the basis for further developments in the field of cultural mediation and heritage enhancement strategies through digital tools.

7. Conclusions

The digital applications created as part of the "Unknown Pavia" project are a concrete example of how technology can be integrated into education to promote a deeper and more participatory understanding of minor historical heritage. The success of the project also underscores the role of digital technologies as a bridge between cultural heritage and communities. In the specific case of Pavia's minor heritage, the use of interactive applications, such as serious games, offered the opportunity to make often forgotten places and assets accessible and engaging. These tools not only allow heritage to be explored in new and creative ways but also foster greater awareness of the importance of preserving and enhancing collective memory. Dialogue with local communities needs to emerge as a key element in this process. Technologies, however advanced, must be put at the service of people, facilitating a path to reappropriation and rediscovery of heritage. Through interactive experiences, people can develop an emotional connection with their cultural heritage, transforming these assets from static and neglected elements into living and dynamic resources. This connection is crucial for stimulating a sense of shared responsibility and promoting collective action for their safeguarding.

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