

Cultural Heritage at a Crossroads

**Sustainable Development
and Digital Transformation**



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Fostering Outreach
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Cultural Heritage at a Crossroads

Sustainable Development and Digital
Transformation

Mar Gaitán & Arabella León
(coords.)



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ISBN: 978-84-9133-851-2 (paperback)
ISBN: 978-84-9133-852-9 (PDF)
Legal Deposit: V-223-2026

DOI: <http://dx.doi.org/10.7203/PUV-OA-9788491338529>

Digital edition

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Introduction

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It is our pleasure to introduce this volume, which emerges from the Blended Intensive Programme *Challenges in Cultural Heritage: Sustainable Development and Digital Transformation*. This collaborative initiative was developed within the framework of the FORTHEM Alliance, a European University consortium dedicated to fostering international cooperation, and brought together students, scholars, and professionals from across Europe and beyond. They were united by a shared purpose: to understand how cultural heritage—one of humanity's most valuable and vulnerable assets—can be responsibly managed in the midst of rapid technological change and increasing global pressures.

The idea for this book grew organically from the programme's interdisciplinary and international nature, a direct reflection of the FORTHEM spirit. Conceived and delivered through a vibrant partnership between the University of Palermo (Italy), the University of Burgundy (France), the University of Valencia (Spain), and Lucian Blaga University of Sibiu (Romania), the programme created a unique microcosm of European academic exchange. Over several days of lectures, discussions, workshops, and collaborative activities, participants encountered a rich array of ideas that reflect the evolving landscape of cultural heritage management. This exploration was hosted in the exceptional setting of Valencia, a city where centuries of cultural tradition coexist with contemporary innovation. Whether participants joined us in person in its historic streets or connected virtually from abroad, all became part of an enriching academic community shaped by diversity and curiosity. Valencia served as a living case study, reminding us that the past is not static but constantly reinterpreted through the lens of present needs and future aspirations.

The chapters and materials compiled here reflect the central themes of the programme, examining the intertwined relationships between cultural heritage, sustainable development, and digital transformation. Through theoretical frameworks, case studies, and practical demonstrations, contributors address pressing questions: How can we safeguard cultural assets while fostering resilience? How do digital tools—from imaging technologies to interactive platforms—reshape the ways we document, analyse, and communicate heritage? Some chapters examine the vulnerabilities of heritage and the policies required to protect it, while others highlight the potential of digital tools to expand access and deepen understanding. Together, they demonstrate that heritage work must be situated at the crossroads of tradition and innovation.

We are particularly proud of the collaborative spirit that underpins this publication, a testament to the core mission of the FORTHEM Alliance. Participants from different academic backgrounds, cultural contexts, and professional trajectories enriched discussions and encouraged new ways of thinking. This intercultural dialogue is reflected in the diverse voices found in these pages, confirming that the future of cultural heritage depends not only on technological advancement but also on shared learning and a commitment to cooperation.

As editors and educators, our aim has been to curate a volume that is not only informative but also inspiring. We hope that the insights gathered here will serve as a valuable resource for students, researchers, heritage professionals, and all those interested in the evolving challenges of the 21st century. More than a record of a successful educational initiative, this volume aims to contribute to a broader conversation—one that recognises heritage as a dynamic, living element of society.

It is our wish that readers find in these pages not only knowledge but also inspiration: to question, to innovate, and to participate in shaping a future where cultural heritage continues to enrich communities across the world. We invite you now to explore the pages that follow—pages shaped by curiosity, collaboration, and shared commitment of the FORTHEM alliance and its partners to understanding and sustaining the cultural heritage that enriches our world.

Mar Gaitán
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Co-Creation as a Transdisciplinary Practice: Knowledge, Sustainability, and Cultural Meaning in Work, Art, and Education at the Universitat de València

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Abstract

This article examines the concept of co-creation as a framework for understanding the ethical, artistic, and civic dimensions of university culture. Tracing its evolution from participatory design to applications in innovation management and transnational cultural studies. The article argues that contemporary co-creation not only reconfigures relationships among users, institutions, and communities, but also demands an epistemological reconsideration of knowledge circulation and distributed agency. The case of the Universitat de València demonstrates how integrating artistic heritage, participatory cultural programming, and contemporary creation fosters co-creation between academia and society, promoting cultural rights and knowledge transfer.

Keywords: co-creation; university culture; cultural rights; heritage; knowledge transfer; Universitat de València

1. Introduction: Co-creation, University Culture, and the Ethics of the Common Good: A Transdisciplinary Perspective

This article examines the evolution of the concept of co-creation as a multidisciplinary notion that connects design, innovation, and cultural studies, situating it as a framework to understand contemporary university culture. Building on the work of Sanders (2005), Seppä and Tanev (2011), and Szulc (2022), it analyses how participatory design, open innovation, and transnational cultural frameworks converge into a shared epistemology of collaboration. Over the past two decades, co-creation has shifted from a user-centred strategy to a paradigm for innovation, cultural production, and ethical, social, and artistic sustainability. This expansion reflects an epistemological shift: creativity and innovation are no longer understood as linear processes within bounded disciplines or institutions but as distributed, dialogical, and transnational phenomena, where artists, designers, and communities act as interdependent agents within complex networks of meaning, technology, and exchange. Thus, co-creation is conceived not only as a methodological tool but as an ontological stance that redefines agency, authorship, and knowledge circulation.

The study proposes a comparative and transnational methodology that analyses co-creation not merely as a design or management practice but as a cultural and ethical paradigm. Three key epistemological shifts are identified: from technique to meaning, from the enterprise to the ecosystem, and from the territory to the network. These changes reconfigure creative agency in artistic, social, and technological contexts, positioning co-creation as a driver of innovation and cultural sustainability.

In the university context, this perspective acquires ethical and civic relevance. As Bok (1982) noted, an authentic university transcends mere knowledge production, taking responsibility for

contributing to society, equality, and students' moral development. At the Universitat de València, the Vice-Rectorate for Culture and Society, through its University Culture Service—which integrates Culture, Heritage, and Society—embodies this mission through cultural policies aimed at democratizing access to knowledge and artistic creation, integrating teaching, research, and civic participation (Pusser et al., 2012). Following Whitehead (1929/1951), university culture is not the accumulation of data but a rhythmic experience between surprise, precision, and generalization, generating curiosity, intellectual discipline, and shared wisdom.

Programs such as *Activa Cultura*, *Activa Música*, *Activa Fest*, and *Residir en la Investigación*, alongside musical, theatrical, and dance groups, illustrate how co-creation materializes in university life. These initiatives foster active participation by students, faculty, and staff, consolidating university culture as a space for producing and circulating knowledge and cultural experiences, promoting creativity, belonging, and community cohesion (Tubillejas, 2025; Marginson, 2016). Within this framework, the university functions as a laboratory for collaboration, ethical innovation, and cultural sustainability, where co-creation integrates the artistic, social, and academic spheres in building a shared common good.

Initially associated with participatory methods in product development and human-centered design (Sanders, 2005), co-creation has since expanded into a guiding principle for innovation ecosystems (Seppä & Tanev, 2011) and a paradigm of cultural interdependence and decolonial knowledge production (Szulc, 2022).

This expansion reflects a wider epistemological shift: creativity and innovation are no longer understood as linear processes within bounded disciplines or institutions but as distributed, dialogical, and transnational phenomena. Artists, designers, and communities increasingly operate as interdependent agents within complex networks of meaning, technology, and exchange. Consequently, co-creation becomes not only a methodological tool but also an ontological stance — a way of conceiving agency, authorship, and knowledge as inherently relational.

The aim of this article is threefold:

- (1) to synthesize the conceptual evolution of co-creation from design research to transnational cultural studies;
- (2) to propose a methodological framework based on comparative and contextual approaches; and
- (3) to discuss how this integrated perspective may inform current artistic and cultural practices engaged in collaborative, sustainable innovation.

The discussion situates co-creation within the broader landscape of art and social innovation, considering both its productive and critical dimensions. It argues that the concept functions as a bridge between artistic practice and global knowledge systems, foregrounding participation, interdependence, and situated creativity as essential elements of a new humanistic and sustainable paradigm.

Methodologically, this article adopts a comparative and transnational framework (Szulc, 2022) articulated in three phases: (1) a systematic review of co-creation models in design (Sanders, 2005) and innovation (Seppä & Tanev, 2011); (2) a critical-discursive analysis of the concept's

expansion into cultural and decolonial studies, considering knowledge circulation among academia, industry, and communities; and (3) a conceptual synthesis guided by the principle of radical contextualism, which privileges situated, multiscalar interpretation over universal application of models.

This approach acknowledges the plurality of social, technological, and cultural contexts in which co-creation unfolds and emphasizes comparison without homogenization (Hepp & Couldry, 2009). The transversal reading of these sources allows co-creation to be understood as a multi-spatial phenomenon that oscillates between instrumental practice and cultural transformation, making it particularly relevant to universities as sites of knowledge production, civic engagement, and ethical innovation.

The approach is inspired by the *radical contextualism* proposed by Ang (1996) and extended by Szulc (2022), which calls for the situated interpretation of cultural phenomena within intersecting local and global frameworks. Rather than empirically testing co-creation as a single model, this research explores it as a meta-framework observable across art, design, and innovation. It integrates textual analysis, conceptual mapping, and selective case illustration to demonstrate how co-creation functions as a relational and transdisciplinary paradigm.

Following the tradition of *comparative cultural analysis* (Hepp & Couldry, 2009), the methodology emphasizes linkages rather than dichotomies—studying how practices of collaboration manifest across heterogeneous contexts without reducing them to a single theoretical scale. This approach aligns with the growing body of art-based and participatory research methodologies (Candy & Edmonds, 2018) that view creative processes as both methods of inquiry and knowledge production.

2. State of the Art: From Participatory Design to Transnational Co-Creation

2.1. Early Frameworks: Information, Inspiration, and Collective Creativity

The term co-creation has become central in contemporary theories of innovation and collaboration. Initially introduced in business and marketing to describe value generation between firms and customers (Prahalad & Ramaswamy, 2004), it now traverses multiple domains—from the digital economy and cultural production to higher education and community development. This expansion reflects a paradigmatic shift from linear, hierarchical models of production toward relational, participatory, and sustainable forms of knowledge creation (Ind & Coates, 2013; Bouncken et al., 2023).

Understanding co-creation is challenging precisely because of its diversity of meanings and contexts. Philosophically and aesthetically, the concept has antecedents in dialogic theories of authorship and meaning (Ind & Coates, 2013). In organizational settings, such as coworking spaces, it denotes distributed work and open knowledge exchange (Bouncken et al., 2023). In the cultural and artistic industries, co-creation mediates relationships among artists, brands, and audiences (Baumgarth, 2018; Angelini et al., 2022). In education, it functions as a pedagogical methodology for building identity and resilience through collaborative creativity (Cerquetti et al., 2023). Across these domains, co-creation operates simultaneously as a cognitive process of

knowledge generation, a social process of community building, and an ethical process of shared responsibility.

The notion of co-creation has evolved from user-centred design frameworks to broader approaches emphasizing participatory and relational innovation. Sanders (2005) identifies this shift as moving from research that “informs” design to research that “inspires” it, situating collective creativity in the *fuzzy front end* of product development. Her model of design spaces—consume, experience, adapt, and co-create—anticipates the emergence of the user-creator as an agent seeking to balance consumption and creativity.

A decade later, Seppä and Tanev (2011) systematized co-creation as a management paradigm and an open innovation model. Within the service-dominant logic of marketing (Vargo & Lusch, 2004), they identify five research axes: general management, product development, virtual environments, service science, and international markets. Here, co-creation is defined as a participatory platform that reconfigures firm boundaries through multi-actor interactions and value networks. Szulc (2022) further expands the horizon of co-creation toward a transnational cultural ontology. His framework of radical contextualism and de-westernization emphasizes that all cultures are “already transnational,” understood as provisional assemblages across multiple scales and historical trajectories. In this sense, co-creation transcends design or corporate innovation, functioning as an epistemic and political practice of cultural interdependence.

The convergence of these perspectives delineates a hybrid field where participatory design, innovation management, and cultural studies intersect around a shared principle: the production of knowledge and value through situated, pluralistic collaboration.

Sanders’s seminal paper *Information, Inspiration, and Co-creation* (2005) marked a turning point in human-centered design research. She reframed the design process as an open and collaborative *fuzzy front end*, in which everyday people—no longer passive consumers—participate as co-creators. Sanders identified four converging shifts underpinning co-creation: (1) relocating research to early exploratory stages; (2) redefining users as participants; (3) moving prototyping to earlier, more improvisational stages; and (4) acknowledging people’s desire to balance consumption with creativity.

Within this framework, design spaces—consuming, experiencing, adapting, and co-creating—represent a progressive democratization of creativity. Co-creation becomes a bridge between professional and everyday creativity, foregrounding imagination, emotion, and experience as valid sources of design knowledge. For Sanders, the goal is not only to design better products but to design with people rather than for them, using generative tools and visualizations to externalize tacit knowledge.

In artistic contexts, this emphasis on generative participation resonates with participatory art practices from the 1990s onward, where spectators become co-authors of the aesthetic experience. The parallel between co-design and relational aesthetics (Bourriaud, 2002) underscores a shared logic of dialogic creation: meaning and form emerge through interaction rather than prescription.

2.2. The Cultural Turn: Transnational and Decolonial Reframings

Łukasz Szulc's *Culture is Transnational* (2022) extends the discussion of co-creation beyond economic and design logics into the domain of cultural epistemology. Drawing on cultural and media studies, Szulc argues that culture must be understood as inherently transnational—an assemblage of multiple, entangled scales rather than a stable, bounded national entity. This perspective carries significant methodological, ethical, and political implications: it calls for contextualizing dominant cultures, employing comparative analysis, and de-westernizing academic approaches.

By advocating radical contextualism, Szulc emphasizes the situated nature of meaning-making. As he writes, culture “is always already transnational” (p. 4); no culture is pure, and all cultural formations are co-created through historical, colonial, and migratory interrelations. The implications for co-creation are profound: collaborative design and innovation cannot be treated as universal or neutral processes but must be understood as contextually negotiated practices embedded in asymmetric global systems.

This transnational perspective situates co-creation within broader debates in decolonial and feminist theory, which challenge epistemic hierarchies and the privileging of dominant knowledge systems. Artistic and cultural projects that employ co-creative methods thus operate as spaces of translation and negotiation, where local and global imaginaries intersect. In these settings, the role of the artist or researcher shifts from that of a sole author to that of a mediator—facilitating encounters among heterogeneous knowledge systems and enabling collaborative, context-sensitive creation.

Synthesizing these three perspectives reveals a gradual broadening of co-creation's scope:

Dimension	Sanders (2005)	Seppä & Tanev (2011)	Szulc (2022)
Domain	Design and everyday creativity	Innovation management and value networks	Cultural studies and transnationalism
Actors	Designers + participants	Firms + users + institutions	Communities + cultures + epistemic positions
Goal	Empower imagination and participation	Generate shared value and innovation	Contextualize culture and decolonize knowledge
Outcome	Generative design methods	Ecosystemic innovation models	Transnational cultural praxis

The convergence of these frameworks suggests that co-creation operates as a meta-concept, linking material, social, and symbolic production. It articulates a new epistemology based on relationality, participation, and situated creativity. In the arts, this epistemology underpins practices where the artwork becomes a process rather than an object; in innovation, it drives sustainable ecosystems; and in cultural theory, it dismantles essentialist notions of authorship and culture.

Universities have historically functioned as sites for the production and circulation of knowledge. However, the contemporary university has expanded its role to encompass ethical responsibilities and cultural engagement within society (Bok, 1982; Marginson, 2016; Ruiz-Corbella & López-Gómez, 2019). In this context, the concept of co-creation captures a fundamental shift: from the university as an isolated producer of expertise to an institution that collaborates with communities, artists, and public organizations to generate cultural value collectively. Co-creation reframes notions of authorship, value, and participation, providing a framework for integrating heritage, art, and science into civic life.

This article develops a theoretical and methodological framework that links co-creation across design, innovation, and cultural studies—drawing on Sanders (2005), Seppä and Tanev (2011), and Szulc (2022)—and applies it empirically to the cultural policies and programs of the Universitat de València (UV). Founded in 1499, the UV has long incorporated cultural activity into its institutional mission. Through initiatives such as *La Nau*, *Activa Cultura*, *Cultura als Campus*, *Residir en la Investigación*, and *Art Públic*, the university demonstrates how artistic heritage and contemporary creation can be mobilized to transfer knowledge, extend cultural rights, and foster civic belonging.

Methodologically, this study combines comparative and contextual analysis with a transnational perspective, recognizing co-creation as both an ethical and epistemic practice. Within UV's cultural ecosystem, co-creation is not merely a managerial or operational strategy but an ethical stance aligned with the university's broader mission: fostering critical citizenship, creativity, social inclusion, and shared cultural value. In this sense, the university operates as a hybrid space where design thinking, participatory innovation, and cultural production converge, enabling collaboration between academic, artistic, and community actors.

By situating co-creation at the intersection of theory and practice, this framework highlights the university as a laboratory for civic engagement and ethical knowledge production, where culture functions as a living, participatory, and relational good that strengthens both individual and collective agency.

If in the last two decades, co-creation has evolved from a marketing concept into a cross-disciplinary paradigm encompassing management, cultural studies, and higher education, co-creation has since expanded into a relational and ethical principle that reframes authorship, value, and participation across multiple domains.

Ind and Coates (2013) define co-creation as a collaborative process in which organizations and stakeholders jointly produce meaning and value. Rather than treating audiences as passive consumers, co-creation engages them as active partners in dialogic meaning-making. They trace its intellectual roots to psychotherapy, critical theory, and design thinking, emphasizing reciprocity and mutual transformation. Drawing on Barthes's (1999) notion of the "death of the author," they argue that value should not be understood as property but as a co-constructed process in which creators, consumers, and institutions share authorship. This relational understanding aligns with the Service-Dominant Logic, which conceives value as co-created in use rather than embedded in products (Vargo & Lusch, 2004). But, Bouncken et al. (2016) extend co-creation to innovation networks, highlighting the balance between structure and openness required for effective creative collaboration. In cultural contexts, Baumgarth (2018)

conceptualizes it as a relational process that generates symbolic and emotional value through participation. In the arts, Angelini et al. (2022) show how artists' names and identities function as human brands within co-creative ecosystems, illustrating how authorship becomes distributed among multiple agents. Cerquetti et al. (2023) further argue that co-creation contributes to the sustainability of cultural heritage institutions by aligning organizational goals with community values. Together, these approaches reposition cultural production as a collective, iterative process rooted in dialogue, trust, and shared authorship—principles that resonate directly with the university's social mission.

These shifts point toward a collaborative epistemology, in which creativity, knowledge, and power circulate among multiple actors—designers, artists, users, communities, and geopolitical contexts. The future of co-creation, therefore, extends beyond technical innovation toward a cultural project of world co-production.

3. Knowledge creation, new work, and sustainability: Co-creation and the university mission

The university has historically balanced three missions—teaching, research, and service—but contemporary debates frame these within a “knowledge triangle” linking education, innovation, and cultural dissemination (Maassen & Stensaker, 2011; Paleari et al., 2015). Within this model, co-creation provides a mechanism for integrating knowledge transfer and cultural participation.

Marginson (2016) and Pusser et al. (2012) emphasize the public sphere as the arena where universities must operate ethically, connecting scientific inquiry with social transformation. From this perspective, culture becomes not a by-product but a strategic dimension of higher education—a means of enacting what Whitehead (1929/1951) described as the rhythm of education: wonder, precision, and generalization. Co-creation thus aligns with the idea of universities as common goods: institutions that produce not only employable skills but also civic imagination, empathy, and critical awareness.

Organizational studies expand co-creation into knowledge ecosystems. Bouncken et al. (2023) analyze coworking spaces as new work environments where knowledge creation and sustainability logics intersect. They identify patterns of inspiration, problem-solving, synthesis, and co-creation that emerge across different zones of coworking spaces. Their findings underscore that exposure to sustainability values within the workspace primes users' practices and affects how knowledge circulates. Importantly, coworking spaces highlight the spatial and social infrastructure necessary for co-creation: shared spaces, trust, community manifestos, and physical designs that embody values. In organizational studies, Bouncken et al. (2023) explore co-creation within the framework of *New Work* and coworking spaces. These environments dissolve traditional boundaries of hierarchy and spatial organization, fostering communities where freelancers and entrepreneurs share knowledge and resources. Their study identifies four modes of collaborative knowledge exchange—*inspiration*, *problem-solving*, *synthesizing*, and *co-creation*—each contributing to both innovation and sustainability.

Crucially, they find that sustainability is not merely an outcome but a *logic* that shapes how communities define value. Coworking spaces that embed sustainability in their manifestos and physical design enable deeper forms of trust and mutual learning. Thus, co-creation operates as

a mechanism of *social sustainability*: a practice of knowledge exchange rooted in community ethics and ecological awareness.

The Universitat de València (UV) has positioned cultural participation and co-creation as core expressions of its educational and civic mission. Through the Aules Culturals, the Vice-Rectorate of Culture and Society brings artistic and cultural programming across the university's campuses and into Valencian society at large. These spaces demonstrate that culture at the UV is not ancillary but a central, rigorous, and indispensable dimension of university life, articulated through programming that combines training, experimentation, and participatory engagement in artistic and humanistic fields.

Tubillejas (2025) stresses that university culture must move “from the seat to the stage”—from passive consumption to active engagement. UV's programs illustrate this shift by transforming students, faculty, and staff into cultural co-producers. Central to this vision is an understanding of culture as a practice of humanity and as an ethical commitment to the common good. Cultural initiatives are conceived not as entertainment but as acts of social responsibility and creative citizenship.

The *Centre Cultural La Nau* represents the historical and symbolic heart of the Universitat de València. Originally built in the 15th century as the university's sole teaching space, La Nau now serves as a cultural hub that connects memory with contemporary creativity. Its Gothic, Renaissance, and Neoclassical architecture houses the Historic Library, the Aula Magna, the Chapel of Wisdom, and multiple exhibition and performance spaces. Following the university's 500th anniversary, La Nau was reimagined as a public cultural center that bridges artistic heritage with present-day innovation. Through exhibitions, debates, concerts, and theater productions, it embodies the university's mission to integrate art, science, and civic dialogue. La Nau thus becomes both museum and agora: a place where heritage is activated through public discourse and creative participation.

The Aules function as transversal learning spaces, offering lectures, workshops, and performances that extend knowledge beyond the formal curriculum. By promoting itinerant cultural programming across campuses, they foster active student participation and engagement with the surrounding community. These initiatives exemplify how universities can expand the educational experience toward ethical dialogue, pluralism, and social commitment through art and cultural practices. In this way, the UV's cultural policy embodies a pedagogy of the common good, where art and education converge in a shared practice of civic responsibility.

The Aules also operate as laboratories of creation and co-creation, integrating diverse disciplines—music, theater, dance, cinema, comic arts, narrative, poetry, gastronomy, history, and democratic memory—into continuous programming that transforms campuses into vibrant cultural spaces. Students, faculty, and citizens converge in these spaces, participating in collaborative learning, research, and creative processes that extend well beyond formal instruction. Here, co-creation functions as both an ethical and epistemic principle: knowledge becomes a shared experience, cultivated through dialogue, collaboration, and collective agency.

Beyond institutional programming, students engage directly in cultural creation through artistic groups. For example, the Grup de Teatre Assaig, founded in 1990, and the Grup de Dansa, founded in 2017, provide students with structured, collaborative artistic experiences under

expert guidance. These groups promote teamwork, discipline, creativity, and shared authorship, fostering skills and values aligned with the university's educational mission. Similarly, ensembles such as the Orquestra Filharmònica, Orfeó Universitari, and Colla de Dolçaina i Tabalet build artistic communities in which rehearsal, performance, and public engagement become exercises in citizenship, social cohesion, and cultural continuity. Each initiative demonstrates that university culture is not taught as abstract knowledge but lived as collective, transformative experience.



Figure 1. Grup de Dansa and Grup de Teatre Assaig

International collaboration further reinforces this participatory ethos. The Escena Erasmus program, awarded the 2023 Valencian Performing Arts Honor Prize, brings together exchange students from across Europe to co-create and perform contemporary theater, touring local communities, including depopulated rural areas. This initiative exemplifies how transnational co-creation integrates artistic, educational, and ethical values, fostering intercultural dialogue, shared identity, and social responsibility.

Music also embodies collective learning and co-creation. The UV Philharmonic Orchestra and Orfeó Universitari provide platforms for shared musical discipline, collaboration, and excellence, while the Colla de Dolçaines i Percussió preserves local musical heritage, cultivating empathy and care for intangible cultural assets within an academic context. Through these ensembles, artistic creation and civic education converge, transforming participation into a medium for ethical formation.

Programs such as Activa Cultura, Activa Música, and Activa Fest extend participatory culture by supporting student-led projects and collective initiatives. These initiatives encourage creativity, collaborative project management, and social responsibility, promoting active engagement with both campus life and the wider community. Similarly, Cultura als Campus decentralizes artistic and cultural programming, bringing exhibitions and public art projects to all university campuses, creating open spaces for interaction between scientific knowledge, social values, and creative expression. These interventions, often developed with local and emerging artists, transform daily academic spaces into laboratories for critical reflection, dialogue, and civic engagement. Strategic programs such as Residir en la Investigació and Art Públic connect art with scientific research, fostering co-creation between artists and research groups. Visual artists collaborate

with scientific teams to translate academic discoveries into accessible, aesthetic experiences, bridging the gap between reason and emotion, academia and society. These initiatives exemplify the university's commitment to knowledge transfer, public engagement, and ethical formation through co-creative practices, making research tangible and socially relevant. Additionally, site-specific murals, developed for the UV's 525th anniversary, integrate contemporary art into university spaces, inviting students from all disciplines to interact directly with artistic creation. These projects repurpose functional university buildings into meaningful, inhabitable spaces, reinforcing the link between art, architecture, and community while consolidating a tradition of participatory and site-responsive artistic expression.



Figure 2. Activa Cultura programme

Among the new projects aimed at revitalizing cultural life on university campuses, a notable initiative is the creation of a new series of murals evoking the founding values of the Universitat de València on the occasion of its 525th anniversary. This project seeks to repatrimonialize the newer university buildings, constructed from the 1980s according to functionalist university architectural models—spaces often perceived as non-places—where the new artistic murals aim, on the one hand, to make the university environment more inhabitable and lived-in, and on the other, to bring art closer to the entire academic community.

In particular, the project intends to involve students from all disciplinary areas, regardless of their field of study, fostering direct and daily engagement with contemporary artistic creation and strengthening the connection between art, architecture, and the academic community. The initiative continues a tradition already present in several faculties, with emblematic precedents such as the murals by Javier Clavo, Joaquín Michavila, Marina Iglesias, Paula Bonet, and Paco Roca, and seeks to consolidate and update this artistic line. A group of contemporary artists—including Chema López, Ernesto Casero, Moisés Mahiques, Ana Peñas, Cachetejack, Calo Carratalà, Julieta, and Olivares—will create new site-specific works that engage in dialogue with the university's founding values and the architectural characteristics of the spaces. All creative processes are documented and accompanied by theoretical texts, aiming to enrich the Universitat de València's mural heritage. Through this initiative, the university not only reaffirms its commitment to the creation and dissemination of contemporary art but also promotes

reflection on the cultural and social function of academic spaces as places of memory, knowledge, and collective participation.

This multiplication of cultural experiences across university campuses has been further strengthened by the Cultura als Campus program, which seeks to decentralize the university's cultural and artistic offerings, making them accessible to the entire academic community. Traditionally, artistic exhibitions were concentrated in prestigious historical spaces in the center of Valencia—such as the five halls of the Centre Cultural La Nau, Palau de Cerveró, Col·legi Major Rector Peset, and the Jardí Botànic—locations of great historical and symbolic prestige but distant from the current campuses. Exhibitions promoted by the Universitat de València are conceived as multidimensional instruments of university cultural expression, capable of reflecting and promoting the founding values of a public institution committed to society and knowledge dissemination.

The exhibitions are distinguished by their attention to the university's scientific and cultural heritage, aiming to foster critical thinking, respect for ideological and cultural diversity, and the recovery and valorization of local culture. They also serve as platforms for the dissemination and support of contemporary creativity, with particular attention to female artistic production and the involvement of local artists. Another central aspect concerns the social and civic role of art: exhibitions aim to highlight inequalities and social exclusion, promoting reflection on ethical and environmental issues, including sustainability and the protection of the natural environment. Furthermore, through participatory design and collaboration with diverse academic and cultural communities, the exhibitions foster the construction of participatory networks, helping consolidate the university's role as an open, inclusive, and socially engaged public space.



Figure 3. Exhibitions Activa Cultura

In summary, the exhibitions at the Universitat de València do not merely display artworks or scientific objects; they constitute tools for education, social awareness, and cultural dialogue, promoting integration between creativity, knowledge, and civic engagement, and strengthening the university's public and social mission.

With the launch of *Cultura als Campus*, the university has initiated a process of decentralization and democratization of visual culture, creating new exhibition spaces and artistic interventions directly within the campuses of Blasco Ibáñez, Tarongers, Burjassot, and Ontinyent, also Center International of Gandia. In this way, contemporary art becomes part of daily university life, promoting a direct dialogue between artistic creation, research, and education. This occurs not only within individual faculties but also in university libraries, which are transformed into cultural spaces open to the academic community, facilitating interaction between knowledge and artistic creation and encouraging new forms of aesthetic enjoyment and cultural participation.



Figure 4. Campus Ontinyent, exhibition “De la càmera a l'aula: fotografies de dones”

The itinerant nature of these exhibitions also extends to the university's satellite campuses, established in collaboration with over twenty municipalities across the region. These sites are conceived as tools for citizen education, following a logic of knowledge transfer, lifelong learning, and equal opportunities.

The initiative is grounded in transmitting the core values of university culture, integrating educational, civic, and cultural dimensions. In this way, the exhibitions not only enrich the artistic offerings of the campuses but also form part of a widespread and participatory educational process, aimed at strengthening the connection between university, territory, and community.

This initiative also reinforces the regular activities of the *Art Públic* program, held annually on the Burjassot and Blasco Ibáñez campuses for approximately one month. The most recent edition, the XXVIII *Mostra Art Públic* (2025), confirms the consolidation of this proposal as a public program and call for contemporary artists. Organized by the *Delegació d'Estudiants* and the *Servei d'Informació i Dinamització d'Estudiants* (SeDI), in collaboration with the Vice-Rectorate of Culture and Society, the initiative aims to activate university spaces through ephemeral and site-specific artistic interventions, fostering critical reflection and dialogue between contemporary art and the academic community.



Figure 5. Art public

The call is open to visual artists of all ages, interested not only in exploring the relationship between art and scientific knowledge but also in engaging with the collections of the university's museums and libraries. In this way, the program consolidates its public character, reinforcing the social and cultural role of the Universitat de València as a space of creativity, participation, and civic commitment.

In recent years, the university has promoted the *Residir en la Investigación* program, an initiative aimed at strengthening the integration of contemporary art with scientific knowledge produced by the university's research groups. The program is organized in two phases: the first selects research groups, while the second invites visual artists to develop artistic proposals based on the previously selected research lines. The primary goal of *Residir en la Investigación* is to facilitate the transfer of scientific knowledge to society through art, which serves as a transversal language enabling broader audiences to understand scientific concepts. The resulting artistic projects are exhibited in university spaces, fostering dialogue between the academic community and the general public.

Ultimately, all these initiatives strengthen the Universitat de València's commitment to university culture as a space for critical reflection, creativity, and social participation. By integrating art into the scientific sphere, the programs contribute to consolidating the university's public and social function, promoting the dissemination of knowledge and access to culture from an inclusive and democratic perspective.

Through these diverse initiatives, the Universitat de València demonstrates that co-creation and participation are not merely pedagogical strategies but fundamental expressions of its values: collaboration, civic responsibility, ethical engagement, cultural inclusivity, and the integration of knowledge, creativity, and community. Art, science, and territory converge to create a university culture that is open, participatory, and committed to the common good.

4. Contemporary art, heritage, and cultural rights

The Universitat de València (UV) maintains a rich constellation of museums and collections—including La Nau, the Botanical Garden, the Museum of Natural History, the Observatory of Astronomy, and the Palace of Cerveró—that together form a cultural ecosystem linking science,

nature, and art. This network exemplifies what Cerquetti et al. (2023) term the “co-creation of heritage value,” where preservation, research, and dissemination are shared responsibilities among institutions, communities, and university actors. Heritage management at UV is thus reframed as a participatory and dynamic process, in which access to art and heritage is treated as a dimension of democratic citizenship, aligning with the university’s commitment to cultural rights. Programs such as *Relecturas: itinerarios museales en clave de género* and UV’s participation in the *Red Española e Iberoamericana de Patrimonio Universitario* reflect this transnational and inclusive approach.

UV’s educational initiatives extend this ethos of co-creation into the classroom. Projects like DICO (Cerquetti et al., 2023) have developed digital storytelling and arts-based methods to foster students’ reflexivity, resilience, and professional identity. Through design thinking, creative writing, and collective workshops, students co-produce narratives that integrate individual and collective meanings, illustrating how co-creation operates pedagogically. Carola Boehm (2023, 2025) highlights the tension between individualism and collectivism in creative education: the neoliberal valorization of the “individual genius” contrasts with the collaborative ethos necessary for sustainable futures. Through these co-creative workshops, students learn to balance self-expression with shared meaning, demonstrating that educational co-creation is also a laboratory for social innovation.

This participatory philosophy extends to UV’s broader cultural ecosystem. Seppä and Tanev (2011) conceptualize co-creation as a network of interdependent agents rather than a firm-centered process. When applied to artistic and cultural production, the DART principles—Dialogue, Access, Risk, and Transparency—become guiding tenets: dialogue as collective imagination and negotiation of meaning; access as open data, shared authorship, and inclusivity; risk as acknowledgment of vulnerability and uncertainty; and transparency as accountability in collective authorship. Such dynamics have shaped UV’s ecosystemic programs, including *Trans.Making*, *IArthisLab*, and *Towched*, *Cheminova*, etc., where artists, researchers, and communities co-produce public value. EU initiatives like the *New European Bauhaus* and *Creative Europe* further recognize co-creation as a mechanism for social and environmental transformation, situating art at the heart of sustainable, collective innovation.

This networked approach challenges traditional territorial and institutional notions of creativity. As Szulc (2022) argues, culture is increasingly a transnational assemblage, unfolding across digital, social, and institutional networks. Platforms such as the *Cultural Analytics Lab* and *OpenGLAM* operate as laboratories of meaning where global data and local interpretation intersect. In this context, co-creation is not merely a set of techniques but a mediating infrastructure, enabling plural temporalities, value systems, and intercultural dialogue. Sanders (2005), Seppä & Tanev (2011), and Szulc (2022) collectively suggest that co-creation functions simultaneously as a methodological practice, an organizational strategy, and an epistemological principle—forming a plural epistemology that unites making, managing, and meaning. Within this framework, artistic collaboration becomes both method and medium for investigating how knowledge is generated, distributed, and transformed across networks.

Empirical practices at UV illustrate these principles in action. Coworking spaces and workshops provide the infrastructure for co-creation, fostering informal exchanges, serendipitous collaboration, and shared authorship (Bouncken et al., 2023; Nonaka & Takeuchi, 1995). In the

visual arts, studies show that artistic value emerges through networks of collaboration among artists, audiences, and institutions (Angelini et al., 2022; Baumgarth, 2018). Educational programs such as *Activa Cultura*, *Activa Música*, and *Activa Fest* involve students, researchers, and staff in designing and implementing cross-disciplinary cultural projects, translating co-creation into practical leadership, creativity, and ethical responsibility. The *Aulas Culturales* function as laboratories for cross-disciplinary learning, integrating academic knowledge with artistic and civic reflection, and fostering teamwork, discipline, and intercultural understanding through projects such as *Assaig*, *Grup de Dansa*, *Escena Erasmus*, *Orfeón universitario*, the *Orquesta Filarmónica*, and the *Colla de Dolçaina i Tabalet*.

UV's initiatives further extend co-creation beyond the campus core. *Cultura als Campus* decentralizes cultural participation across peripheral campuses in Blasco Ibáñez, Tarongers, Burjassot, and Ontinyent, transforming exhibitions, performances, and installations into itinerant spaces of collective engagement. Similarly, *Residir en la Investigación* links artists with research groups, translating scientific findings into accessible visual and performative forms and fostering shared authorship (Maassen & Stensaker, 2011; Angelini et al., 2022). The *Art Públic / Universitat Pública* program transforms campus grounds into outdoor galleries of ephemeral, site-specific art, reinforcing the university as a space where knowledge, creativity, and civic imagination intersect.

Finally, UV's co-creative model reaches beyond students to citizens of all ages. Programs such as *La Nau Gran* and *Unisocietat* invite adults over 50 to engage with university life, embodying Wallerstein's (2005) vision of lifelong learning as a form of cultural citizenship. The establishment of *Universitats Estacionals* across more than twenty municipalities strengthens UV's territorial presence, transforming higher education into a vehicle for community development and social cohesion.

In summary, co-creation at UV is a transdisciplinary, networked ecosystem in which artistic production, heritage preservation, educational innovation, and civic engagement converge. It operates pedagogically, culturally, and socially, producing knowledge and cultural value while fostering dialogue, resilience, and democratic participation. Through this integrated approach, the *Universitat de València* exemplifies how universities can function as spaces of shared creativity, intercultural exchange, and sustainable innovation.

5. Conclusions

The experience of the *Universitat de València* illustrates how co-creation can redefine the role of the university in contemporary society by integrating ethics, culture, and education into a coherent and participatory model. Co-creation at UV exemplifies how the arts can articulate the university's ethical mission. The cultural programs analyzed encompass three interrelated dimensions: epistemic co-creation, which integrates artistic and scientific knowledge through collaborative processes (*Residir en la Investigación*, *Art Públic*); participatory co-creation, which actively involves the academic community in cultural production (*Activa Cultura*, *Aulas de Cultura*); and civic co-creation, which engages external communities in lifelong learning and cultural dialogue (*Cultura als Campus*, *La Nau Gran*). This triadic model positions the university as both a producer and mediator of public value. As Baumgarth (2018) notes, co-creation is not

merely an operational technique but an ethical orientation: a way of recognizing the other as a co-author in the creation of meaning. UV's initiatives demonstrate that the university's cultural mission can no longer be confined to the dissemination of existing knowledge but must cultivate creative ecosystems where new forms of collective intelligence emerge.

UV's programs show that the university must configure creative ecosystems where art, science, and community collaborate in the production of knowledge, public value, and shared meaning. Initiatives such as *Residir en la Investigación* and *Art Públic* exemplify the integration of artistic and scientific knowledge through collaborative processes, while *Activa Cultura* and the *Aulas de Cultura* foster the active involvement of the academic community in cultural creation. At the same time, programs such as *Cultura als Campus* and *La Nau Gran* consolidate the commitment to citizenship by promoting lifelong learning and democratic access to culture, reaffirming the public right to participate in the creation and enjoyment of cultural goods.

Co-creation at UV also shows that creative processes are not neutral but closely linked to ethical and sustainability principles. Knowledge emerges through interdependent relationships, and its value arises from dialogue, cooperation, and critical reflection on power and authorship. Co-creative practices promote resilience, equity, and social awareness, transforming educational, artistic, and community spaces into ecosystems where innovation and civic responsibility converge. In education, projects demonstrate how digital storytelling, participatory design, and collective workshops enable students to co-construct their professional identities and develop ethical and creative skills, while UV's cultural initiatives transform the university into an open space where culture, science, and citizenship meet and enrich each other.

Furthermore, co-creation redefines the notion of authorship and cultural value as collective achievements that transcend traditional hierarchies among creators, institutions, and audiences. In this sense, the university acts as a mediator of knowledge and creativity, fostering networks of interaction among laboratories, artistic studios, and external communities. This plural epistemology, which integrates methodological practice, organizational strategy, and ethical principle, allows contemporary challenges to be addressed in an integrated manner, promoting innovation, sustainability, and inclusive cultural participation.

Overall, the experience of the Universitat de València demonstrates that co-creation constitutes an ethical, educational, and cultural paradigm that transforms the university into a common good. The institution becomes a space where culture humanizes knowledge, where art and science intertwine, and where learning is a shared act of imagination, care, and social responsibility. UV thus offers a replicable model for other universities, demonstrating that co-creation not only produces knowledge and art but also strengthens social cohesion, cognitive justice, and the ethics of public engagement.

Co-creation, understood in a broad sense, constitutes a convergence point between participatory design, innovation management, and critical cultural studies. Its contemporary development requires recognizing the transnational interdependence of creative processes and the active role of local contexts in the construction of global knowledge. This perspective calls for an interdisciplinary agenda grounded in radical contextualism and a collaborative ethic, oriented toward the sustainability of innovation ecosystems and cognitive justice.

Across organizational, artistic, and educational contexts, co-creation emerges as a unifying paradigm for sustainable knowledge and cultural development. In coworking spaces, it transforms economic competition into community learning; in the arts, it reconceptualizes authorship and market value as collective achievements; and in education, it empowers students to co-construct their professional identities through creativity and reflection.

What connects these spheres is a fundamental shift from production for others to creation with others (Fancourt and Finn, 2019). Co-creation thus becomes both an epistemic framework and a social ethic—a way of knowing and being that counters fragmentation by emphasizing interdependence. As global challenges increasingly demand integrative and inclusive solutions, co-creation provides a foundation for reimagining sustainability, innovation, and cultural participation.

Future research should continue exploring how co-creation can bridge institutional divides—between business and art, academia and society—by fostering practices that value diversity, dialogue, and shared responsibility. Ultimately, to co-create is to affirm that knowledge, like art, is inherently a collective act of imagination.

The experience of the Universitat de València unequivocally demonstrates that co-creation is not merely a pedagogical or artistic tool, but an ethical and social imperative that radically redefines the university's role in contemporary society. By integrating artistic creation, scientific research, and community participation, UV shows that knowledge is not produced in isolation, but through constant interaction among diverse actors, contexts, and scales.

The university ceases to be merely a producer of content and becomes a living ecosystem of innovation, creativity, and critical citizenship. The programs analyzed not only democratize access to art and knowledge, but also transform university spaces into laboratories of collective intelligence and ethical reflection. Culture ceases to be an ornamental addition and becomes a central axis of education, research, and civic engagement.

In a world marked by social fragmentation, technological acceleration, and environmental crisis, co-creation emerges as an indispensable strategy for generating resilient, inclusive, and sustainable communities. It acknowledges the interdependence between local and transnational actors, balances cultural rights with ethical responsibilities, and turns education and research into collective acts of imagination and care.

Ultimately, to co-create is to affirm that knowledge, art, and culture are common goods, collectively constructed and shared, and that the university, far from being a passive observer of the world, must place itself at the heart of its transformation. The Universitat de València offers a model of reference: a space where ethics, creativity, and social participation converge to demonstrate that another future is possible, and that the university can be not only a space for learning, but a driver of cognitive justice, responsible innovation, and genuine social change.

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Foundations of Cultural Heritage Conservation and Sustainable Development: Theoretical Perspectives and Contemporary Challenges

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Abstract

The paper explores the theoretical foundations of cultural heritage conservation in the broader context of sustainable development, emphasizing the importance of social engagement along with the input of “heritage professionals” in accordance with the new economic, environmental and technological realities.

Taking into consideration the Sustainable Development Goals (SDGs) adopted by the United Nations, the study is focused also in pointing out the links between the preservation of cultural heritage and the UN initiative and how heritage should be perceived as a system of good practices within communities, of course, taking into consideration the contemporary challenges.

The study comprises a theoretical part regarding the historical development of the concept of CH, showing how international frameworks have progressively expanded their scope. Starting with foundational documents in what concerns the conservation of cultural heritage, such as the *Venice Charter* (1964), where modern principles: authenticity, integrity, and reversibility, are included, but also the UNESCO Conventions are mentioned. From the *UNESCO World Heritage Convention* (1972), to the *Convention for the Safeguarding of the Intangible Cultural Heritage* (2003), to *Faro Convention* (2005), it can be noticed a shift from the formalized international protection mechanism for cultural and natural heritage site, to the increasingly importance of digital heritage and a more community centred approach in what regards heritage.

The study also addresses some illustrative case studies in the author’s attempt to exemplify how the challenges that cultural heritage faces can affect transmission of our cultural legacy to the further generations. More, heritage can be regarded as an economical resource, helping to the development and financial grow of communities through artisanal economies and connected industries. Additionally, the use of digital innovation, such as 3D documentation platforms, scanned documents or virtual exhibitions, highlights the growing relevance of digital heritage in conservation, accessibility, and education, but this type of heritage faces, again, its own particular challenges.

The paper concludes that sustainable heritage conservation calls for interdisciplinary collaboration among heritage professionals, environmental scientists, local authorities or policy makers, NGOs and educators.

Key words: Cultural heritage; sustainable development; SDG

1. Introduction

Cultural heritage represents one of humanity’s most important resources, connecting people to their history, identity, and collective memory and its significance extends beyond material

remains, intangible and symbolic dimensions being elements that that can define us. Today, heritage conservation can be easily linked to a more ample framework: the global agenda for sustainable development, particularly following the adoption of the United Nations 2030 Agenda and the Sustainable Development Goals (SDGs).

This article aims to analyse the theoretical foundations of heritage conservation while illustrating practical approaches to integrating heritage within sustainable development. The focus is on understanding the multiple dimensions of cultural heritage—tangible, intangible, natural, and digital—and exploring how heritage contributes to education, economic growth, environmental responsibility, and social cohesion, but still faces some contemporary challenges.

2. Theoretical Framework of Heritage Conservation

The concept of cultural heritage has evolved from a narrow focus on monuments and collections, to a broader understanding of heritage as encompassing tangible, intangible, natural, and digital expressions of human creativity.

In 1964, the *International Charter for the Conservation and Restoration of Monuments and Sites*, commonly known as the *Venice Charter*, established the theoretical and ethical foundations of modern heritage conservation. Adopted during the Second International Congress of Architects and Technicians of Historic Monuments in Venice, the Charter stated a universal starting point for protecting monuments and sites through scientifically grounded and ethically responsible approaches (International Council on Monuments and Sites [ICOMOS], 1964). It emphasized that conservation must preserve the **authenticity, integrity, and historical evidence** of heritage assets, maintaining their material and cultural truth without speculative reconstruction. Article 9 states that restoration “must stop at the point where conjecture begins,” highlighting the importance of verifiable historical documentation. The Charter also broadened the concept of a “monument” to include not only great architectural works but also vernacular ensembles and urban or rural contexts that bear witness to the continuity of civilization.

The Charter’s influence is evident in later documents and initiatives, such as the 1972 *UNESCO World Heritage Convention*, the *Burra Charter* (1979/2013), and the *Nara Document on Authenticity* (1994), all of which build on its core philosophy of safeguarding the past as an important foundation for future development.

UNESCO’s 1972 *Convention concerning the Protection of the World Cultural and Natural Heritage* marked a key moment in defining heritage of ‘outstanding universal value.’ Later, the 2003 *Convention for the Safeguarding of the Intangible Cultural Heritage* recognized traditions, rituals, and craftsmanship as essential elements of living heritage. The Faro Convention (2005) further expanded this framework by linking heritage with human rights and democratic participation.

The concept of digital heritage has gained formal international recognition as a distinct and integral component of cultural heritage. The *UNESCO Charter on the Preservation of Digital Heritage* (2003) defines digital heritage as the “unique resources of human knowledge and expression” created in digital form or converted from existing materials, encompassing texts, databases, images, audio-visual content, and software. The Charter affirms that digital heritage

constitutes part of humanity's common legacy and must therefore be preserved, protected, and made accessible to future generations.

So, cultural heritage is not only a reflection of the past but also a dynamic force shaping the present and the future. It fosters intercultural dialogue, promotes social inclusion, and supports local economies through tourism and creative industries. As noted by Thurley (2005), heritage has both cultural and economic dimensions that contribute to sustainable communities.

3. Cultural Heritage and the Sustainable Development Goals (SDGs)

The Sustainable Development Goals (SDGs), also known as the *Global Goals*, are a collection of 17 interconnected goals established by the United Nations in 2015. They represent a worldwide call to action to eradicate poverty, protect the environment, and ensure that peace and prosperity are accessible to everyone by the year 2030 (United Nations Development Programme. (n.d.). *Sustainable Development Goals*. <https://www.undp.org/sustainable-development-goals>).



Figure 1. The Sustainable Development Goals (SDGs Source: https://commons.wikimedia.org/wiki/File:Sustainable_Development_Goals.svg (accessed 19.10.2025).

The integration of cultural heritage in the SDGs framework is a natural and obvious step to be taken. This topic has been already approached by different specialized organizations (Culture 2030 Goal Campaign, 2021; ICOMOS, 2023), aiming to highlight how cultural heritage, in all its forms—tangible, intangible, natural—can contribute to the achievement of the 2030 Agenda and the 17 Sustainable Development Goals. Ideas, such as the relationship between heritage and SDGs, involvement of development actors and professional alignment are under discussion, emphasizing that heritage is not a "side activity" but an essential component of sustainability strategies, encouraging a shift from an exclusively protectionist vision to a broader one, focused on living cultural systems, social cohesion, education, and local development.

The integration of *the cultural dimension* in the SDGs process, alongside the social, economic, and environmental dimensions should be regarded as a component in local development policies. The study *Culture 2030 Goal Campaign* also suggest how culture can be integrated in the "5 Ps of the SDGs": though "People" culture contributes to education, equality, and inclusion (SDGs 4,

5), thought the "Planet", there are links between traditional knowledge and nature conservation, but these are poorly represented (SDGs 12, 13), though Prosperity the strongest connection can be made by cultural industries, tourism, and heritage that support the local economy (SDG 8, 11), through "Peace", culture supports diversity, human rights, and civic participation (SDG 16), through "Partnerships", cultural collaborations can strengthen local and international networks (SDG 17).

Another approach regarding heritage and the SDGs was the attempt to integrating **cultural heritage** into **urban planning and development policies** enhances the sustainability of cities within the framework of the **2030 Agenda for Sustainable Development** (Hosagrahar et al. 2016).

All these sources converge on the notion that cultural heritage, when embedded in urban planning, education, and governance, contributes simultaneously to economic vitality, social inclusion, and ecological balance.

4. Current Challenges in Heritage Conservation and Sustainable Approaches

Despite of the fact that nowadays, the conservation and valorisation of cultural heritage has its legal background solidly defined and there is a clear tendency in the development of international frameworks that promote the suitability of CH, the preservation of these cultural values, including the material, immaterial and digital heritage, faces a diverse pallet of challenges: environmental, social, technological, and political.

The first issue to be mentioned here also arises from the growing accessibility of heritage — a development that is, in fact, a positive outcome. One of the most visible and persistent problems is mass tourism, that can endanger both the physical part of CH, but also its environment and authenticity. Several examples can be named here, from overcrowded cities as Venice, or Barcelona, to archaeological and natural sites, such as Machu Picchu. The uncontrolled visitors are very likely to lead to the deterioration of heritage, but with the involvement of the national and local authorities, through sustainable tourism strategies which might imply alternative routes, digital resources, the community participation solutions can be found.

Another critical threat is climate change, which increasingly exposes heritage to the devastating effects of extreme weather, or, in the case of natural heritage, to irreversible transformations. These patterns highlight the urgent need for integrating climate adaptation and risk-management strategies into conservation planning. ICOMOS (2023) recommends that heritage managers incorporate green technologies, energy efficiency, and nature-based solutions within adaptive strategies. Moreover, traditional knowledge, such as vernacular architecture or water management systems, can still provide sustainable models for resilience, demonstrating that heritage itself can be a model in preserving our world.

The establishment of UNESCO in 1945 was a direct response to the devastation caused by the Second World War, when many cultural landmarks, museums, archives, and monuments were damaged or destroyed. Conceived as part of the broader effort to rebuild not only economies but also moral and intellectual solidarity, UNESCO sought to prevent the recurrence of such

cultural loss by promoting international cooperation in education, science, and culture. The war had revealed how fragile humanity's shared heritage could be in times of conflict. Thus, UNESCO's founding mission emphasized the protection of cultural property. This commitment later materialized in key instruments such as the 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict, marking a global recognition that safeguarding heritage is essential for preserving collective identity and historical memory. But, still nowadays, armed conflicts remain a devastating force that can target also heritage and sometimes, the destruction of cultural landmarks, such as in Syria, with the assault of ISIS over Palmira archaeological site (Whose Culture? – Harvard University), or in Ukraine, where according to UNESCO by September 22, 2025, it was confirmed the damage to 509 cultural sites since February 24, 2022, including 152 religious buildings, 268 structures of historical or artistic significance, 34 museums, 33 monuments, 18 libraries, one archive, and three archaeological sites.

Both UNESCO's *Unite4Heritage* campaign and ICCROM's *First Aid to Cultural Heritage in Times of Crisis* program exemplify the growing international commitment to safeguarding cultural heritage in situations of armed conflict and disaster. Launched in 2015, *Unite4Heritage* emerged as UNESCO's response to the deliberate destruction of cultural sites in the Middle East, aiming to mobilize global awareness, promote respect for cultural diversity, and counter extremist ideologies through public engagement and education. ICCROM's *First Aid to Cultural Heritage in Times of Crisis* program (Tandon 2018) provides a practical framework for emergency preparedness and response. It trains professionals and local communities to assess damage, stabilize endangered structures and artifacts, and integrate cultural recovery into broader humanitarian action. Together, these initiatives highlight the shift from reactive to proactive heritage protection, emphasizing that safeguarding culture is not only about preserving the past but also about strengthening resilience, identity, and peace in the present.

The rise of digital heritage introduces both opportunities and vulnerabilities. While 3D scanning, photogrammetry, and digital archives enhance documentation and access, they also expose cultural data to cyberattacks, data loss, and technological aging (Bouragohain et al., 2024). For instance, ransomware attacks on museums or corrupted heritage databases demonstrate how digital collections can be as fragile as physical artifacts. Effective digital preservation demands cybersecurity, storage resources, and metadata standardization to ensure long-term accessibility and authenticity.

Another challenge that heritage still must face nowadays is the illicit trafficking of cultural artifacts. For instance, in Romania, several high-profile cases have exposed the scale and sophistication of such operations.

One of the earliest and most notorious incidents occurred in **1968**, when eight important European paintings—including works attributed to **Anthony van Dyck, Titian, Frans van Mieris, and Rosalba Carriera**—were stolen from the **Bruckenthal Museum** in Sibiu. As documented by **Hrib and Chituță (2022)**, the theft, estimated at 25 million USD, exploited minimal security and the absence of anti-burglary systems. Four paintings were recovered thirty years later, in 1998, following international cooperation involving INTERPOL and U.S. authorities, while others—such as *The Death of Cleopatra* by van Dyck—remain missing.

Another striking example, from Romania, is the illicit removal of the gold bracelets from the Sarmizegetusa Regia site in the Orăștie Mountains. Illegal excavators dogged into the archaeological site and extracted, between 1999 and 2001, several ancient solid gold bracelets (Yates 2012). Afterwards, many of them were sold into the international antiquities black-market. Fortunately, through years of international cooperation and legal action, a part of these priceless artifacts was recovered and repatriated, becoming emblematic examples in the global fight against cultural property trafficking. But, in January 2025, four cultural treasures — including three of the bracelets and the gold Helmet of Coțofenești — were stolen from an exhibition in the Netherlands, from the Museum of Drenth (Reuters 2025). This situation revealed that heritage continues to be vulnerable even under enhanced legal frameworks.

Beyond Romania, **high-profile thefts from institutions such as the Louvre Museum** remind us that no collection is immune to risk. Collectively, these incidents demonstrate that the illicit trade in cultural property transcends borders, requiring coordinated global action among law-enforcement agencies, museums, and international organizations such as **UNESCO** and **INTERPOL**.

Rapid urbanisation represents one of the most significant contemporary threats to both tangible and intangible cultural heritage. Expanding cities often affect upon historic environments, archaeological layers, and vernacular landscapes, erasing traces of collective memory and place identity. Large-scale infrastructure projects can lead to the physical destruction or fragmentation of built heritage, while poorly coordinated governance and insufficient integration of conservation within planning systems exacerbate these risks (Bandarin & van Oers, 2012; ICOMOS, 2011). The *UNESCO Recommendation on the Historic Urban Landscape* (2011) emphasizes that heritage should not be treated as an obstacle to development but as an integral component of sustainable urban policies. Nonetheless, many historic centres continue to be marginalized or transformed into commercialized enclaves, detached from the communities that once animated them.

Equally vulnerable is intangible cultural heritage. The *UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage* (2003) and subsequent analyses stress that accelerated urbanisation and population mobility threaten the continuity of traditional knowledge and community rituals (Labadi, 2022; Vecco, 2010). As long-standing neighbourhoods are redeveloped, local artisans, oral traditions, and social interactions risk being displaced or commodified for tourism (Ripp & Rodwell, 2015). Preserving cultural vitality in urban contexts therefore requires participatory planning frameworks that balance modernization with cultural continuity.

5. Conclusions

Cultural heritage occupies today a central place in the global discourse on sustainability, identity, and development. It is no longer perceived exclusively as a collection of monuments and artifacts but as a living system encompassing tangible, intangible, natural, and digital dimensions that connect humanity across time and space.

The evolution of international heritage policies—from the *Venice Charter* (1964) to the *World Heritage Convention* (1972), the *Convention for the Safeguarding of the Intangible Cultural Heritage* (2003), The *UNESCO Charter on the Preservation of Digital Heritage* (2003), and the *Faro Convention* (2005)—reflects a growing recognition of the importance of culture, traditions and legacy in the human progress. These frameworks established the principles of authenticity, integrity, and community participation, emphasizing that the preservation of cultural heritage must be not only a technical act but also a social and ethical responsibility.

However, the contemporary world also presents unprecedented challenges to the safeguarding of heritage. Climate change, environmental degradation, and natural disasters increasingly threaten cultural landscapes and monuments, while armed conflicts continue to target symbols of identity and history, as the cases of Syria, Ukraine, and other conflict zones demonstrate. UNESCO's *Unite4Heritage* campaign and ICCROM's *First Aid to Cultural Heritage in Times of Crisis* program illustrate an encouraging shift from reactive to preventive approaches, promoting resilience through education, community empowerment, and international cooperation. Similarly, the rise of digital technologies offers both opportunities and vulnerabilities: while digitization enhances access, it also exposes cultural data to cyber threats and raises questions of authenticity and long-term preservation.

Illicit trafficking of cultural property further undermines collective heritage. The Romanian examples—from the 1968 *Brukenthal Museum* theft to the smuggling of the *Dacian gold bracelets* and the recent 2025 *Drepts Museum* robbery—demonstrate that heritage crime transcends borders and requires sustained international collaboration between museums, law enforcement, and judicial institutions. Global initiatives by UNESCO, INTERPOL, and ICOM have shown that cultural restitution is possible when supported by political will and public awareness, yet prevention remains the most effective form of protection.

Urbanisation, one of the defining phenomena of the 21st century, has become another critical arena where heritage faces transformation and risk. Expanding cities reshape landscapes and social structures, often marginalizing historic districts and displacing the communities that sustain intangible traditions. The *UNESCO Recommendation on the Historic Urban Landscape* (2011) and the *Valletta Principles* (ICOMOS, 2011) underline that heritage conservation must be integrated into urban planning, ensuring that development respects the historical layers and living cultures of cities.

In conclusion, cultural heritage conservation in the 21st century must evolve beyond protection toward active engagement with sustainable development. The field calls for interdisciplinary collaboration between heritage professionals, urban planners, climate scientists, and digital experts and community members.

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Reflectance Imaging Spectroscopy (RIS) for Cultural Heritage documentation

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Abstract

Reflectance Imaging Spectroscopy (RIS) has become one of the most versatile, non-invasive analytical techniques in cultural heritage, transforming how researchers, conservators, and art historians research, preserve, and understand artworks and archaeological objects. RIS collects spectral and spatial information from artworks without the need for physical sampling, thus preserving the integrity of fragile and valuable objects. Unlike traditional point-based techniques, it can identify and map pigments, binders, and restoration materials across entire surfaces, including complex or layered artworks. Can be used to visualize underdrawings, *pentimenti*, earlier restorations and subsurface features beneath visible layers, providing invaluable insights into artists' techniques. Modern RIS systems are portable, enabling on-site analysis of large or immovable sensitive cultural heritage. By combining spectral data with imaging, RIS produces false-colour and abundance maps that reveal features and material distributions that would otherwise be invisible, thereby aiding both scientific analysis and general public interpretation. The following document provides a synthesis of recent scientific literature on RIS, offering a brief overview of its history, technological development, practical applications and limitations. At last, within the framework of FORTHEN's Blended Intensive Programmes (BIPs) and the European research project ChemiNova (<https://cheminova.eu/>), reflectance imaging spectroscopy (RIS) was used alongside other non-invasive analysis techniques, such as multiband imaging (MBI) and portable X-ray fluorescence (pXRF), to study cultural artefacts at different scales during an international, multidisciplinary workshop event.

Key words: RIS; cultural heritage; conservation science; technical art history

1. Reflectance Imaging Spectroscopy

Reflectance Imaging Spectroscopy (RIS), also called hyperspectral imaging when hundreds of bands are collected (Striova et al., 2020), is an analytical technique that combines imaging and spectroscopy to map and identify the materials and features present on the surfaces of objects. In RIS, the object is imaged at many contiguous narrow wavelength bands, typically across the visible (VIS), near-infrared (NIR), and sometimes shortwave infrared (SWIR) regions, resulting in a three-dimensional data "cube" where every pixel contains a reflectance spectrum. The primary advantage of RIS over traditional point-based spectroscopic analysis is its ability to study entire objects or artifacts at high spatial and spectral resolution, revealing the distribution of different materials in a non-destructive and non-contact manner (Picollo et al., 2020). This capability is particularly critical in the field of cultural heritage, where minimizing invasiveness is a priority, or when the object is not suitable for sampling.

RIS originated in remote sensing and terrestrial exploration but was rapidly adopted by cultural heritage scientists in the late 20th and early 21st centuries thanks to advances in sensor technology, data acquisition speed, and portability of equipment (Jones et al., 2020). Although early systems were limited by complex setups and low sensitivity, offering only point-based or

low-resolution multispectral data, recent hyperspectral systems can cover surfaces ranging from a few centimetres to several meters, with hundreds of bands across the visible, near-infrared and short-wave infrared spectrum (typically 400–2500 nm). Improvements in detector arrays, optical designs and real-time data processing have made this possible (Delaney & Dooley, 2022). Key milestones include the miniaturization of spectrometers and adapting line-scanning and filter-based imaging systems for use in museums and in the field. Successive improvements have increased accessibility and throughput, enabling the study of monumental wall paintings and large canvases through museum-based RIS investigations.

Hyperspectral cameras produce data "hypercubes": 3D datasets consisting of two spatial (X, Y) and one spectral (λ) dimension. Processing these cubes involves several calibration steps (radiometric, geometric and spectral) to ensure the accuracy and reliability of each pixel's spectrum, as well as pre-processing steps such as noise removal, band selection and normalization. Despite this, common treatments include data reduction based on principal component analysis (PCA) and clustering to facilitate material mapping and visualization, as well as spectral matching, which encompasses comparing spectra to reference libraries to identify materials, often combining automated and expert-guided methods (Radpour et al., 2024).

Finally, the dual nature of the data (spatial and spectral dimensions) can be exploited to visualize the findings in an intuitive way for both scientists and the public using methods such as false-colour images, abundance maps and chemical maps. Overall, this workflow facilitates the detailed, objective and reproducible analysis of cultural heritage materials at different scales (Vettori et al., 2021).

2. RIS applications in Cultural Heritage

RIS has proven to be a very useful tool for identifying and mapping artists' pigments (de Viguierie et al., 2020). It reveals the distributions, mixtures and alterations of the constituent materials without the need for sampling. By comparing the spectra of objects to those of reference materials, scientists and researchers can observe differences between visually similar pigments, sometimes at concentrations below the limits of visual detection. Combining RIS with other analytical techniques (e.g. XRF, Raman and FTIR) further improves this process, providing a more comprehensive characterization (Mulholland et al., 2017). Indeed, RIS has enhanced our understanding of original materials, enabling us to detect later interventions and assess conservation issues in multiple artefacts, as well as wall paintings, textiles, and ceramics.

RIS can be used to visualize underdrawings, pentimenti (artistic changes) and hidden features beneath the visible surface of paintings. In spectral ranges where paint or drawing materials become transparent or opaque (especially in the near-infrared and short-wave infrared ranges), artists' sketches, alterations and even palimpsests can be visualized and mapped. This provides invaluable insights into the creative process and practices. In addition, RIS allows for the non-invasive documentation of the conservation state and degradation, as well as the effectiveness (or reversibility) of restoration treatments (Pozo-Antonio et al., 2016). This includes identifying residues such as varnish, oxidation products and efflorescence, as well as the presence of conservation coatings. It is also used before, during and after conservation interventions to monitor material changes and support decision-making processes.

Thanks to its portability, RIS measurement is feasible in situ for monumental paintings, architectural decorations and archaeological sites. This enables the repeated, non-invasive monitoring of heritage exposed to environmental conditions, as well as large-scale mapping projects in museums and on sites. Hyperspectral data of archaeological sites or artefacts can help to identify the materials used, reconstruct lost or faded decorations, and detect traces of organic remains that are invisible to the naked eye.

Despite its potential, this technique faces several practical challenges. The size and complexity of hyperspectral cubes require advanced processing and spectral matching, which is beyond the capabilities of most institutions and conservation labs. For instance, it is not always possible to unambiguously separate materials by reflectance alone: pigment mixtures, degradation products and overlapping absorption bands can all hinder interpretation (Solbes-García et al., 2025). However, comprehensive and accessible spectral databases are essential for consistent and repeatable material identification. These databases remain an ongoing international effort, especially when working with contemporary art and materials. To ensure a robust interpretation, it is important to integrate other techniques, such as elemental X-ray fluorescence (XRF), which reveals element-specific distributions and complements spectral material assignment, as well as molecular spectroscopies, such as Raman and FTIR spectroscopy, which confirm molecular identity and phase. ATR-FTIR can be used to extend the range of reflectance spectroscopy beyond the conventional limits and Multiband Technical Imaging (MBI) can capture fluorescent features that are specific to binders or related to degradation, which assists in distinguishing original materials from later additions.

To end, a wide range of equipment nowadays in use and environmental constraints can affect the data acquisition process. Illumination, atmospheric, and geometric artifacts can impact data quality, especially in non-controlled environments. On the other hand, high-end hyperspectral systems remain expensive, although ongoing research and commercialization are reducing prices.

3. Case study: ChemiNova project

ChemiNova is an EU-funded initiative (Horizon Europe programme) aiming to transform conservation practices for European cultural heritage. Its main goal is to develop an intelligent computational system that addresses structural and chemical damage caused by climate change and civil conflicts. Unlike traditional conservation technologies, ChemiNova stands out for its commitment to accessibility and inclusivity: the system is designed so anyone, including both heritage professionals and non-experts, can use it from anywhere. The project actively involves local communities through citizen science, making conservation a collaborative and resilient effort.

The project's participating partners form a multidisciplinary consortium with expertise in areas such as art history, architecture, analytical chemistry, climate change, engineering, conservation, and computer science. In addition to other international partners such as ICCROM, DIADRASIS (an NGO) and the National Conservation Area 'St. Sophia of Kyiv' (NCA-SSK), the ChemiNova consortium includes universities from the FORTHEM network, as represented by the University of Burgundy (UB) and the University of Palermo (UNIPA). The University of Valencia (UVEG) is leading the overall coordination, with two teams involved from the Department of Art History and the Institute of Robotics and Information and Communication Technologies (IRTIC).

The project has two objectives: to provide heritage conservators and restorers with new technological tools to facilitate their daily work, and to make the results of scientific studies more accessible to the public to raise awareness of the impact of climate change and civil conflict on cultural heritage. As part of this work, ChemiNova is responsible for organizing various events, including participation in FORTHEM's Blended Intensive Programme (. BIPs are short-term group programmes, such as summer schools, open to students at all levels (bachelor's, master's and PhD). These programmes facilitate group activities involving students from at least three partner universities. BIPs consist of a physical component, where students meet in one university city (Figure 1), and a virtual component held online, either before, during or after the mobility.



Figure 1. Workshop on non-Invasive spectroscopies and imaging for Cultural Heritage at the University of València – BIPs FORTHEM (Esperanza Villuendas, 2025).

At the event, 'Challenges in Cultural Heritage: Sustainable Development and Digital Transformation', held in collaboration with the Lucian Blaga University of Sibiu (Romania), we ran a workshop on non-invasive techniques for documenting cultural heritage, making use of the tools and methodologies of the ChemiNova project. During the workshop, the students acquired data using multiband technical photography, hyperspectral imaging and portable X-ray fluorescence spectroscopy.

A SpecimIQ camera (Specim, Spectral Imaging Ltd.) and a halogen light were used for hyperspectral data acquisition. The camera has a CMOS sensor that can acquire images in the visible and near-infrared spectrum (wavelength 400–1000 nm) with a mean spectral resolution of 7 nm. It has a spatial sampling of 512 pixels and 204 spectral bands, as well as a 5-megapixel viewfinder camera that is rescaled to 1280 x 960 pixels. During the workshop, few acquisitions were made, including a mixed media artwork on canvas titled 'Lola Flores Portrait' by the artist

Dario Villalba (1939-2018). This piece belongs to the contemporary art collection of the UVEG's Martínez Guerricabeitia (Figure 2).



Figure 2. *Retrato de Lola Flores* (1995), by Darío Villalba. Oil and photograph on canvas, with varnish, 128 x 118 cm (Carmen Cano, 2025).

This Villalba's artwork is a portrait of Lola Flores printed on commercially primed canvas. The artist applied a layer of varnish and oil paint to the portrait, which was then treated with localized heat once dry. This caused bubbles, ripples and flaking, resulting in a certain loss of material. This gave the print a rich texture, creating an effect reminiscent of burnt plastic or celluloid and evoking the surface of an arid, unknown planet riddled with small craters and irregularities (see Figure 1). Several hyperspectral images were acquired of this beautiful surface.

Reflectance imaging spectroscopy (RIS) enables us to document cultural objects by capturing data in both spatial and spectral dimensions. We can analyse the 204 images (512 x 512 pixels) captured within the 400–1000 nm range and extract a reflectance spectrum for each pixel in the data cube. By combining images alone, we can generate false RGB composites or false-colour infrared images or explore them individually in areas not visible to the human eye. Meanwhile, the reflectance spectra or curves reveal how materials behave in the presence of incident radiation, such as halogen light in this case. In simplified terms, materials reflect, absorb, and transmit this radiation according to their composition and different electronic transition processes.

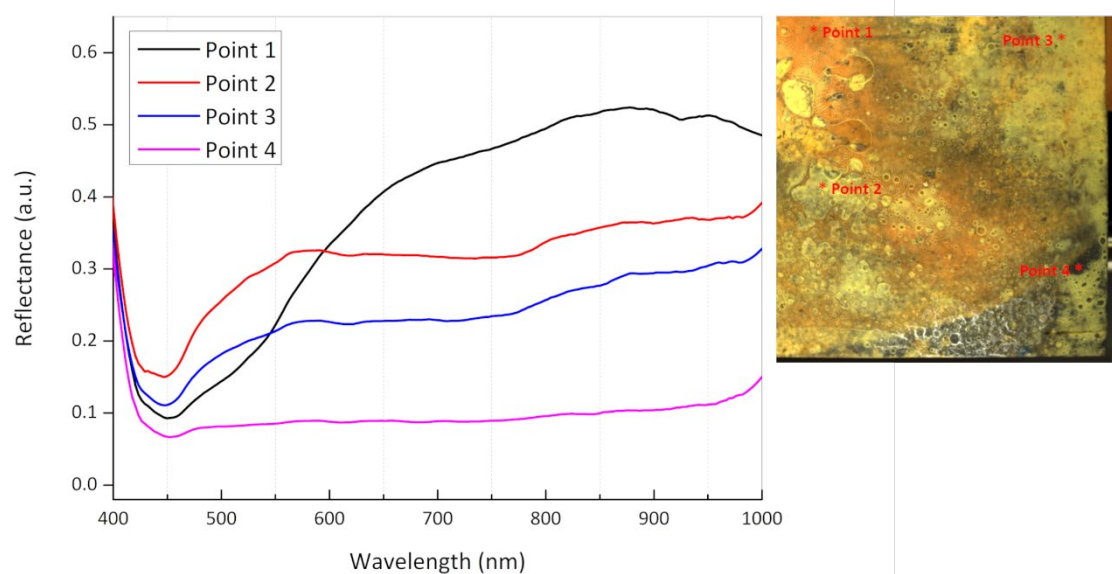


Figure 3. Reflectance curves from a four-point analysis (1–4) and a false RGB composite image acquired with the hyperspectral camera (ChemiNova, 2025).

Figure 3 shows four analysis points taken from the surface of the artwork. All the spectral curves display reflectance absorption around 450 nm, followed by a gradual rise, except for Point 4, where the black colour of the print is visible. This absorption band corresponds to the blue region between 450 and 495 nm. Point 1 shows a sigmoid curve with an inflection point between 550 and 600 nm, like semiconductor materials. Points 2 and 3, differentiated only by reflectance intensity, show a sustained increase in reflectance from 750 nm onwards. It is therefore now crucial to consider different processing methods, such as generating SAM (Spectral Angle Mapper) classification maps, and combining the results with those from other spectroscopies (e.g. XRF) to develop more precise hypotheses about the composition of the materials.

4. Conclusions

Reflectance imaging spectroscopy is an analysis technique that is becoming increasingly popular in the field of cultural heritage. In addition to being versatile and portable, it quickly and semi-automatically provides spectral data and images, depending on the capabilities of the existing equipment. This facilitates the non-invasive study of cultural heritage at different scales — both objects and buildings — and, despite its limitations, the data continues to provide useful information that enhances our understanding of the materials it comprises.

In the context of the BIPs and the FORTHEM network, this activity generated significant interest among a diverse group of students with a professional interest in the documentation, conservation and dissemination of cultural heritage. During the workshop, advances in digital imaging techniques were highlighted, as were their capacity for non-invasive analysis and ease of use. The need to combine analytical techniques at different levels to improve the diagnosis and study of cultural heritage was also discussed. Transdisciplinary was encouraged, and incipient synergies were created for future collaborative work among the participants.

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Workshop on portable X-Ray Fluorescence for Cultural Heritage: A Multidisciplinarity and interdisciplinarity approach.

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1. Introduction

Multidisciplinary and interdisciplinary studies constitute an essential dimension in education within the Social Sciences and Humanities. If by multidisciplinary we understand a set of sciences without an exchange of knowledge among them, interdisciplinary can be defined as the relationship between disciplines. Especially in fields such as cultural heritage and archaeology, interdisciplinary studies can be interpreted as the solution to broad and complex problems that require methodological and analytical approaches drawn from various disciplines (Díaz-Andreu & Coltofean, 2020; Díaz-Andreu & Portillo, 2021). Among these, analytical tools and data management and analysis emerge as key competencies for addressing research problems from an empirical perspective, supported by quantifiable data that allow for the formulation and testing of hypotheses.

In the last decade, the possibilities of working with tools originating from the basic sciences have increased consistently, and this has highlighted a widespread lack of such skills among students in humanities degrees. This often leads to insecurity or even rejection, especially when faced with tools that are not perceived as belonging to their field of study (Chandramohan & Fallows, 2008). When students are invited to apply methodologies that differ from those traditionally associated with the Humanities, a teaching and learning environment of “discomfort” is created. Various studies focused on multidisciplinary contexts agree that initial resistance may arise, particularly when students lack prior knowledge of methodologies from other fields of study (Smith & Parack, 2018; Spelt, 2017). Consequently, it is essential to incorporate teaching methodologies that help the participants to the workshop becoming confident approaching multidisciplinarity, thus avoiding limitations in more advanced educational stages such as master’s and doctoral programs.

2. The educational basis for the development of the workshop

The development of the workshop has been implemented employing innovative teaching and learning methodologies especially based on collaborative learning, giving the opportunity to the participant to enhance motivation and the development of both autonomous and collaborative skills.

During the COVID-19 lockdown period (Gallello et al., 2020), the virtual classroom became an essential tool that, through videoconferencing, allowed the sharing of files, applications, and the use of a virtual whiteboard for interaction, thus facilitating both synchronous and asynchronous online learning (integrated into the UV's virtual classroom on the Moodle platform).

As a result, materials are created for Flipped Teaching (fig.1), where learners first study at home with the materials provided individually, and during the workshop, the contents are reinforced collectively. Video tutorials are prepared, giving students tools to develop autonomous learning.

As a complementary support, gamification materials are prepared to help addressing issues that are particularly complex for participant encountering methodological and practical analytical subjects for the first time. In addition, the use of the case method is useful for the understanding of concepts in a learning environment (Machause et al., 2021).

To introduce the activity, videos on the importance of multidisciplinary in cultural heritage and archaeology are shown (<https://www.youtube.com/watch?v=UaewZLS3MX>). Furthermore, a short video was recorded (<https://www.youtube.com/watch?v=3NTm55C2umM>) highlighting the importance of chemical analysis in cultural heritage and archaeology, as part of the topic developed in the workshop. Specifically, the video focuses on two methods, one invasive and the other pXRF (non-invasive) used to chemically characterize raw materials. It is very useful for students to become familiar with methodologies from other disciplines such as chemistry, simplifying technical knowledge and fostering a multidisciplinary learning environment.

Overall, a methodology based on the combined use of different teaching strategies such as traditional lectures, flipped classrooms, and the case method is developed. The learning of theoretical and practical content is reinforced in a single activity which included several stages. We understand that developing activities covering all theoretical and practical content can have a very positive impact on learning and student performance (Gallello et al., 2022).

An effective method to improve understanding of concepts is gamification using for example LEGO® Classic pieces (Gallello and Machause López, 2024) or a truly innovative tool using Minecraft Education Edition (MEE) by Microsoft, which can transform the way complex concepts such as archaeological stratigraphy (Jimenez-Puerto & Gallello, 2025).

Therefore, an effort has been made to create tools enabling students to become familiar with multidisciplinary methods applied to data analysis. This approach is based on the case method and problem creation (Fernández-García et al., 2025).

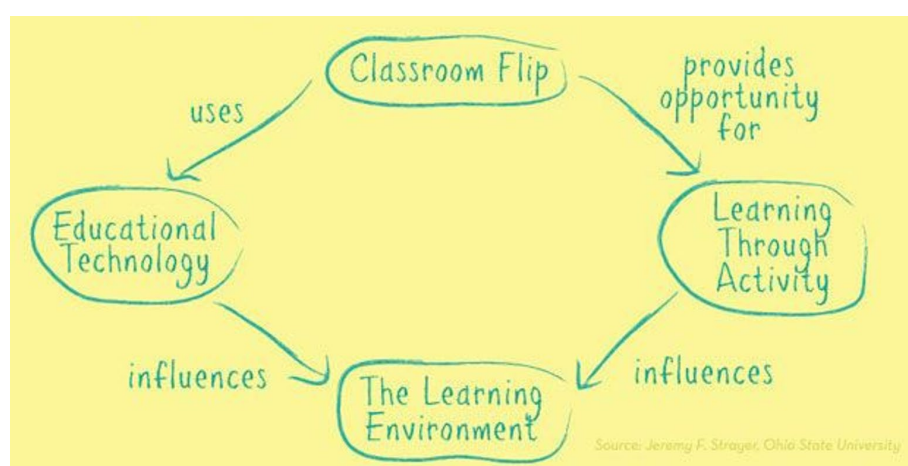


Figure 1. Part of the Infography for The Flipped Classroom Project: <https://www.theflippedclassroom.es/>

3. Main Objectives

The general objective of our workshop proposal is to encourage student participation, interest, and ability in order to facilitate the assimilation of chemical analytical approaches applied to cultural heritage, achieving an optimal learning dynamic that is reflected not only in the students' engagement with the practical components but also in the theoretical aspects, thereby promoting an improvement of these tools.

Regarding the specific objectives of the proposed activity, these can be summarized as follows:

1. The incorporation of new technologies into cultural heritage and archaeological studies allows us to offer a new vision of the past, discovering and generating data that reveal a new dimension and understanding of objects related to the ancient world, where new codes need to be deciphered.
2. To understand the purpose of X-ray analyses when studying cultural heritage materials (structures, ceramics, lithics, paintings, metals, etc.). In an engaging way, different materials will be prepared and measured while explaining how the instruments work and how to interpret the results obtained.

The fundamental idea of this activity is to bring equipment for analysing ancient materials to classrooms at the University, but also in middle and high schools and raising awareness about the concept of multidisciplinary and interdisciplinary studies. Our workshop can even be adapted for primary school students.

3.1 Development of the Innovation

The balance between theoretical and practical components of the workshop is needed, to smoothly develop the session.

The activity has a transversal character, encompassing the theoretical content of cultural heritage and archaeological basic concepts:

1. Typological identification and use of the studied material throughout different historical periods.
2. Chemical characterization of ancient materials. This approach consists of different stages implemented across the work section: data acquisition and understanding of the methodological aspects (Fig. 2).



Figure 2. The workshop at the European Research Night 2025 (University of Valencia, Valencia, Spain) explaining basic chemistry concept applied at cultural heritage sector.
(<https://www.uv.es/uvweb/museo-historia-natural/es/novedades/este-ano-no-celebramos-noche-europea-investigadores-1285943428347/Novetat.html?id=1286451979060>)



Figure 3. Running pXRF analysis to identify the elemental profile of pigments in an artwork at Schönbrunn Palace (Vienna Austria) under the framework of ChemiNova project
(<https://cheminova.eu/>).

Design of a problem based on the case method, aimed at enhancing students' engagement consolidating the learning of some of the workshop's basic contents that are more difficult to assimilate. This exercise consists of classifying or identifying materials, their manufacturing method, chronology, and the environment in which these objects or structures were used emulating the work of a professional in the field (Fig. 3).

To broaden the learning perspective, students are asked to place themselves in the role of researchers carrying out their daily activities, using a set of materials available to them (Fig. 4).



Figure 4. Materials employed during the workshop at Expociencia 2025 (University of Valencia, Valencia, Spain). (<https://www.pcup.es/es/expociencia-2025/presentacio>)

As part of the development of this activity, a portable X-ray fluorescence (pXRF) device is used to determine the chemical composition of the different materials), thereby confirming whether or not the working groups had correctly identified the type of material used during the macroscopic characterization.

Thus, each working group (3-4 students) is required to analyse by pXRF the object developing a sampling strategy (Fig. 5). Later, the members are processing the data obtained during the measurements and results description and discussion is carried out among the team members.

Finally, an individual evaluable exercise is proposed: based on the information gathered and agreed upon by the groups during the practical sessions, each student prepared a report in which they process the data analysed in the previous session.



Figure 5 . In-situ technical study of contemporary painting from the heritage collection of the Universitat de València, Spain. Canvases and colorful landscapes by Manuel Moreno Gimeno (Vázquez de Ágredos Pascual et al., 2023). PXRF measurements points.

4. Discussion

During the last six years, the developed workshop has shown very clear benefits regarding participants learning.

First, the development of coordinated activities and contents between theoretical and practical sessions is pivotal when designing a workshop. In fact, the key content worked on the activity carried out (pXRF practices) is previously introduced with examples and possible applications in cultural heritage sector.

Secondly, the didactic material used to deepen the key concepts, through the flipped classroom method, is effective since it was designed to clarify technical aspects regarding the analytical method employed.

The third point is inherent to the case method itself, which is developed working in small groups (3-4 people) and has entailed an approach both to the professional working method and to physical-chemical analytical materials approaches.

This activity also allow participants to understand the importance of multidisciplinary in cultural heritage and archaeology studies, enhancing both motivation and the quality of learning.

The final stage of this process is for participants to reflect individually and autonomously based on their achievements and group discussions.

The development of the proposed workshop contributes, as well, to the achievement of various competencies, highlighting the capacity for abstraction and analysis, problem-solving and creativity, as well as decision-making and autonomous learning.

5. Conclusions

In this work, we have shown the development of a multidisciplinary and interdisciplinary workshop, for participants involved in the study of cultural heritage. The proposed work consists of a series of learning methods, ranging from lectures and practises to autonomous work, employing various participative active methodologies.

The workshop carried out during the last six years demonstrate the effectiveness of these methodologies in improving participant learning, allowing us to draw the following relevant conclusions:

1. Activities that allow working with multidisciplinary and interdisciplinary design lead to a consistent improvement in understanding technical concepts and their application.
2. The practical component also supported by the theoretical part, demonstrating that the concepts learned are transversal and applicable in different situations and several case of studies related to different cultural heritage materials.

Although here we report just descriptive aspects without quantitative results, the potential of the workshop is clearly promising and its quality need to be further tested in upcoming activities. The advantage is that we already know that this activity can be applied to various cultural heritage subjects and different areas of knowledge, as it have already been tested in art, archaeology, conservation, material sciences and chemistry.

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Reflectance Transformation Imaging (RTI) for Cultural Heritage: Principles, Data Processing, and Applications

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Abstract

Reflectance Transformation Imaging (RTI) is a computational photographic technique increasingly used for documenting the surface appearance of cultural heritage artifacts. By capturing multiple images under different lighting conditions, RTI allows for interactive visualization of fine surface details and supports both qualitative and quantitative analyses. This paper provides a concise overview of RTI principles, data processing methods, and recent applications developed within the Cheminova project. It describes the acquisition modes and pre-processing steps necessary for accurate reflectance modeling, including illumination correction and image stitching. The paper also introduces reflectance reconstruction methods (PTM, HSH, DMD, and neural RTI) and advanced analysis tools such as saliency and distance maps for surface evaluation. Two case studies—one involving paintings from Valencia and another featuring anatomical wax models from Palermo—demonstrate RTI's practical relevance to conservation. The discussion highlights current trends in automation, multimodal integration, and standardization, affirming RTI's role as a key imaging method for heritage documentation and analysis.

Keywords: RTI, cultural heritage, heritage documentation, multimodal integration

1. Introduction

The study of surface appearance is key to documenting and analyzing cultural heritage artifacts. It offers valuable insights into materials, manufacturing methods, and conservation conditions. Among various imaging techniques, Reflectance Transformation Imaging (RTI) has grown in popularity because it allows for the visualization and analysis of surface microgeometry through light interaction and further examination. RTI is a computational photographic technique introduced in the early 2000s by Malzbender, Gelb, and Wolters (2001) to enhance the visualization of surface details. It involves capturing a series of images of an object under different lighting directions with the camera fixed in place. The resulting data set supports interactive relighting and the estimation of surface reflectance properties. This method has been widely used in cultural heritage and archaeology for documenting inscriptions, reliefs, paintings, and other artifacts where non-invasive surface examination is essential (Mudge et al., 2006). Over the past twenty years, advancements in mathematics and instruments have expanded RTI's capabilities. The adoption of new reflectance models such as Hemispherical Harmonics and Discrete Modal Decomposition has improved reconstruction accuracy and interpretability (Pitard et al., 2017). Concurrently, technological developments have diversified data acquisition setups, from controlled laboratory systems to portable, in-situ devices. These developments highlight the method's ability to adapt to various observation and documentation environments. This article offers an overview of RTI principles, data processing, and key applications. Section 2

covers acquisition principles and implementation methods. Section 3 discusses data analysis, including pre-processing, reflectance reconstruction, and interpretation. Section 4 presents case studies from the Cheminova project, followed by discussion and concluding remarks in Sections 5 and 6.

2. RTI Imaging: Principles and Implementation

2.1 Acquisition Principle

Reflectance Transformation Imaging is based on the idea that how a surface looks depends mainly on the direction of light. The method involves taking a series of photos from a fixed camera position while moving a light source around the object. Each pixel so captures how reflected brightness changes with the direction of illumination, as shown in Figure 1.

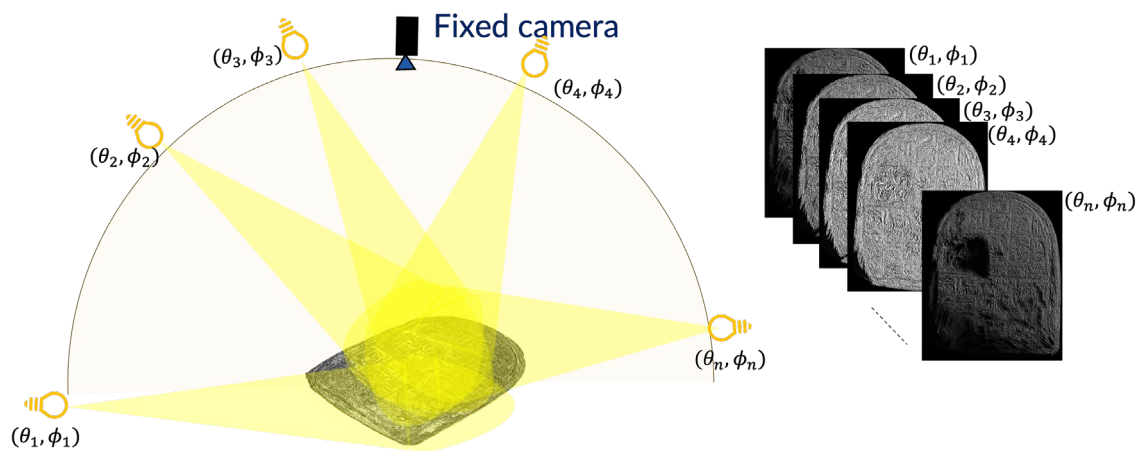


Figure 1: Principle of RTI acquisition showing multiple controlled light directions over a hemisphere.

This multi-light image collection uses a mathematical model at each pixel—often a polynomial or hemispherical harmonic function—to describe local reflectance behavior. The coefficients from the model enable virtual relighting, which highlights fine surface details such as tool marks, cracks, and brushstrokes.

Accurately estimating light direction is essential. Dome-based systems provide predefined geometries and reproducibility, while free-form setups determine directions from specular reflections on calibration spheres. Consistent exposure, distance, and lighting stability are key to obtaining reliable photometric data for reflectance modeling.

2.2 Implementation Modes

Different configurations have been created to adapt RTI to various scales and operational settings, as shown in Figure 2.



Figure 1: some examples of RTI implementation. Handhel (left), Dome-based (middle) and Robotic-arm based ((right)

1. Fixed-dome systems: hemispherical structures with integrated LEDs at known coordinates, ensuring reproducibility and rapid data collection but limited to small objects.
2. Free-form or handheld systems: use manually moved light sources with calibration spheres for direction estimation, offering flexibility but requiring more operator skill.
3. Robotic or gantry systems: automate light positioning, suitable for larger or complex surfaces in controlled environments.
4. Drone-based systems: enable RTI in inaccessible or elevated areas. A drone equipped with a calibrated light source moves along controlled paths while its position and orientation are tracked (Dahmouni et al., 2025). This setup extends RTI to ceilings, vaults, and architectural features beyond the reach of traditional systems.

Each mode balances cost, portability, geometric accuracy, acquisition time, and repeatability as shown in Table 1. The goal remains consistent: to obtain a dense, uniform sampling of illumination directions, enabling reliable reflectance reconstruction and accurate surface visualisation.

	Free-Form RTI	Fixed light dome	Mechanized light dome
Portability			
Adaptability to size			
Accuracy			
Repeatability			
Automation			
Time efficiency			

Light versatility			
Cost			

Table 1: Comparison of RTI acquisition modes and their respective advantages and limitations (© Amalia Siatou).

3. RTI Data Exploitation

From RTI image datasets, the goal is either to reconstruct continuous models that support interactive visualization (relighting) or to directly utilize the raw data by extracting features or creating derived maps such as segmentation or saliency representations, as shown in Figure 3.

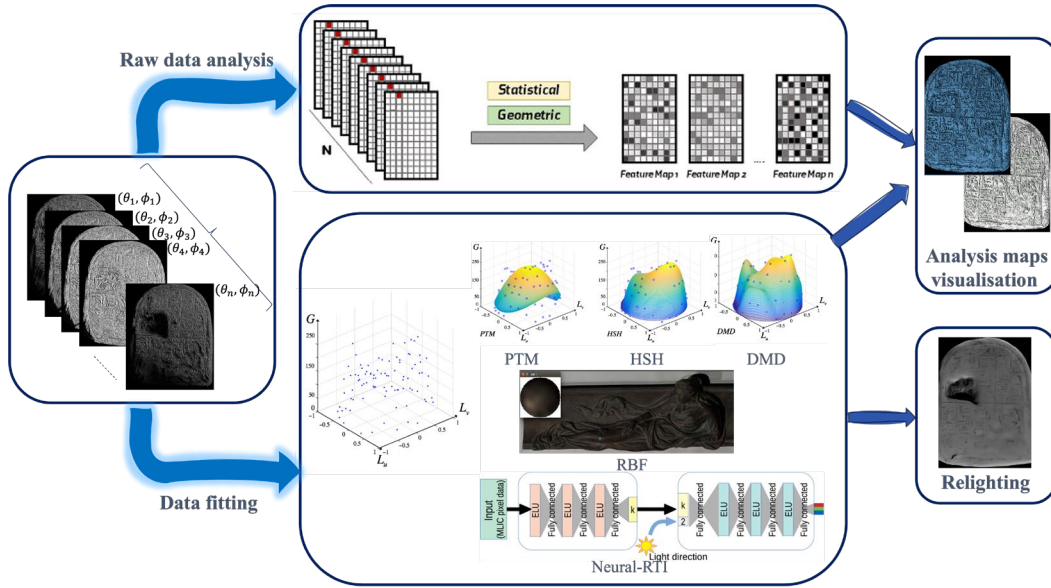


Figure 3: Synoptic of RTI data exploitation

Before these data can be effectively used, several preprocessing steps are necessary, including illumination calibration, stitching, and reflectance fitting, as described in the following sections.

3.1 Pre-processing

3.1.1 Illumination Non-Uniformity Correction

Lighting conditions often change with distance and angle between the source and the object, causing brightness gradients. Two physical laws explain these effects: Lambert's cosine law and the inverse-square law. Figure 8 demonstrates the concept of these variations. Corrections based on these principles normalize image intensity and reduce artifacts as explained in (Castro et al. 2023).

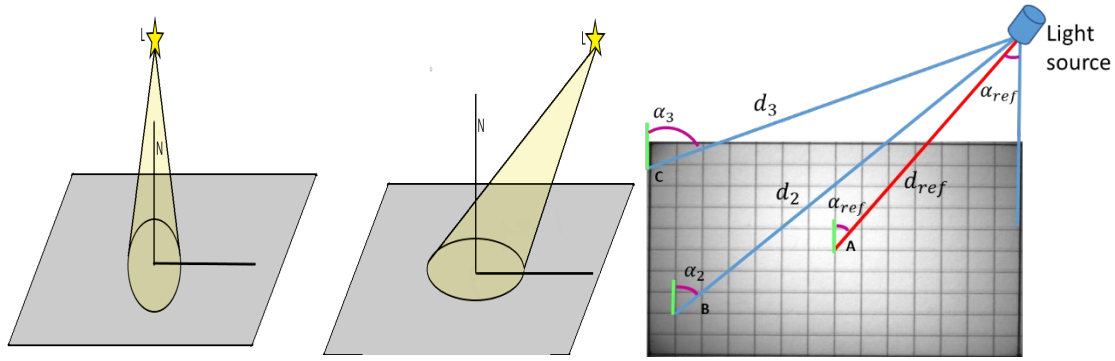


Figure 4: illustration of the unevenness of illumination due to angle and distance variations.

3.1.2 Stitching for Large Objects

When a single RTI capture cannot cover the entire surface, multiple overlapping datasets are acquired and merged in a process called stitching. Stitching ensures both geometric alignment and photometric consistency across zones. Feature-based methods such as SIFT or SURF (Lowe, 2004; Bay et al., 2006) support accurate registration, while global illumination correction maintains brightness continuity (Castro et al., 2019). This approach is essential for documenting large artifacts such as sizable paintings or architectural decorations, and an illustrative example is shown in Figure 5.

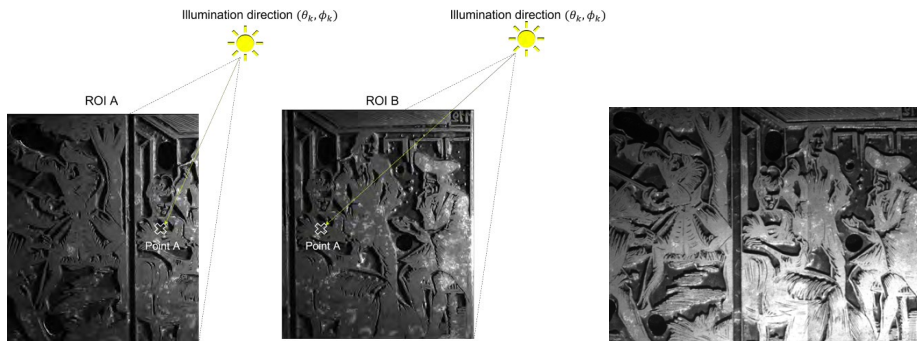


Figure 5: Example of stitched RTI data. Left two partial views for the same light direction and right, stitched image after illumination correction.

3.2 Reflectance Reconstruction for Relighting

- The modelling phase transforms raw image data into a reflectance function describing how each surface point responds to illumination. Different mathematical formulations exist:
 - Polynomial Texture Mapping (PTM) (Malzbender et al., 2001) uses a second-order polynomial to approximate reflectance variations.
 - Hemispherical Harmonics (HSH) (Mudge et al., 2006) extend the model to non-Lambertian surfaces using spherical Harmonics.
 - Discrete Modal Decomposition (DMD) (Pitard et al., 2017) represents surface reflectance using modal basis functions derived from vibration mechanics.

- Neural RTI (Dulecha et al., 2020) employs a neural network-based method to infer reflectance directly from fewer samples.

These models produce relightable visualizations under any lighting directions. Derived renderings like diffuse gain, specular enhancement, and normal or curvature maps offer improved interpretation of micro-relief and texture, as shown in Figure 6.

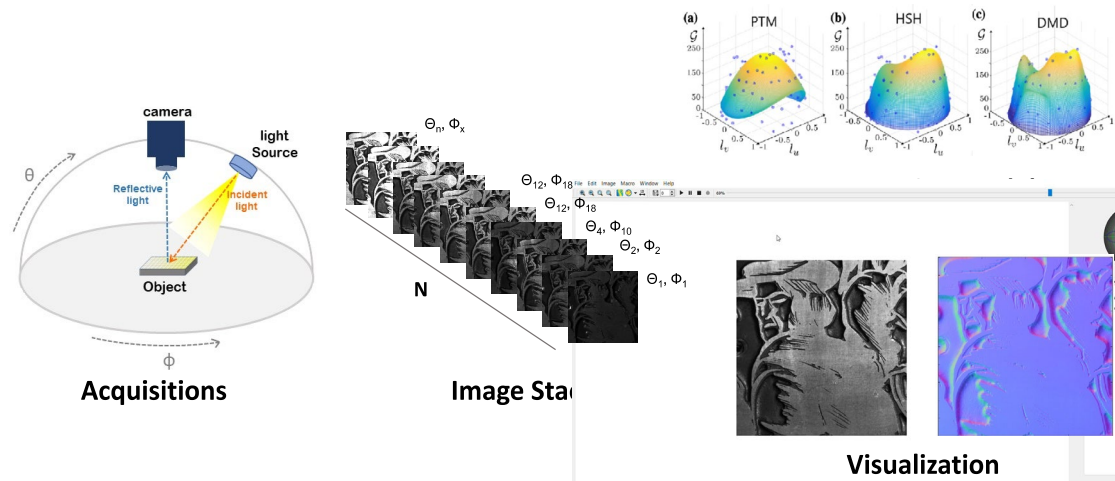


Figure 6. Examples of relighting and derived visualizations from RTI data (© Amalia Siatou).

3.3 Data Analysis and Feature Extraction

Beyond visual inspection, RTI datasets can be analyzed quantitatively. Statistical and geometric descriptors—such as mean gradient, variance, or local curvature—characterize the surface morphology. Recent studies suggest computing visual saliency and distance maps to aid interpretation (Siatou et al., 2022). These analyses identify visually significant regions, helping conservators detect deterioration, monitoring, or traces of restoration. The combination of descriptive and quantitative approaches positions RTI as both an imaging and analytical method in heritage science.

4. Case Studies from the Cheminova Project

Within the framework of the European project CHEMINOVA (<https://cheminova-project.eu>), a series of multimodal imaging acquisitions—including 3D scanning, Reflectance Transformation Imaging (RTI), hyperspectral, thermal, and X-ray fluorescence (XRF) imaging—were conducted on several case studies located in Valencia, Palermo, Vienna, and Kyiv.

RTI imaging was deployed and adapted to the specific characteristics of each object and building. Two representative examples are presented below.

4.1 Valencia Pilot: paintings and building

During the first acquisition campaign in Valencia (conducted before the flood), the study focused on the roofs and courtyard statue of Lanau and several modern paintings. The paintings are large (approximately $1 \times 1 \text{ m}^2$), requiring a specific acquisition strategy based on image stitching to capture their entire surface at sufficient resolution. The figures below illustrate this process applied to the Anzo Aillament painting, showing the stitching, relighting, and the resulting normal map, which highlights the fine variations in the painted surface.

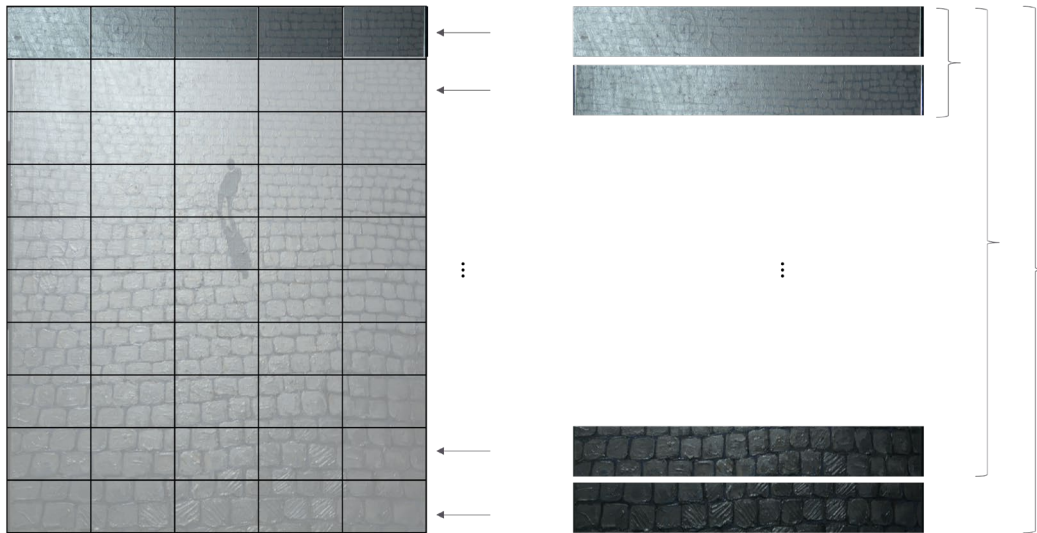


Figure 7: Enzo Aillament painting acquired using RTI across several partial RTI views, then stitched.

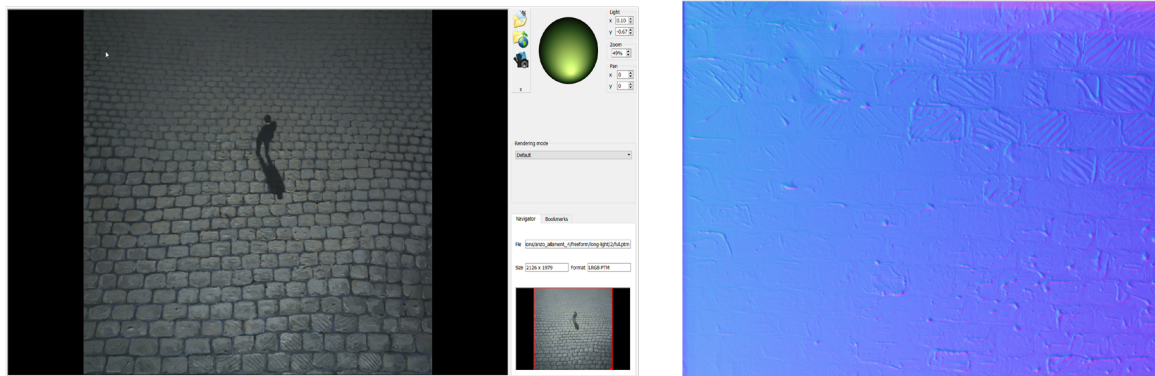


Figure 8: Enzo Aillament painting relighted (left) and a zoom-in on its associated normal map (right).

4.2 Palermo Pilot: anatomical Wax Models

The second case involves anatomical wax models from Palermo. These highly reflective artifacts, created for anatomical instruction, feature complex geometries that challenge traditional documentation methods. We capture them using RTI and multi-view imaging. After reconstruction, changing the virtual lighting allows us to easily distinguish between optical reflections and actual morphological irregularities, enhancing diagnostic interpretation. An example of relighting and normal map reconstruction is shown in Figure 9.

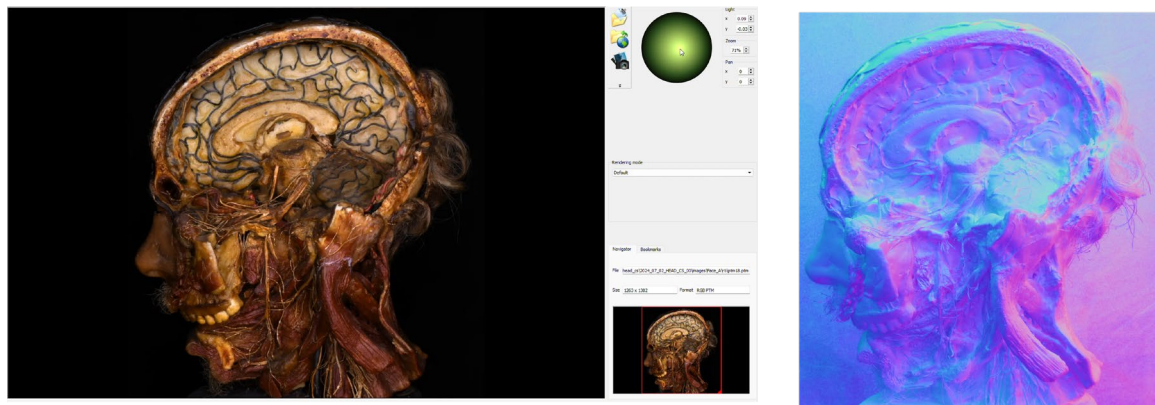


Figure 9: RTI visualisation of an anatomical wax model from Palermo showing surface details.

5. Discussion and Trends in RTI Imaging

RTI has become a mature method adaptable to many documentation contexts. Recent developments aim to improve acquisition adaptability through portable, robotic, and drone-based systems. The integration of RTI with photogrammetry, 3D scanning, and hyperspectral imaging broadens its analytical scope. Machine learning approaches facilitate automated defect detection and material classification, transforming RTI into a source of quantitative surface descriptors. Efforts toward standardization and metadata formalization enhance reproducibility and data sharing. Remaining challenges include reflective materials, lighting control, and interoperability with other imaging formats. Future directions involve multi-view RTI, HDR acquisition, and adaptive illumination to improve accuracy.

6. Conclusion

Reflectance Transformation Imaging has proven to be a reliable and non-invasive method for documenting and analyzing the surface features of cultural heritage artifacts. Its ability to visualize micro-topographical details and reflectance patterns makes it a valuable addition to geometric and spectral imaging techniques. The Cheminova case studies show its relevance for artworks ranging from paintings to intricate wax anatomical models. Future advancements—such as automation, multimodal integration, and AI-based analysis—will further strengthen RTI's role within computational heritage science, connecting optical measurement with visual interpretation for conservation and research.

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Imaging techniques and strategies for conservation of cultural heritage

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Abstract

The workshop entitled **“Imaging Techniques and Strategies for Conservation of Cultural Heritage”** is an integral component of the Blended Intensive Programme, which is itself entitled "Challenges in Cultural Heritage: Sustainable Development and Digital Transformation" hosted by Universitat de València. The seminar signified the beginning of the second day of the programme, which focused on innovative technologies and tools for the conservation of cultural heritage.

In order to explore the landscape of cultural heritage preservation in the digital age the center is placed on the process of documenting and studying cultural heritage. This course is undertaken according to a specific methodology which begins with a visual examination of the work and continues with non-invasive scientific analysis. This non-invasive procedure starts with imaging techniques, followed by reflectance spectroscopy. The significance of initiating studies with a non-invasive procedure is predicated on the capacity to acquire information about the artwork without inducing alterations or reliance on sampling.

The Institute of Robotics and Information and Communication Sciences, in collaboration with the Department of Art History, is overseeing a European project within the Horizon Europe framework, entitled ChemiNova. The primary objective of this project is the creation of new technological tools to enhance on-site and remote monitoring, analysis and conservation of European cultural heritage, which is under threat from climate change and armed conflicts. The project employs non-invasive image techniques and spectroscopies for the analysis of cultural assets, including multiband imaging (MBI), hyperspectral imaging (HSI) and X-ray fluorescence (XRF).

The following report will address imaging techniques, with a particular focus on multiband photography, in theoretical terms. This will be followed by a practical case study component of ChemiNova's project, which was conducted on the day of the programme. Multiband technical photography is a widely utilised technique within the domain of cultural heritage examination and analysis methodologies. This relatively low-cost technique is portable, allowing researchers to conduct fieldwork and thus enabling its use in workshops such as the one previously mentioned. Within the multiband image, different technical images are produced that reveal information that is not visible to the naked eye about the artwork and help us to define its state of conservation.

Key words: Multiband imaging, conservation, cultural heritage, non-invasive techniques.

1. Introduction

In recent years, a series of sophisticated imaging techniques have been developed. These instruments are being used in an increasingly diverse array of applications, thus demonstrating their importance and consolidation as a research field within the scientific domain of cultural heritage and conservation. This report analyses the use of imaging techniques for the conservation of cultural assets in the field of sustainable development. The primary focus of this study is the utilisation of multiband technical imaging.

Since the 1980s, the heritage scientific community has identified technologies and defined methodologies for the study, analysis and characterization of aspects of cultural heritage. These methodologies encompass a wide range of techniques, including non-invasive, micro-destructive and, when necessary, destructive techniques (Ferdani et al., 2025).

The methodology employed in the studies and analysis of works of art to gain a better understanding and documentation of the artwork follows a protocol that seeks to gather as much information as possible using non-destructive techniques.

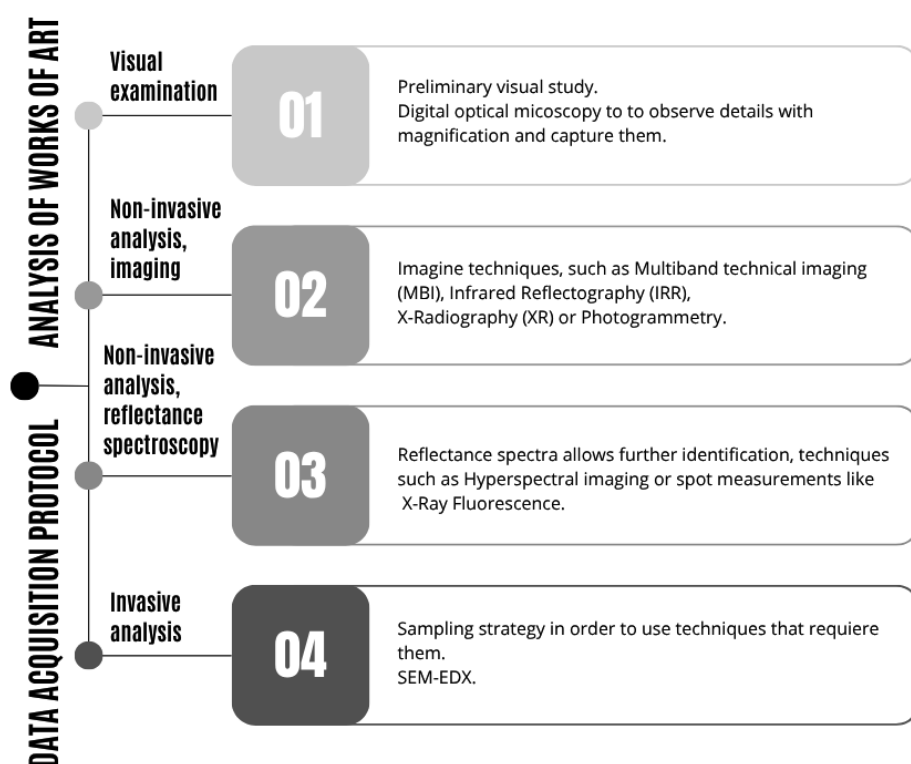


Figure 1. Workflow in technical analysis of artworks. Source: own.

A preliminary visual study constitutes the initial phase of the research process. This part includes the observation of the work through the use of magnification techniques, such as optical microscopy or a portable digital microscope. The second step in this protocol is the use of non-invasive imaging techniques. Starting with the most basic ones, such as multiband imaging or infrared reflectography and followed by non-invasive analyses related to reflectance

spectroscopy, which would include hyperspectral imaging and X-ray fluorescence. Finally, a sampling strategy should be developed in order to use techniques that require samples or that are destructive.

The focal point of this study is imaging techniques, which serve as a fundamental toolkit that facilitates the acquisition of physical, chemical and aesthetic characteristics of heritage items. Since antiquity, imaging techniques have been employed for diagnostic purposes. However, recent technological advancements in equipment and instrumentation have facilitated the examination of small targets and the conduct of research in the fields of conservation and materials science. Furthermore, there are numerous techniques that were not initially used for the study of cultural heritage, but which are now considered part of this toolkit. At present, these practices facilitate the documentation, diagnosis, evaluation and conservation of cultural heritage.

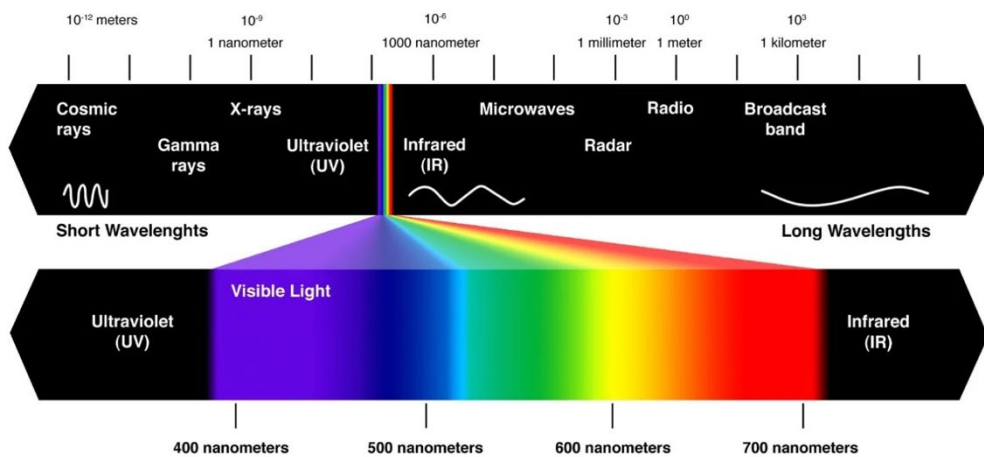


Figure 2. Electromagnetic spectrum. Source: Color Matters ©, 2025. (*ElectroMagnetic Color*, n.d.)

As previously mentioned, the implementation of all the techniques under discussion (MBI, HIS and XRF) is possible thanks to three fundamental components. Firstly, an incoming radiation source is required. Secondly, the artwork to which the radiation is to be applied. Thirdly, a detector that is specifically designed for the given technique is necessary. The functionality of the sensor or detector is different depending on the technology and technique that are employed; the range of the electromagnetic spectrum within which they operate varies accordingly. X-ray fluorescence (XRF), a spot methodology, operates within the X-ray range. In contrast, multiband (MBI) and hyperspectral (HIS) imaging methodologies operate within the ultraviolet, visible, and infrared ranges (Piroddi et al., 2023).

In the same manner that detectors function within specific ranges of the electromagnetic spectrum, the utilisation of incoming radiation from concrete parts of the spectrum is also essential for the execution of the aforementioned techniques (Figure 2). In order to accomplish this objective, a variety of light sources are employed for each technique, a subject that will be addressed in greater detail subsequently.

2. ChemiNova project

The importance of sustainability and digital innovation is continually being emphasized, and in this field, Universitat de València is coordinating a research project under Horizon Europe Program called ChemiNova. In the digital age in which we live, it is crucial to advance within heritage science having always in mind these two concepts.

ChemiNova is an app in process for enhancing the accessibility and preservation of cultural heritage. It aims to create innovative technological tools to improve the conservation, monitoring and analysis of European cultural heritage, particularly that which is threatened by climate change and armed conflicts. These innovative methods are cost-effective for both remote and on-site monitoring of Cultural Heritage assets.

Unlike traditional devices, our technology ensures accessibility for all, engaging local communities through citizen science. The project not only pioneers novel monitoring methods, but also actively involves heritage practitioners and non-experts raising awareness about the effects of climate change and about the importance of our cultural heritage assets.

Combining multiple technologies enables us to collect diverse data about a single object, thereby enhancing our understanding of the artwork's history, from its creation to its current state of preservation. This data is grouped into enriched 3D (e3D) models. Images captured using techniques such as multiband technical imaging are incorporated into these models, enabling all this information to be viewed in virtual replicas within a single, shared virtual space.

ChemiNova system integrates several tools to address the challenges and depending on the tool you wish to use different information will be available.

First, we have ChemiPortal, is the main access point to ChemiNova database. ChemiSensing is designed for the inspection and documentation of damage, in a collaborative mixed platform that use Mixed Reality with video streams from Unmanned Aerial Vehicles (UAVs) where professionals and non-professionals work with virtual replicas. Another application designed for inspection is ChemiInspection, designed for mobile devices it is an augmented reality application. The e3D model is enriched with the information acquired with the techniques included in the project, among other levels of information, such as multiband imaging, hyperspectral imaging and x-ray fluorescence data. To connect the data created by ChemiNova and the non-expert audience we are creating ChemiSee, that is going to make the negative impact of climate change and conflicts tangible through immersive experiences. It wants to encourage citizen participation in conservation processes. ChemiAnalysis is an interactive tool to facilitate the collaboration in the analysis of the generated information about composition, materials, deteriorations, etc. A based on machine learning algorithms is going to be ChemiAI, it will predict various types of structural and chemical damages automatically. Finally, ChemiModel is a software module responsible for 3D reconstruction of objects from images, it generates the e3D models with the spatial information, multimodal representations that include spectral (from hyperspectral imaging), photometric, semantic and temporal data. These models serve as a foundation for other tools (*Tools - ChemiNova*, n.d.).

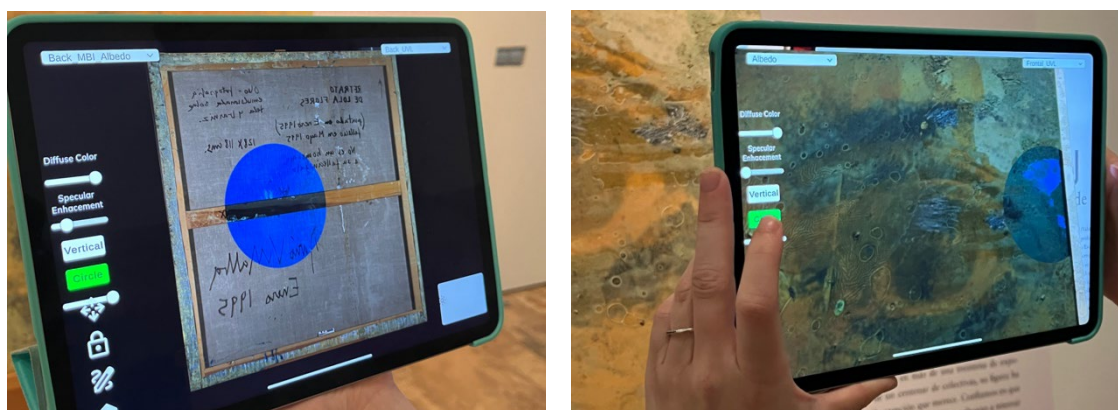


Figure 3 and 4. ChemiInspection, visualization of *Retrato de Lola Flores* in different images from multiband technical imaging. Source: ChemiNova project.

As mentioned above, these analytical techniques presented today in the workshop have been widely used for many years. The advances in the project rely in the possibility of applying the information acquired with existing techniques, which are extremely useful in the field of conservation, to a new way of visualizing heritage: digital twins. These are capable of containing all the information in a single space and combining it with other innovative technological tools such as artificial intelligence (AI), augmented reality (AR) and mixed reality (MR).

3. Multiband imaging

Multiband technical image is a set of procedures used to observe an object using selected ranges of wavelength that include visible and non-visible wavelengths; ultraviolet radiation (UV 200-400nm), visible light (VIS 400-700nm) or infrared radiation (IR 760-1700nm). This reveals information that extends beyond the capabilities of the human eye.

This technique is widely used by conservation and restoration professionals in order to obtain information about the surface state of conservation and allowing the localization of materials that appear different under diverse wavelengths of illumination in a completely non-invasive and non-destructive way.

Multiband imaging has many advantages, as it is a technique that does not require overly complicated procedures, and enables conservators, restorers, art historians, and cultural heritage professionals to observe the artwork's surface in a different way. It is a relatively low-cost technique, that covers a large wavelength range using modified commercially available cameras (Dyer & Newman, 2020.). As it was mentioned before, it is a non-invasive and portable technique that allows us to work with any type of artwork without causing damage beyond that caused by exposure to light.

The equipment that we use in our laboratory, is a D850 NIKON digital camera modified and sensitive to the spectral range about 360-1000 nm. There are two filters removed from this camera, the Hot mirror filter that blocks UV and IR and the Dust Reduction Filter that has an IR-reflective coating it also stops the UV.

The set of acquisition needs the camera, the band-pass filters for selecting different wavelength regions, the different lights, and a computer with DigiCamControl® that is used to control the

camera conditions and to acquire photos. This application allows us to control the camera remotely, ensuring that we do not move the camera while adjusting the settings or when pressing the shutter button.

As it is said, with this technique we use specific wavelengths with different lighting sources and filters on the camera lens to differentiate pigments and materials as well as to determine certain conditions for the conservation and diagnosis of cultural heritage.

The radiation reaching the object interacts with it in different ways, it can be reflected directly, here the wavelength range of incoming and that one that is outgoing are the same. Radiation can be absorbed or absorbed and re-emitted, in this last case the wavelength range of the incoming radiation is different from the outgoing radiation, which is less than the incoming.

In MBI we differentiate two categories of photographs depending on the interaction of the light that that we have just explained.

-In reflectance images the radiation incoming and outgoing are the same.

-Luminescence: Luminescence refers to the generation of light through the conversion of energy. Luminescence is observed during the excitation, while the term phosphorescence is reserved for the emission that lasts also after removal of the exciting radiation source (Picollo et al., 2019) The energy is absorbed by a molecule, it brings the electrons to a higher energy level, but it makes it unstable. This instability causes the electron to fall back to the ground state, so it releases energy in form of heat, vibrational energy and photons. Those photons are the luminescent emission.

The images that multiband imaging include are:

Visible Images (VIS) reflected.

This technique corresponds to standard photography, and we use it as a reference point. We will use visible light and the Visible region filter in the camera to filter from 400 to 700nm approximately.

Ultraviolet-induced visible fluorescence (UVF)

The image records the emission of ultraviolet light in the visible region. We must illuminate the object with ultraviolet radiation and use the Visible region filter (400 to 700nm). This technique is useful to investigate the distribution of some materials (especially organic materials) like binders, colorants or varnishes. It reveals also added materials like repainted areas of restoration interventions.

Ultraviolet Reflectance (UVR)

UVR images record the reflected radiation in the ultraviolet region (200-400nm) so we use the ultraviolet filter while the object is illuminated with ultraviolet radiation. It is used to characterize the superficial distribution of materials, and it helps us to understand even better the surface of the artworks.

Infrared Reflected (IRR)

These images are the result of the infrared radiation recorded in the infrared region using the infrared filter (700-1000nm). The infrared radiation is highly penetrative, and many materials generally used in cultural heritage are transparent to these wavelengths.

The last images that we obtain with multiband imaging are Visible reflected and Infrared Reflected photos but changing the position of the light.

Grazing light

In this case we only use a light source that is positioned at the same height as the artwork emphasizing the piece's relief, its crack or fissures. It helps us to identify fabric stretching or deformations in the supports.

Transmitted light

For the last photography the radiation is behind the artwork so we can see better changes in opacity, tears, breaks and cracks.

IMAGE	INCOMING RADIATION	FILTER	LIGHT POSSITION
VIS	Visible	Visible (400-700nm)	Frontal
UVF	Ultraviolet	Visible (400-700nm)	Frontal
UVR	Ultraviolet	Ultraviolet (200-400nm)	Frontal
IRR	Infrared	Infrared (700-1000nm)	Frontal
VIS - Grazing	Visible	Visible (400-700nm)	Grazing
VIS – Transmitted	Visible	Visible (400-700nm)	Transmitted
IRR - Transmitted	Infrared	Infrared (700-1000nm)	Transmitted

Table 1. Multiband Images summarize. Source: own elaboration.

In order to have a complete record of the work, we perform each of the techniques on both the front and back.

4. Case Study

To demonstrate all the theoretical concepts explained in the first hour, a practical component was added to this session in the form of a multiband image acquisition set.

To bring together practice, theory and the ChemiNova project, one of the works included in the project's pilot Valencia works has been selected. The artwork is El Retrato de Lola Flores by Dario Villalba. The intensive program took place in one of the classrooms at the Centre Cultural de la Nau, where the artwork is stored.

TITLE	Retrato de Lola Flores (The Portrait of Lola Flores)	
AUTHOR	Dario Villalba	
DATE	1995	

PLACE	Martínez Guerricabeitia Colletion, Centre Cultural de La Nau	
OWNER	Universitat de València	
TECHNIQUE	Varnish, water and oil on photolinen canvas	
DIMENSIONS	128 x 118 cm	

Table 2. Technical aspects, Retrato de Lola Flores. Source: own elaboration.

The painting is part of the contemporary art collection donated by the Martínez Guerricabeitia family to the University of Valencia. We can see represented the Spanish artist, Lola Flores. It is an impression on canvas, to the surface of which a mixture of varnish, water and oil was added.

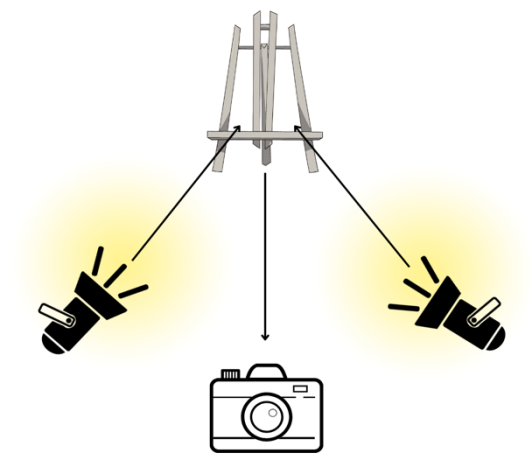


Figure 5. Set in frontal illumination. Source: own elaboration.

In the practice, all the techniques described above that are part of the Multiband Imaging were carried out, so the set was assembled in its entirety. The camera used throughout the process is the modified Nikon D850, whose technical specifications have been documented, along with the filters. The lighting for each technique varies depending on the data acquisition, although in our case we only use two different types of lighting: one set for both visible and infrared light, and another for ultraviolet light.

The set lights in the Visible Images (VIS) and Infrared Images (IR)

The illumination kit that we usually use, ARRILITE 750 PLUS, directs the radiation of an HPL* 750 W lamp. Two lights have to be positioned as CIE recommends using one

of four standard geometries (Figure 5), projecting symmetrically onto the surface at a 40-45° angle to avoid specular reflectance. This illumination kit emits both ranges so we can use it in visible and infrared images.

Ultraviolet light.

We use Fabrizio UV LED lamp from Cultural Heritage Science Open Source (*Ultraviolet Lamp - Cultural Heritage Science Open Source*, n.d.) that has been specifically designed for this purpose. The emission of this light is at 365nm and has not a detectable visible-infrared noise emission because it has a UV pass filter that cuts off the violet light and infrared radiation.

The lighting in the grazing image and the transmitted image is different from all the others (Figures 6 and 7).

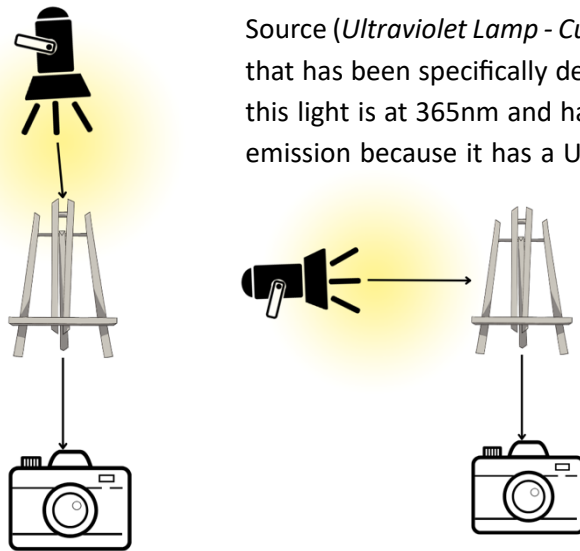


Figure 6 a) and b). a) Set illumination transmitted in images.

b) Set illumination in grazing images.

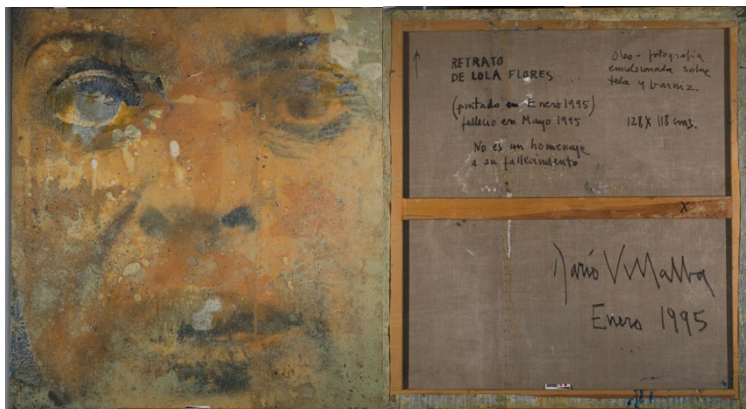


Figure 5. Front and back VIS.



Figure 6. Front and back UVF.

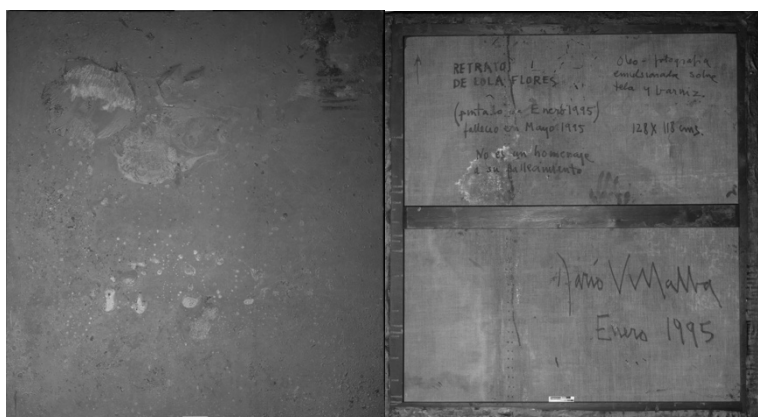


Figure 7. Front and back UVR.

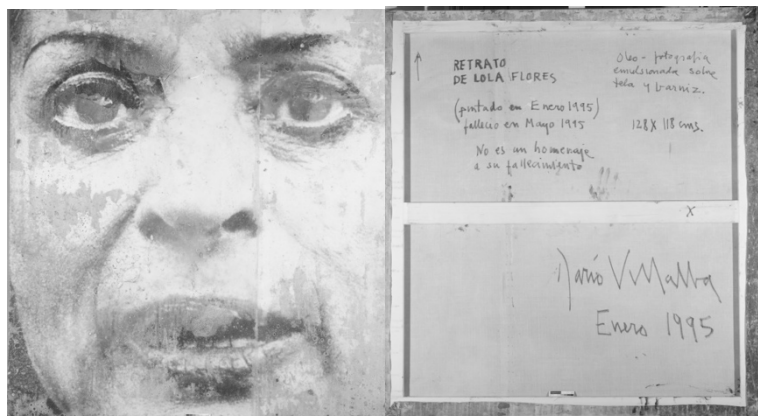


Figure 8. Front and back IRR.



Figure 9. Front grazing VIS images.



Figure 10. Front Transmitted VIS-IR.

5. Conclusion

The integration of advanced imaging techniques into the field of cultural heritage conservation has redefined the way artworks are documented, studied, and preserved. As demonstrated throughout this workshop and case study, multiband technical imaging offers a versatile, non-invasive, and cost-effective approach to understanding the physical and material characteristics of cultural assets. By revealing information that lies beyond the visible wavelengths and the comparison of each of the images, it provides invaluable insights into the condition, composition, and historical evolution of artworks.

Within the framework of the ChemiNova project, these imaging techniques take on a new dimension. Their incorporation into digital environments, such as virtual replicas called enriched 3D (e3D) models allows for the visualization, interpretation, and dissemination of cultural heritage in innovative and open access way. The combination of new technological tools based on artificial intelligence, augmented reality, and mixed reality not only enhances diagnostic capabilities but also encourages public engagement and participatory conservation.

Ultimately, the synergy between technology, sustainability, and heritage science encourages a more comprehensive and forward-looking approach to preservation. Through initiatives such as ChemiNova, the Universitat de València and its collaborators are contributing to a paradigm shift

that embraces digital transformation as a means to safeguard, interpret, and transmit cultural heritage for future generations.

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Urban Heritage in Movement. Some case studies from Transylvania and Banat

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Abstract:

Urban heritage should be understood not only as a collection of physical structures but as a dynamic field of social, cultural, and affective interactions. Engagements with urban space generate emotional, political, and cultural dispositions that shape human experiences, identities, and collective memory. From this perspective, heritage is relational and performative: even modest historic structures acquire significance over time by contributing to the lived and perceived character of the city. Recognising these affective and spatial dimensions reframes urban heritage as an active participant in the production of cultural meaning, rather than as a static record of architectural forms.

The nineteenth and early twentieth centuries were transformative for cities in Transylvania and the Banat, as modernization and urban expansion reshaped both their physical and symbolic landscapes. The dismantling of medieval fortifications enabled the development of new streets, squares, and public institutions, while architectural eclecticism, Secessionist, and Jugendstil forms introduced contemporary European stylistic currents into the urban fabric. Buildings such as the Lloyd Palace and Palatul Jakab Löffler and Sons in Timișoara, the ASTRA Palace, and the Public Bath in Sibiu illustrate how architecture integrated aesthetic innovation with functional and social purposes, supporting cultural, civic, and commercial activities. These case studies demonstrate that urban heritage operates at the intersection of architecture, social practice, and historical memory, highlighting the importance of preserving both tangible structures and the intangible cultural and communal dynamics they embody.

Key words: architectural heritage, symbolic of space, multicultural cities

1. Concept and methods of analysis

Urban heritage can be understood not merely as a collection of material objects but as a field of affective encounters shaped through spatial practices and socio-cultural meanings. By considering heritage as *intangible* in its primary orientation, the analytic gaze shifts from the monument or event itself to the affects that emerge through people's engagements with urban space. Drawing on Thrift's (2004) theorisation of affect as a form of embodied, non-reflective thinking, urban environments can be seen as generating emotional, political and cultural dispositions that orient bodies toward action. This aligns with Harvey's (1996) argument that social relations are fundamentally spatial, embedded within and shaped by the meanings of place. In this view, urban heritage is not simply the preservation of architectural forms but a relational and affective structure through which experiences, identities and collective memories are produced. Consequently, even modest historic works and their surrounding settings contribute to this affective landscape, as they acquire cultural significance over time and participate in the spatial conditioning of human encounters. Understanding heritage through these spatial and affective dynamics underscores how cityscapes both represent and actively shape cultural meaning, making affect central to contemporary urban heritage theory (Smith, 2006).

The expansion and modernisation of multicultural cities in the Austro-Hungarian Monarchy profoundly reshaped their urban landscapes, producing new spatial narratives and heritage formations. Transnational and dynastic naming practices—visible in hotels, cafés, schools, and

railway stations—articulated loyalty to the Habsburg monarchy, while the creation of new streets honouring Hungarian kings, heroes, and ministers asserted a parallel national discourse (Horel: 2023, 5). Cultural institutions built along these axes further materialised competing identities within the urban fabric. As Horel (2023, 5) argues, cities operate as “imagined communities,” experienced primarily through familiar neighbourhoods and everyday spaces. Conceived as a palimpsest (Horel 2023, 5), the city is continuously rewritten through social practices yet retains earlier spatial inscriptions, making urban space a stratified assemblage of past and present narratives. This layering is intensified in East-Central European cities, where shifting borders, diasporic conditions, and recurrent patterns of mobility and marginalisation have historically reshaped demographic and cultural configurations. As Csáki (2010, 20) notes, the city becomes a *mélange* of deep interconnections and networks formed through these movements. Understanding the city as a living repository of heritage therefore highlights how the public arena not only accommodates cultural practices but embodies accumulated layers of historical memory. Within this dynamic space, the self-expression of social actors both continues and reinterprets inherited traditions, making the city itself a stage on which heritage is enacted, negotiated, and continually renewed.

2. Heritage and urbanity in Transylvania and Banat

The nineteenth century marked a decisive period of urban transformation in Transylvania and the Banat, as cities within the Habsburg Empire underwent extensive modernisation processes that reconfigured their spatial organisation, architectural fabric, and cultural identity.

The nineteenth century brought significant transformations to urban planning in Transylvania and Banat, as municipal authorities and architects within the Habsburg Empire increasingly adopted modern, rational approaches to the organisation of urban space. The obsolescence of medieval defensive structures, especially evident following the 1848 revolutions, compelled city administrators to reconsider the spatial constraints imposed by fortified urban cores. In this context, cities such as Sibiu/Hermannstadt/Nagyszeben and Timișoara/Temeschwar began to articulate new forms of urban development that aligned with broader Central European trends (Breier, 1994). These measures included not only the removal of outdated military fortifications, but also the systematic redesign of streetscapes, the construction of public institutions, and the creation of infrastructures that supported economic, cultural, and administrative growth. By the late nineteenth century, both regions experienced an unprecedented phase of urban modernisation, positioning their cities within the wider project of Habsburg imperial urban development.

A defining characteristic of this process was the large-scale demolition of medieval fortifications, which opened the way for substantial urban expansion. In Sibiu, the dismantling of the Heltauertor (the Cisnădie Gate Tower) in 1836 marked the beginning of a long period of defortification, later followed by the removal of defence walls near the present-day Natural History Museum in 1895 and the demolition of the Priests’ Tower in 1898 (Sigerus, 54). Similar dynamics were at work in Timișoara, where the Vauban-style fortress had long constrained urban growth. Under the leadership of Mayor Karl Telbisz, who governed from 1885 to 1914, the city undertook a comprehensive programme to dismantle its three concentric defensive walls, culminating in their removal in 1905. These interventions liberated extensive areas of land for development, enabling the construction of key administrative, commercial, and educational buildings—such as Lloyd Street, the central Post Office, and the Palace of the Bank—and accompanying infrastructural improvements, including the canalisation of the Bega River and the modernisation of water and sewer systems. The demolition of gates and towers thus facilitated a profound spatial reconfiguration that fundamentally altered the morphology and future trajectory of these cities.

The removal of fortifications was accompanied by an architectural renewal that reshaped the visual and symbolic identity of Transylvanian and Banat cities. New constructions reflected the aesthetic currents circulating in Europe at the end of the nineteenth century, most notably the eclecticism characteristic of the period. Buildings with taller profiles, large interior rooms, and richly decorated façades in neo-Classical, neo-Gothic, and neo-Baroque styles began to dominate the urban landscape. At the same time, German-inspired Jugendstil introduced more modern, ornamental forms into the architectural vocabulary of the region. One notable example is the public bath in Sibiu, designed by the Munich architect Karl Hocheder, also known for the celebrated Müller'sche Volksbad in Munich—an emblematic work of Jugendstil on the banks of the Isar. Taken together, these stylistic developments placed the cities of Transylvania and the Banat firmly within the architectural evolution of Central and East-Central Europe, reflecting both the cosmopolitan influences of the Habsburg world and the ambitions of local elites to project modernity through the built environment.

3. Some case studies of urban heritage

The urban space of Timișoara began to be reconceptualised in the early modern period, following a rational, centrally planned model characteristic of Habsburg imperial urbanism. Designed by Austrian military engineers, the city's restructuring aligned with the broader Central European tendency to rebuild and standardise urban centres according to principles of geometric order, functional zoning, and defensive optimisation. The reconstruction plan adopted in the early eighteenth century envisaged the complete reorganisation of the inner city, consistent with contemporary strategies of replacing medieval urban fabrics with regulated street grids and fortified perimeters. As Bleyer notes, the underlying model adhered to the prevailing Vauban-inspired typology of fortifications, reflecting the diffusion of early modern military engineering and its influence on the spatial form of cities across the región (Szekely, 2016).

At the middle of the nineteenth century, the city presents a welcoming appearance, with well-developed infrastructure, paved streets, commercial areas, and urban furniture. While it does not offer the grandeur of major European capitals, it provides a variety of urban experiences, including leisurely movement along avenues connecting the center to the periphery. Central squares serve as focal points for social interaction, enriching public life, while the modernization of the urban landscape reflects the transfer of cultural and architectural influences from the imperial center. Residential buildings of two to three stories indicate a relatively high standard of living and the growth of a prosperous bourgeoisie (Szekely, 2016).

The nineteenth century was characterized by the global expansion of cities, a trend visible within the Habsburg, later Austro-Hungarian, Monarchy. Cities acquired an eclectic, cosmopolitan character, with broad boulevards and imposing buildings, and the pace of public and residential construction accelerated. In Timișoara, industrial and commercial development expanded notably in the mid- to late 1800s. Following the Revolution of 1848, the need to reshape the urban fabric and create residential and administrative spaces became pressing. Architectural eclecticism emerged as the dominant style, reflecting broader European trends and shaping the city's evolving identity.

In the following lines, a short description of some selected case studies of urban heritage in Timișoara and Sibiu will be made, in order to understand some of the key insights of the architectural milieu of this space.

The Lloyd Palace, located in Timișoara, is an exemplary manifestation of early twentieth-century Art Nouveau, also known regionally as Secession style. Designed by Lipót Baumhorn and completed in 1912, the building demonstrates the principles of the Gesamtkunstwerk, or “total work of art,” integrating architectural form, ornamentation, and interior design into a cohesive

aesthetic experience. Its façade is characterized by four monumental columns supporting allegorical statues, elaborate classical and zoomorphic motifs, and a roof finial shaped as a globe, symbolizing the building's commercial and civic functions. Decorative elements such as mascarons, abstract owls, and representations of Mercury highlight the eclectic yet harmonious visual vocabulary typical of the Secession style, while the irregular plan and volumetry of the structure reflect a sophisticated adaptation to urban context and function.

Functionally, the Lloyd Palace played a pivotal role in the social and economic life of Timișoara. It accommodated commercial activities on the ground floor, including the Lloyd restaurant, while the upper floors hosted clubs, associations, and meeting spaces, such as the Lloyd Club, the Merchants' Association, and the local Freemasons' lodge. The integration of civic, commercial, and social functions within a single building illustrates the evolving urban typology of the period, in which multi-purpose edifices contributed significantly to the public and cultural life of the city. As part of the historic ensemble of Piața Victoriei, Palatul Lloyd embodies both the cosmopolitan ambitions of early twentieth-century Timișoara and the broader European trends of architectural eclecticism and modern urban planning. Its preservation as a historic monument underscores its continued significance as a landmark of architectural and urban heritage. (<https://heritageoftimisoara.ro/cladiri/Cetate/adresa/Victoriei/2>)

The Palace Jakab Löffler and Sons, situated in the centre of Timișoara, is a distinguished example of mature Secession, or Art Nouveau, architecture and a valued component of the city's cultural heritage. Designed by Henrik Telkes in collaboration with Lipót Löffler and completed in 1913, the four-storey building forms a prominent part of the historic "Corso" ensemble. Its façades are richly articulated, combining stucco reliefs, sculptural ornamentation, and intricate plasterwork. Sculptural elements by Géza Rubletzky, including mascarons and allegorical motifs, enhance the lateral elevations and contribute to the expressive character of the building. The interplay of classical references with Secession motifs, such as geometric and vegetal forms, demonstrates a sophisticated adaptation of late nineteenth- and early twentieth-century decorative vocabularies, marking the building as a significant cultural asset.

The palace's volumetric composition and design further underscore its heritage value. Projections, recesses, bow windows, loggias, and balconies create a dynamic façade, while the roof, covered in eternit, complements the irregular massing and visual rhythm. Originally constructed as a revenue building with 46 apartments encompassing 142 rooms, it exemplifies both functional efficiency and urban ambition. Its preservation as a historic monument, alongside visible traces of the 1989 Revolution, highlights the building's enduring cultural, historical, and social significance within Timișoara's urban landscape. (<https://heritageoftimisoara.ro/cladiri/Cetate/adresa/Victoriei/1>)

The ASTRA Palace represents a landmark of cultural, historical, and architectural heritage in Sibiu. The palace was constructed between 1903 and 1904 according to designs by architect Aladár Baranyai, with construction overseen by Gustav Maetz. Its interiors were furnished by Fritz W. Elges, sculptural work executed by Iosif Schneider, and mural paintings by the Bohemian artist Johann Hofrichter. Architecturally, the building is notable for its rich Secessionist and eclectic façade, including a main entrance flanked by two atlantes, a ceremonial hall distinguished by elaborate interior ornamentation, and a gallery of busts celebrating prominent Romanian cultural figures. These elements collectively demonstrate the building's dual role as both a centre of aesthetic innovation and a repository of national and cultural identity.

Historically and urbanistically, Palatul ASTRA has played a central role in Sibiu's cultural and social life. Inaugurated on 19 August 1905 as the "Casa Națională Centrală ASTRA," it originally housed a public library on the ground floor, the Historical and Ethnographic Museum of Transylvania on the first floor, and the ASTRA Conference and Lecture Hall, which also served as the first Romanian theatre stage in Transylvania. The palace hosted seminal events, including the first

literary gathering of the Romanian Writers' Society in 1911 and the inaugural congress of Romanian merchants in 1919. Today, commemorative plaques and preserved decorative features highlight its enduring significance, confirming the palace as an essential component of Sibiu's historical, architectural, and urban heritage (https://patrimoniul.sibiu.ro/cladiri2/parcul_astra/168)



Figure 1. Postal card with the ASTRA Palace at the beginning of the 20th century

Located in the centre of Sibiu, **the Public Bath** is among the city's oldest public buildings of interest, originally conceived to provide accessible bathing facilities for all residents. The initiative was promoted by Dr Carl Wolff (one of the public figures of the city at the beginning of the 20th century), and the General Assembly of the Savings and Consignments House supported the project financially through its reserve funds. The site previously hosted a stearin factory, and in the mid-nineteenth century, Franz Frübek established the first steam baths in Sibiu, later acquired by Johann Habermann. The present building, completed in 1904, was designed by Professor Karl Hocheder of the Technical University of Munich, who blended Baroque stylistic forms with late nineteenth- and early twentieth-century elements, a style known as Münchener Barock. Hocheder entrusted the construction to his assistant Hans Heckner, together with master builder Gustav Maez and his team, enabling the rapid completion and inauguration on 11 December 1904. Structurally, the Sibiu Public Bath closely follows the design of the Müller Bath in Munich, also by Hocheder.

Architecturally, the complex is organised around a central hall, which houses the cashier and main entrance. To the left, visitors access the primary swimming pool, measuring 21 metres in length, 9 metres in width, and up to 3 metres in depth, set within an architecturally impressive space. To the right is the Roman-Irish sauna, unique in Romania for its complex facilities,

including a sudation room with 32 individual cabins, wet and dry saunas, alternating hot and cold baths, showers, and a massage area. The upper floor contains ten private bathing cabins with tubs and showers, alongside hairdressing, manicure, pedicure, and cosmetic treatment rooms, all equipped with modern appliances and operated by experienced professionals. The basement accommodates a recently modernised laundry, a high-efficiency heating plant, and, surrounding the interior garden, rooms dedicated to physical exercise and bodybuilding. The building's architectural design, functional diversity, and attention to public health and hygiene exemplify its historical and urban significance as a centre of civic and social life in Sibiu (<https://patrimoniu.sibiu.ro/cladiri2/saguna/371>)

4. Conclusions

The case studies of Timișoara and Sibiu illustrate how urban heritage extends beyond individual monuments to encompass the complex interplay of architecture, function, and social meaning within the cityscape. Buildings such as the Lloyd Palace and Palatul Jakab Löffler și fiii demonstrate the centrality of Secessionist and Art Nouveau architecture in articulating the aspirations of early twentieth-century urban elites, blending aesthetic innovation with multifunctional use. Similarly, the ASTRA Palace in Sibiu exemplifies the integration of cultural, educational, and performative functions within a single structure, reinforcing the role of architecture as a medium for national identity and civic engagement. These edifices, together with the Sibiu Public Bath, underscore the ways in which public and private urban spaces were designed to facilitate social interaction, promote public welfare, and reflect broader European stylistic currents, positioning architecture as both a material and symbolic agent in the shaping of urban life.

Collectively, these heritage sites reveal the layered and relational nature of urban space, where historical memory, social practices, and architectural form converge. The removal of fortifications, the creation of new streets and squares, and the construction of culturally significant institutions transformed both the physical and symbolic landscapes of Transylvanian and Banat cities. These transformations illustrate that urban heritage is simultaneously a product of historical processes and an active site of cultural negotiation, where collective memory, identity, and affective experiences are continuously reproduced and reinterpreted. Recognising these dimensions highlights the value of preserving not only the physical fabric of historic buildings but also the intangible cultural and social dynamics they generate, reinforcing their ongoing significance within contemporary urban life.

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<https://heritageoftimisoara.ro/cladiri/Cetate/adresa/Victoriei/1>

<https://heritageoftimisoara.ro/cladiri/Cetate/adresa/Victoriei/2>

Living Legacies: Heritage, Cultural Mediation, and Sustainability

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Abstract

This paper advances a “living legacies” paradigm that reframes heritage as a dynamic, co-created process rather than a static assemblage of monuments and artifacts. We argue that current sustainable development architectures—most visibly the SDGs—insufficiently capture social and cultural sustainability, leading to regeneration models that privilege economic returns over community well-being, authenticity, and intangible practices. Through a critical synthesis of international frameworks and scholarship, we integrate the Sustainable Development Goals with the New Urban Agenda and the Historic Urban Landscape approach, anchored in a human rights-based lens. We identify cultural mediation as the operative mechanism that links global mandates to local realities, enabling multivocal interpretation, participatory governance, and equitable benefit-sharing. Emphasizing youth as co-creators and decision-makers, we highlight digital engagement and place-based arts as levers for resilience, identity formation, and intercultural understanding. The paper proposes an integrated evaluation scaffold that complements economic metrics with qualitative and process indicators—community participation, performativity, integrity/authenticity, livability, and well-being—operable across scales and attentive to power relations. We demonstrate how this synthesis redirects heritage-led urban regeneration from tourism-driven commodification toward inclusive, people-centered development, and outline governance pathways that prioritize co-production, adaptive management, and intergenerational equity. By positioning heritage as knowledge capital, social infrastructure, and an engine for just transitions, the “living legacies” model clarifies how heritage can substantively drive multiple SDGs while strengthening social cohesion, ecological responsibility, and future-making capacities in cities and regions.

Key words: cultural heritage, community, sustainability

1. Introduction

Cultural heritage can be defined beyond mere historical artifacts, encompassing both tangible and intangible expressions that embody the collective identity and legacy of societies (Palladino & Bodard, 2023). The preservation and interpretation of these legacies are not static endeavours but rather active, evolving processes essential for fostering social cohesion and intercultural understanding in contemporary contexts (Spina, 2025).

Indeed, understanding heritage as a dynamic and participatory process necessitates a continuous re-evaluation of its narratives to ensure inclusivity and address historical imbalances (Hirsch et al., 2024). Furthermore, this dynamic perspective aligns with the principle that heritage, while rooted in the past, serves as a crucial resource for shaping future societal development and addressing global challenges (Pappalardo, 2020). More specifically, a human rights discourse can enable a unified language to define and discuss global inequalities, injustice, and historical repressions in relation to heritage management (Toonen et al., 2019). This integrated approach extends beyond conventional conservation to integrate heritage

management with broader sustainable development objectives, particularly through people-centered methodologies (Rosetti et al., 2022).

This shift underscores the importance of community engagement and participatory practices in heritage management, moving beyond professional exclusivity to involve diverse stakeholders in decision-making processes. This integrated approach ensures that heritage practices are not only culturally sensitive but also contribute to sustainable development by promoting economic growth, social equity, and environmental protection. This is particularly relevant as heritage stakeholders increasingly aim to integrate Sustainable Development Goals into their operations, recognizing the intricate interdependencies between heritage and broader sustainability objectives (Jørgensen et al., 2024). Nonetheless, this integration necessitates an understanding of heritage management outcomes to be measured not only economically but also by improvements in local communities' living conditions and their participation levels in decision-making (Faouri & Sibley, 2024).

This paper examines the necessity of integrating diverse UN initiatives to address the existing shortcomings of the SDGs, particularly in emphasizing social and cultural sustainability as foundational pillars alongside economic and environmental considerations. This integration aims to overcome the current fragmentation between various UN and UNESCO endeavours, which frequently leads to conflicts of interest in heritage preservation efforts (Faouri & Sibley, 2024). Specifically, this paper argues for a clearer pathway to leverage heritage as a primary driver for achieving the SDGs, moving beyond the current underrepresentation of social and cultural dimensions as well as to untap its full potential in promoting socially responsible and innovatively sustainable development models.

2. Heritage as a dynamic process

Cultural heritage cannot be understood as static but as a continuously evolving process, intrinsically linked to identity formation and societal resilience (Faouri & Sibley, 2024). In other words, cultural heritage is more than just the cultural assets that comprise it; it is movable, immovable and intangible assets that shape people's identity, memory and sense of place. Therefore, heritage does not come from objects but from subjects, thus making the process of heritage preservation a process of constructing collective memory (García 2008). Indeed, heritage is not at the origin of creation; it is part and result of the interaction of human beings with their environment and their peers (Choay 1992). Thus, heritage stands as a social creation and construction. The term established by Riegl remains valid, although certain aspects have changed. Cultural heritage aims to revive in the present a past submerged in time. The essence of a monument is its way of relating to the past by mobilising memory and activating affectivity (Choay, 1992, pp. 12–19).

On the other hand, human societies use a social language formed by signs and symbols to communicate, in addition to verbal and body language. Heritage then emerges as a sign for interpreting the past, and the possibilities for symbolic interpretations through historical heritage assets for communication are enormous. For Silvio Mendes (2009), objects are transmitters of culturally relevant meanings that are passed down from generation to

generation, as they are what give meaning to communities. That is why conservation depends on the meanings that society attributes to them.

Heritage is part of culture, just as culture is part of heritage, as it is a corpus of resources that individuals draw on. In this way, heritage can be spoken of as a cultural goal. When we talk about cultural heritage, we are talking about symbols that have become meanings, while also being an important resource in the construction of identity, whether through political, scientific or economic construction. At the same time, heritage is presented as an element of culture, which gives it an added resource (Ladrón de Guevara 2016). Similarly, it is necessary for there to be a community for the construction of cultural heritage. The transition from an individual to a collective subject must be taken as a prerequisite for the expressive mastery of heritage, thus acquiring a function of cohesion and identity generation. Therefore, cultural heritage is an evolving social concept, charged with dynamism, complexity and multiplicity as intrinsic characteristics.

This dynamic understanding requires a more nuanced approach to measurement, moving beyond simple financial outlays to encompass qualitative metrics like community engagement, integrity, and authenticity. Furthermore, the integration of established UN initiatives like the Historic Urban Landscape and the New Urban Agenda can enhance the comprehensiveness of goals for sustainable heritage-led regeneration, addressing the Sustainable Development Goals (SDGs) in social and cultural sustainability (Faouri & Sibley, 2024). These frameworks offer crucial methodologies, including cultural mediation, for balancing social and cultural priorities within sustainable development by explicitly acknowledging the complex interplay between tangible and intangible heritage, and the necessity of community-led approaches.

3. Cultural mediation: Sustainability in practice

Cultural mediation, therefore, emerges as a critical mechanism for bridging the gap between cultural heritage preservation mandates and local community needs, fostering participatory approaches that ensure the long-term viability and authenticity of heritage practices. This involves facilitating dialogue between diverse stakeholders, interpreting cultural values for broader audiences, and empowering communities to actively shape their heritage narratives .

By engaging local populations in decision-making processes and heritage management, cultural mediation can counteract the adverse effects of top-down development and ensure that regeneration initiatives genuinely reflect community aspirations (Alvarado et al., 2023). Furthermore, cultural mediation is essential for translating global sustainable development goals into localized, tangible measures that are genuinely derived from the specific needs and contexts of local communities, thereby overcoming embedded obstacles in data acquisition and systematic methodology development for cultural heritage (Faouri & Sibley, 2024). It emphasizes the creation of inclusive frameworks that balance global heritage recognition with local socioeconomic specificities, moving beyond conventional growth models to incorporate community-initiated, participatory governance structures (Spina, 2025).

This approach transforms heritage from a passive inheritance into an active, community-driven process that can address contemporary urban challenges effectively (Pérez & Colomer, 2023). Such mediation can particularly address the inequalities in cultural heritage enjoyment that arise from homogenizing public discourses and the commodification of cultural practices (Eichler, 2020). Through such mediation, cultural heritage becomes a catalyst for inclusive sustainable development, fostering a sense of belonging and identity that contributes to the social sustainability of communities (Guttormsen et al., 2023).

This perspective aligns with the growing recognition of culture's central role in achieving broader sustainable development objectives, moving beyond mere conservation to encompass community-led participation in heritage management (Rosetti et al., 2022). This integration underscores how cultural heritage, encompassing both tangible and intangible forms, contributes significantly to sustainability by promoting inclusive growth and addressing social and economic disparities (Naheed & Shooshtarian, 2022).

The expanded role of cultural heritage aligns with the 2030 Agenda for Sustainable Development, which implicitly acknowledges culture's integral contribution to long-term development across multiple goals and targets (Naheed & Shooshtarian, 2022). Specifically, the UN Agenda for Sustainable Development, particularly Goal 11, highlights the preservation of cultural heritage as fundamental to creating inclusive, safe, resilient, and sustainable cities (Zhang et al., 2024). This holistic view positions culture not merely as an aesthetic value but as a critical social, cultural, and economic resource essential for the long-term sustainable development (Burnham, 2022).

Consequently, a proactive engagement with heritage not only preserves historical connections but also facilitates the creation of sustainable, liveable, and inclusive environments. Indeed, cultural legacy has garnered international attention, notably through the efforts of organizations like UNESCO, which advocate for culture's inclusion in the global agenda for sustainable urban development (Naheed & Shooshtarian, 2022). This recognition extends beyond mere preservation, viewing heritage as a dynamic contributor to social cohesion, economic vitality, and environmental responsibility, thereby reflecting a comprehensive understanding of sustainable development (Zhang et al., 2024).

Finally, this integrated approach acknowledges culture as a transversal driver, functioning as both a knowledge capital and a source of creativity and innovation, crucial for addressing contemporary challenges and finding appropriate solutions (Fabbricatti et al., 2020). This evolution in understanding positions cultural heritage not as a static relic, but as an active resource for regional development, contributing significantly to urban livability and fostering distinct local identities (Chukwurah et al., 2025). The integration of heritage conservation into sustainable development frameworks, therefore, necessitates of an approach that respects local cultural contexts and value systems, while also integrating diverse theoretical perspectives to address the complex spatial, mental, and functional dimensions of urban landscapes (Ginzarly & Teller, 2024).

4. Identity and Intercultural Understanding: the path for social cohesion and resilience

An inclusive approach to heritage management involves to include diverse narratives and cultural expressions, in turn, it contributes to a richer, more nuanced understanding of shared histories and identities. This participative framework also enables the negotiation of complex intercultural dialogues, allowing heritage to serve as a bridge for understanding and collaboration among different communities. This recognizes that communities are not merely recipients of heritage management but active agents in constructing narratives and identities attached to valued places and practices, thereby strengthening their sense of place and well-being (Chinen, 2021).

These frameworks emphasize learning from local traditions and perceptions, recognizing inhabitants' roles in assessing cultural landscapes and the meanings, values, functions, and rights they impart to historical settings (Mortensen et al., 2023). That means to bottom-up approaches to heritage management, moving beyond purely technical, expert-based methodologies to include diverse community perspectives (Knight et al., 2022). This approach facilitates a more people-centered understanding of heritage, moving beyond static interpretations to embrace the dynamic interaction between cultural assets and societal values (Ginzarly et al., 2018). Hence, allowing for multivocal heritage narratives to confront controversies over cultural heritage, enabling cross-dialogue among diverse stakeholders and providing a platform for communicating valued aspects of urban landscapes, daily practices, and personal experiences.

This participative and inclusive framework is particularly crucial given that traditional heritage management often overlooks the unique perspectives of underrepresented groups, such as youth, whose narratives are essential for a comprehensive understanding of cultural heritage. By actively involving these groups, heritage management can decentralize expert authority and foster co-creation spaces that reflect what truly matters to communities, moving away from a monolithic view of the past (Chinen, 2021). Indeed, integrating diverse voices into heritage discourse transforms heritage from a static historical record into a dynamic social construct that continuously adapts to contemporary values and societal needs (Ginzarly et al., 2018). Moreover, the empowerment of youth, through mechanisms such as youth councils and parliaments, coupled with their engagement in digital documentation and mapping of heritage assets, can significantly enhance their capacity building and stimulate intergenerational partnerships within heritage management.

Finally, this comprehensive approach necessitates acknowledging power relations inherent in heritage practices, ensuring that youth participation moves beyond superficial engagement to genuine empowerment where young people can assert control over power dynamics and contribute meaningfully. Such an approach moves beyond conventional awareness-raising and capacity-building to foster deep empowerment through iterative processes of engagement. Consequently, adopting a bottom-up approach is essential for resolving conflicts of interest among locals, experts, and policymakers, aiming for maximum consensus on heritage-related decisions (Ginzarly et al., 2018).

5. Challenges and Opportunities

Despite these advancements, significant challenges persist in ensuring meaningful and equitable youth participation, often due to underestimation of their capabilities and a lack of consistent motivation. This challenge is compounded by the limited research comprehensively conceptualizing youth participation within cultural heritage management, thereby hindering the development of effective, integrative strategies. Specifically, a more nuanced understanding of youth as a heterogeneous group, rather than a monolithic entity, is needed to tailor participatory approaches that acknowledge diverse identities and perspectives (Singh et al., 2024). This lack of attention can result in the assumption that involving young people is always advantageous, without properly considering possible adverse effects or the intricate dynamics of power within participatory frameworks.

Therefore, it is crucial to thoroughly examine voice, agency, and empowerment within existing hierarchical frameworks to develop truly inclusive and effective heritage practices. This requires moving beyond mere token participation to genuine co-creation, where young people are not only consulted but also take a leading role in decision-making. This challenges the inherent adult biases and hierarchical structures that often marginalize diverse youth perspectives. This strategy demands a shift in perspective from seeing youth as passive recipients of heritage to acknowledging them as active co-creators and decision-makers, thus promoting a genuinely collaborative and intergenerational management of cultural resources (Allen-Handy et al., 2021).

Furthermore, these frameworks should adopt a human rights-based perspective, ensuring that youth involvement is marked by accountability, non-discrimination, and empowerment. This approach moves beyond mere tokenism to facilitate the authentic co-creation of heritage narratives (Mkwanzani et al., 2023). It guarantees that young individuals are not just recipients but active participants in shaping the future of cultural heritage, promoting their acknowledgment and prioritization in decision-making processes (Panther et al., 2024).

This necessitates a critical examination of the power dynamics inherent in traditional heritage management, which often prioritize adult-centric and euro-centric perspectives and inadvertently marginalize other communities contributions. This includes challenging established norms and assumptions about heritage to advocate for more democratic and inclusive practices that acknowledge diverse voices and power dynamics (Cabrera-Jara & Greene-Zuñiga, 2024). This critical lens reveals that a narrow focus on tangible and monumental heritage often overshadows intangible elements and diverse community experiences, underscoring the need for a more holistic understanding that incorporates the underlying ideologies and power dynamics within heritage frameworks (Cabrera-Jara & Greene-Zuñiga, 2024).

However, the use of collaborative frameworks can incorporate a variety of participatory approaches, such as workshops and cultural campaigns, designed to engage community interests and support their progression from raising awareness to achieving empowerment in heritage practices (Zhang et al., 2023). These efforts encourage understanding across

generations by enhancing capacity, providing access, and creating opportunities for meaningful decision-making, which ultimately validates their role in policymaking. This approach ensures that heritage practices are dynamic and responsive to contemporary societal needs, reflecting a broader commitment to intergenerational equity and cultural sustainability.

This necessitates a shift from purely conservational approaches to models that prioritize adaptive management and community co-creation, ensuring that heritage remains relevant and resilient in the face of ongoing societal and environmental transformations. This paradigm shift fosters a sense of belonging and responsibility towards heritage among community members, transcending institutional definitions of cultural heritage and statements of Outstanding Universal Value (Lao, 2024). This proactive engagement helps to bridge the gap between official declarations and lived experiences, fostering a deeper connection between individuals and their heritage.

This reimagining of heritage emphasizes its role as a resource that people identify with as an expression of their evolving values, beliefs, knowledge, and traditions (Fabbricatti et al., 2020). This participatory paradigm also enables heritage to serve as a catalyst for social cohesion and sustainable development, moving beyond mere preservation to active generation of cultural value and societal benefit.

6. Conclusion

This process-oriented view of heritage emphasizes that it is continuously built and rebuilt through everyday life, with several communities playing a crucial role in expressing their identities and realizing their potential within sustainable communities.

When communities experience autonomy within these contexts, they report increased well-being, demonstrating a clear link between local ownership and positive developmental outcomes (Mortensen et al., 2023). This signifies that for strong, sustainable communities to thrive, the integration of perspectives and their sense of proprietorship over cultural spaces is paramount. This local ownership fostered through active engagement in cultural practices, is a fundamental prerequisite for establishing sustainable societies and ensuring that heritage is cherished and preserved across generations. Such initiatives highlight how longitudinal collaborations and social networks can create robust, interrelational embodied processes that initiate political advocacy and re-create diverse interpretations of cultural heritage (Mkwananzi et al., 2023).

These participatory methods, especially when centered on arts-based approaches, enable the community to materialize their narratives and co-create heritage, moving beyond conventional conservation to an understanding of heritage as a continuous act of making meaning in the present (Abranches & Horton, 2023). This approach transforms youth from passive recipients into active shapers of heritage, ensuring its continued relevance and vitality within evolving societal landscapes (Macarimbang, 2025). This necessitates a re-evaluation of heritage management paradigms to embrace a process-oriented view where tangible and intangible

heritage are continually reworked according to present interests (Jørgensen et al., 2024). This re-evaluation acknowledges that heritage is not merely an inheritance but a dynamic and participatory process that informs contemporary cultural, social, and environmental realities. By foregrounding cultural mediation, it emphasizes the ways in which dialogue, interpretation, and community engagement allow heritage to be continuously re-signified and mobilized as a resource for identity, inclusion, and intercultural understanding.

Integrating sustainability into this discussion positions heritage as a driver for long-term social cohesion and ecological responsibility, highlighting its potential to inspire innovative responses to global challenges. Framed through a Human Rights-Based Approach, the necessity of ensuring participation, accountability, non-discrimination, and empowerment in heritage practices is underscored (Götzen et al., 2022). In this way, living legacies are conceptualized not only as the preservation of cultural expressions but also as frameworks for fostering equity, resilience, and shared responsibility across generations.

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ESD and Cultural Mediation: Fostering Democratic Ideals and Historical Memory Through LGBTQ+ Artistic Legacy

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Abstract

This study argues for the critical integration of Education for Sustainable Development (ESD) and cultural mediation to cultivate democratic ideals and strengthen historical memory among young people, using the artistic legacy of the LGBTQ+ community as a key resource. Framed within the context of Sustainable Development Goals (SDGs), particularly SDG 16 (Peace, Justice, and Strong Institutions) and SDG 5 (Gender Equality), the paper posits that cultural mediation is indispensable for heritage conservation and achieving social equity. We explore how engaging with the often-suppressed histories and artistic expressions of the LGBTQ+ community, notably during authoritarian regimes like Franco's dictatorship in Spain, fosters empathy, critical thinking, and resistance to contemporary extremist and exclusionary ideologies.

The research emphasizes the utilitarian value of historical memory as an enabling element for SDG 16, directly countering anti-LGBTQ+ educational agendas that hinder inclusion. We further critique the heteronormative limitations of the current SDG 5 framework and advocate for a more nuanced, expansive conceptualization of gender and sexuality within ESD to truly promote equality and social sustainability. By reclaiming and engaging with marginalized artistic heritage, cultural mediation transforms historical inquiry into a proactive exercise of civic engagement. This approach is vital for developing a citizenry capable of challenging dominant narratives, upholding democratic values, and championing social justice, ultimately promoting peaceful, just, and inclusive societies.

Key words: Education for Sustainable Development (ESD); Cultural Mediation; Historical Memory; LGBTQ+; Youth Engagement

1. Introduction

This study examines the critical role of Education for Sustainable Development and cultural mediation in fostering democratic ideals and historical memory, particularly among young people, by leveraging the artistic legacy of the LGBTQ+ community. It argues that cultural mediation, framed within an ESD paradigm, is an indispensable tool for heritage conservation, directly contributing to the achievement of Sustainable Development Goals, specifically focusing on SDG 16 and SDG 5. This approach underscores how cultural diversity serves as a vital resource for sustainable development, necessitating its protection and promotion within educational frameworks (Dedieu et al., 2020). Specifically, SDG 16 emphasizes peace, justice, and strong institutions, while SDG 5 champions gender equality and the empowerment of all women and girls, both of which are intrinsically linked to the equitable recognition and preservation of diverse cultural narratives, including those of marginalized communities (Vázquez et al., 2021).

Cultural mediation, when applied to historical memory, particularly in contexts of past oppression, functions as an active exercise that can counteract the contemporary rise of extremist ideologies among youth ([Vázquez et al., 2021](#)).

This research posits that by engaging with the often-suppressed histories and artistic expressions of the LGBTQ+ community, particularly during authoritarian regimes such as Franco's dictatorship in Spain, young people can develop a more nuanced understanding of democratic values and human rights. Such engagement cultivates empathy and critical thinking, empowering younger generations to actively resist divisive narratives and promote inclusive societal structures ([Vázquez et al., 2021](#)). Through this lens, the paper will explore the utilitarian value of historical memory as an enabling element for achieving SDG 16, specifically in relation to peace, justice, and strong institutions.

2. The Role of Cultural and Social Equity in ESD

Cultural mediation, in this context, acts as a crucial bridge between heritage sites, historical narratives, and contemporary audiences, facilitating a deeper understanding of cultural values and their relevance to sustainable development ([Vázquez et al., 2021](#)). It enables individuals, particularly youth, to critically engage with diverse perspectives, fostering social awareness, inclusivity, and equity. This process is vital for promoting societies that are both peaceful and just, aligning directly with the objectives of SDG 16. Moreover, by exploring historical memory, particularly through educational activities focused on difficult pasts, cultural mediation enhances empathy and allows for the transfer of lessons learned to contemporary humanitarian and refugee crises. This pedagogical approach transforms historical inquiry into a proactive exercise of civic engagement, wherein the study of past societal injustices informs present-day commitments to human rights and democratic principles. Such engagement cultivates empathy and critical thinking, empowering younger generations to actively resist divisive narratives and promote inclusive societal structures ([Vázquez et al., 2021](#)). This pedagogical approach transforms historical inquiry into a proactive exercise of civic engagement, wherein the study of past societal injustices informs present-day commitments to human rights and democratic principles.

2.1 Sustainable Development Goals and Social Equity

Within this framework, the interconnectedness of SDG 16, which champions peace, justice, and robust institutions, with SDG 5, advocating for gender equality, is critical, as both goals underscore the imperative for inclusive governance and the protection of fundamental freedoms for all citizens ([Vázquez et al., 2021](#)). The pursuit of these SDGs through ESD and cultural mediation offers a pathway to confront historical injustices, particularly those impacting marginalized groups like the LGBTQ+ community, thereby strengthening democratic foundations and promoting social cohesion. This integration is vital for challenging hegemonic narratives and ensuring that diverse voices, especially those historically silenced, are acknowledged and valued within the broader societal discourse. This approach directly counters anti-LGBTQ+ agendas, which seek to exclude LGBTQ+ content from educational curricula and ban relevant literature, thereby hindering the pursuit of equity and inclusion central to the SDGs ([Wilson-Daily et al., 2022](#)). Furthermore, such efforts are essential for achieving broader educational aims, as

outlined in SDG 4, which emphasizes inclusive and equitable quality education and lifelong learning opportunities for all ([Wilson-Daily et al., 2022](#)) ([Hidalgo-Sánchez et al., 2022](#)). Social sustainability in education, as a critical yet underexplored area, bridges these gaps by fostering inclusive, just, and cohesive societies through targeted educational interventions.

Embedding social sustainability within ESD frameworks provides a comprehensive strategy for addressing contemporary societal challenges, including those related to historical memory and the marginalization of vulnerable populations. This holistic approach extends to addressing the psychological impacts of discrimination, as research indicates that LGBTQ+ identifying students often experience preventable aggressions in schools that negatively affect their mental health and well-being ([Wilson-Daily et al., 2022](#)). Moreover, the marginalization of LGBTQ+ narratives can impede comprehensive educational development, as equitable access to quality education, encompassing well-being and inclusion, is unattainable without addressing the specific needs and histories of all students, including those identifying as LGBTQ+ ([Wilson-Daily et al., 2022](#)). This includes creating more inclusive school environments through the effective curricular integration of LGBTQ+ topics, which moves beyond superficial discussions to present nuanced understandings of identity and experience ([Wilson-Daily et al., 2022](#)). Nonetheless, current educational frameworks in Spain often lack mandatory integration of LGBTQ+ issues, leading to their marginalization in curricula and perpetuating systemic exclusion within secondary schools and teacher training programs ([Wilson-Daily et al., 2022](#)). This oversight necessitates the development of comprehensive national and local education action plans and policies designed to explicitly address the exclusion and marginalization of LGBTQ+ students and integrate LGBTQ+ inclusive content within educational frameworks. Such reforms are crucial for fostering a truly equitable learning environment that acknowledges and celebrates the diversity of human experience, thereby strengthening the democratic ideals of pluralism and respect for all individuals.

These ideas would require explicit recognition of LGBTQ+ individuals within SDG frameworks and related policies, moving beyond the current generalized and often heteronormative interpretations. Explicitly recognizing LGBTQ+ individuals within SDG frameworks is crucial for fostering equity and inclusion through top-down policy actions, as current curricula often neglect these critical issues ([Wilson-Daily et al., 2022](#)). This neglect often results in missed opportunities to address the unique challenges faced by LGBTQ+ students and to integrate their experiences into educational narratives, despite the potential for such inclusion to promote acceptance and reduce victimization.

2.2 Intersections of Gender, ESD, and the LGBTQ+ Community

The current SDG framework, particularly SDG 5, has been criticized for its heteronormative and oversimplified conceptualization of gender, failing to adequately address the specific challenges faced by marginalized groups such as the LGBTQ+ community ([Wilson-Daily et al., 2022](#)). This limitation often translates into educational settings where discussions of gender and sexuality are either absent or confined to heteronormative perspectives, thereby marginalizing LGBTQ+ students and their histories ([Wilson-Daily et al., 2022](#)). Consequently, the absence of explicit recognition of LGBTQ+ individuals within SDG frameworks perpetuates their invisibility in educational policies and practices, hindering the development of truly inclusive curricula

([Wilson-Daily et al., 2022](#)). This oversight necessitates a re-evaluation of how gender is defined and operationalized within sustainable development discourse, advocating for a more expansive and nuanced understanding that encompasses diverse gender identities and sexual orientations ([Frank et al., 2024](#)). Such a reconceptualization would enable ESD to more effectively challenge discriminatory norms and facilitate an understanding of gender and sexual diversity as integral components of social sustainability. This expanded perspective is essential for developing educational interventions that genuinely promote equality and justice for all, aligning with the core principles of ESD and cultural mediation ([Frank et al., 2024](#)). Furthermore, acknowledging the "doing" of gender rather than solely "being" allows for a more dynamic understanding that moves beyond binary representations, fostering an environment where power is distributed equitably across all gender expressions ([Mittner et al., 2023](#)). This approach is critical for fostering inclusive environments within educational institutions, especially given that many school curricula currently lack adequate representation of LGBTQ+ issues, often reducing them to "fun facts" rather than integrating them as fundamental components of historical or ethical studies ([Wilson-Daily et al., 2022](#)). This narrow conceptualization, primarily focused on women in binary terms, risks overlooking the complex interdependencies between gender identity, sexual orientation, and broader sustainability challenges, as well as the unique vulnerabilities experienced by LGBTQ+ individuals ([Frank et al., 2024](#)).

3. Fostering Historical Awareness in Youth

Educational initiatives that integrate cultural mediation within ESD frameworks can serve as powerful tools to actively engage young people in an exercise of historical memory, particularly regarding marginalized communities ([Gajardo et al., 2022](#)). This process critically examines historical narratives, often unveiling the systemic erasure and oppression faced by LGBTQ+ individuals and other minority groups ([Gajardo & Mata, 2023](#)). By unearthing and critically analyzing these suppressed histories, young people can develop a deeper understanding of the socio-political forces that have shaped contemporary inequalities and injustices. This active engagement in historical memory, facilitated by cultural mediation, empowers youth to challenge dominant narratives and foster a more nuanced appreciation of diverse cultural heritage, thereby reinforcing democratic ideals ([Fernández et al., 2021](#)). This pedagogical approach helps deconstruct simplified historical accounts and equips young people with the critical thinking skills necessary to identify and resist the resurgence of exclusionary ideologies, such as fascism. This is especially pertinent in contemporary contexts where there is a concerning alignment of some young people with such ideals, highlighting the urgent need for educational strategies that actively counteract these trends through comprehensive historical and cultural literacy ([Zhang et al., 2023](#)). Such initiatives can leverage cultural heritage, including artistic expressions and social movements, as primary sources to illustrate the historical struggles and resilience of LGBTQ+ communities, thereby promoting empathy and challenging prejudice ([Tutchell & Sharp, 2022](#)). This approach also aligns with SDG 16, promoting peaceful and inclusive societies by fostering a sense of shared humanity and respect for diverse identities, while simultaneously countering the rise of extremist ideologies through informed civic engagement. This active re-examination of historical narratives, especially those concerning subjugated heritage, can foster critical thinking and empathy among students, thereby discouraging adherence to exclusionary ideologies ([Carrasco, 2022](#)).

3.1 Case Study: LGBTQ+ Rights and Artistic Activism in Francoist Spain

The dictatorship of Francisco Franco (1939-1975) enforced severe repression against LGBTQ+ individuals, criminalizing homosexuality and gender nonconformity through legislation such as the Law on Vagrants and Ruffians and later the Law on Social Danger and Rehabilitation ([Amat et al., 2020](#)). This period effectively erased the public presence of LGBTQ+ identities, forcing expressions of gender and sexuality underground and severely limiting artistic and cultural output that deviated from heteronormative ideals ([Corrêa, 2023](#)). This systematic oppression highlights how authoritarian regimes weaponize legislation to enforce rigid social norms and suppress diverse forms of human expression. Within this restrictive environment, however, clandestine artistic and cultural movements emerged as vital spaces for resistance and the preservation of queer identities, offering nuanced counter-narratives to the official discourse. These underground expressions, though often subtle, served as crucial acts of defiance, preserving a nascent queer consciousness amidst state-sanctioned homophobia and transphobia ([Gajardo & Mata, 2023](#)).

Reviving and researching the work of LGBTQ+ artists and activists from this era can thus serve as a powerful tool for ESD cultural mediation, enabling young people to engage with a period of intense historical oppression and understand the importance of democratic freedoms ([Gajardo et al., 2022](#)). This engagement facilitates a deeper appreciation for the ongoing struggle for human rights and reinforces democratic values, particularly SDG 16, by illuminating the consequences of their erosion ([Vázquez et al., 2021](#)). Such historical examinations, particularly through the lens of marginalized narratives, can serve as a potent antidote to contemporary trends of rising authoritarianism and intolerance ([Lopes & Persson, 2023](#)). They underscore how cultural heritage, when critically engaged with it, can become a dynamic site for confronting "dissonant heritages" and fostering civic learning. This active engagement helps to demystify nationalist narratives that often omit or distort inconvenient truths about oppression, such as those propagated during Franco's regime ([Carrasco, 2022](#)).

3.2 Law 16/1970 and its Impact on LGBTQ+ Individuals

This legislative framework, particularly Law 16/1970 on Social Dangerousness and Rehabilitation, codified widespread discrimination, subjecting individuals perceived as homosexual to severe legal penalties and societal ostracism ([Pérez et al., 2024](#)). This period forced many LGBTQ+ individuals into clandestinity, yet paradoxically, some instances of tolerance emerged among the upper classes and foreign tourists, highlighting the complex and often contradictory enforcement of these repressive laws ([Guasch et al., 2023](#)). The systematic humiliation and public exposure of those arrested under such laws served as a stark warning to the wider LGBTQ+ community, reinforcing a climate of fear and conformity ([Guasch et al., 2023](#)). Moreover, the absence of public discourse surrounding LGBTQ+ identities in educational settings, even in areas with visible queer communities, further perpetuated this cycle of silence and marginalization ([Wilson-Daily et al., 2022](#)).

This institutionalized silencing contributed to a lack of awareness and support for LGBTQ+ students, even in subsequent democratic periods ([Wilson-Daily et al., 2022](#)). Addressing this

historical gap through ESD initiatives can illuminate the enduring impacts of such legislative oppression on mental health and social well-being, particularly for sexual minority students (Wilson-Daily et al., 2022). By unearthing and critically analyzing these historical injustices, cultural mediation can foster an understanding of how legal frameworks have historically been used to marginalize specific communities, thereby promoting critical legal literacy among youth (Vázquez et al., 2021). The process not only educates about past injustices but also empowers young people to advocate for equitable legal systems and human rights in the present (Vázquez et al., 2021). This historical analysis can further strengthen the achievement of SDG 5 by examining how gender roles and expectations under Francoism were rigidly enforced, impacting not only women but also gender non-conforming individuals, thus underscoring the interconnectedness of gender equality and broader human rights. By analyzing the socio-legal landscape of Francoist Spain, educators can demonstrate how the suppression of gender and sexual diversity directly undermined principles of equality and justice, making it a critical case study for advancing both SDG 5 and SDG 16 objectives.

3. 3 Reclaiming LGBTQ+ Artistic Heritage for Defeating Fascist Ideals

The reclamation of LGBTQ+ artistic heritage from oppressive regimes serves as a potent vehicle for cultural mediation, offering a tangible means to counteract the resurgence of fascist ideals by showcasing resilience and resistance against enforced homogeneity (Alonso, 2024). This process not only validates historically marginalized identities but also provides contemporary youth with powerful examples of art and culture as instruments of social transformation and democratic reinforcement (Christopher, 2024). By engaging with these historical narratives, young people can develop a critical understanding of how artistic expression can challenge dominant oppressive ideologies and foster inclusive societal norms (Christopher, 2024). Such an approach allows for the development of historical memory, transforming abstract concepts of justice and equality into tangible, emotionally resonant experiences that challenge exclusionary narratives (Vázquez et al., 2021). Furthermore, artistic interventions, often termed "activism," have historically been crucial in amplifying the voices of marginalized communities and advocating for human rights and LGBTQ+ rights in various contexts (Christopher, 2024). This creative engagement, particularly through virtual platforms, can connect diverse audiences with queer art and history, thereby promoting respect and inclusion for sexual and cultural diversity (Fernández et al., 2021). For instance, festivals and art installations provide crucial spaces for LGBTQ+ individuals and their allies to challenge existing gender norms and subvert traditional notions of art, fostering dialogue and education about normative ideologies (Christopher, 2024). Moreover, the re-examination of artistic heritage with a gender perspective, which actively incorporates works by women and addresses androcentric biases, can further enrich this cultural mediation by promoting gender equality and challenging historically ingrained patriarchal narratives (Carrasco, 2022). This deliberate re-evaluation can empower young people to question existing power structures and recognize the agency of art in shaping societal values, aligning closely with the transformative goals of ESD. Such initiatives contribute significantly to fostering a more nuanced understanding of identity, history, and social justice, equipping young people with the critical tools to resist authoritarian tendencies and promote democratic values.

3. 4 Youth Engagement with Historical Narratives for Social Change

Engaging youth with these historical narratives cultivates a deeper appreciation for democratic principles and reinforces the importance of human rights by demonstrating the devastating consequences of their erosion (Christopher, 2024). This engagement provides a critical pedagogical tool to counter the appeal of fascist ideologies by revealing their historical failures and the suffering they inflict, thus encouraging young people to actively champion inclusive and equitable societies. The integration of activism, especially through accessible mediums like comics, further facilitates this engagement by transforming complex social issues into relatable visual narratives, which is particularly effective for younger audiences (Christopher, 2024). These artistic forms not only provide representation but also actively shape cultural imaginations, fostering a diverse understanding of childhood and combating discrimination at early developmental stages (Christopher, 2024). Moreover, participatory theatrical and dramatic techniques can be exceptionally effective in enabling young people to explore and engage with sensitive issues surrounding gender and sexual diversity, fostering empathy and critical thinking through experiential learning (Peng, 2024). Such creative and interactive methodologies empower youth to become active agents in deconstructing historical prejudices and envisioning alternative, more inclusive futures. This active engagement transforms historical understanding into a dynamic tool for social change, equipping young individuals with the capacity to critically analyze contemporary socio-political landscapes and challenge discriminatory practices. This active participation aligns with critical pedagogy, encouraging students to question, analyze, and challenge dominant ideologies and power structures, which is crucial for personal and social transformation (Lopes & Persson, 2023). This approach ensures that learning about historical oppression and resistance is not merely an academic exercise but a direct catalyst for promoting social justice and democratic values in contemporary society (Videla et al., 2025) (Carrasco, 2022). Furthermore, active learning methodologies, such as historical trials, have been shown to significantly enhance students' understanding of complex historical events and foster competencies essential for civic engagement and critical thinking (Limiñana & Soler, 2024). By connecting past struggles for freedom with present-day issues, young people can draw parallels between historical atrocities and current injustices, fostering a sense of shared experience and motivating them to advocate for change. This experiential learning is crucial for developing critical consciousness, allowing youth to recognize and challenge systemic inequalities that persist in modern society. This form of education, rooted in exploring controversial topics, empowers children to become informed and active citizens, linking educational processes with social justice to promote the inclusion of marginalized groups (Gonçalves et al., 2025). These pedagogical strategies, which prioritize open discussion and critical inquiry, allow students to explore diverse perspectives and challenge preconceived notions, thereby developing a nuanced understanding of social complexities and fostering an inclusive mindset (Hammer, 2021). Moreover, integrating digital resources and gamification into these active learning methods can further amplify their effectiveness, especially in history classes, by providing engaging and interactive platforms for students to explore historical events and concepts (López-García, 2023).

4. Conclusion

In conclusion, this paper underscores the pivotal role of ESD and cultural mediation, particularly through the lens of SDGs 16 and 5, in fostering democratic ideals and confronting historical injustices, especially regarding gender and LGBTQ+ communities. It highlights how these approaches can serve as powerful tools for historical memory, enabling young people to critically engage with the past to inform their present and future actions. By actively engaging with complex and controversial aspects of history, young individuals develop a sophisticated understanding of societal evolution and the continuous struggle for human rights (Vázquez et al., 2021). This critical engagement is particularly vital in addressing the resurgence of fascist ideals among youth, demonstrating how historical awareness can counteract such movements by highlighting their detrimental societal impacts. Furthermore, the exploration of controversial heritage within educational frameworks strengthens eco-citizenship education, encouraging a critical examination of historical narratives that resonate with contemporary social issues and foster a transformative democratic commitment (Carrasco, 2022). The re-examination of androcentric and sexist perspectives within historical narratives is therefore crucial, necessitating a focus on training educators to highlight the contributions and experiences of all marginalized actors (Gajardo et al., 2022).

This necessitates a re-evaluation of curricula to incorporate diverse historical perspectives, ensuring that future generations are equipped to challenge dominant narratives and advocate for equitable societies (Ros et al., 2021) (Carrasco, 2022). Such comprehensive pedagogical reform is essential for cultivating a citizenry capable of discerning truth, upholding democratic values, and championing social justice in an increasingly complex global landscape (Carrasco, 2022) (Gigerl et al., 2022). This expanded understanding of history and its implications empowers students to become active participants in shaping a more inclusive and sustainable future (Carrasco, 2022) (Vázquez et al., 2021). Therefore, educational initiatives must strategically integrate cultural mediation within ESD frameworks to cultivate a generation deeply committed to democratic principles and critical historical consciousness. This involves reforming teacher training to equip educators with the competencies and knowledge necessary to embed new narratives and recognize the historical experiences of marginalized groups within their teaching (Gajardo & Mata, 2023). These efforts are fundamental to developing critical historical literacy, which empowers young people to resist authoritarian narratives and actively participate in democratic processes, aligning with the objectives of SDG 16 regarding peace, justice, and strong institutions (Carrasco, 2022). Moreover, by emphasizing the stories of marginalized groups, including the LGBTQ+ community during periods like Franco's dictatorship, ESD fosters empathy and encourages young people to challenge contemporary forms of discrimination and injustice. This approach not only honors the memory of those who suffered but also provides a powerful framework for promoting inclusive societies and safeguarding human rights for future generations.

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New Technologies and Sustainability in Art History and Cultural Heritage Training: A Mixed-Methodological Approach for Higher Education

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Abstract:

The intersection of digital technologies and sustainability has emerged as a central concern in art history and cultural heritage education. As universities adapt to evolving pedagogical paradigms, new methodologies are required to train professionals capable of navigating the digital transformation of heritage while promoting sustainable practices. This paper explores a mixed-methodological approach combining online and hands-on training to foster digital literacy, critical awareness, and ethical engagement in higher education. The study integrates theoretical analysis with practical experimentation to evaluate the pedagogical potential of blended learning in developing the interdisciplinary competencies demanded by the heritage sector.

The literature review highlights the growing body of research on immersive technologies—including Virtual, Augmented, and Mixed Reality (VR/AR/MR)—and their application to cultural heritage education. These tools enhance accessibility, promote inclusivity, and transform passive observation into active engagement through interactive learning environments. Building Information Modelling for Heritage (HBIM), photogrammetry, and 3D scanning emerge as key technologies for the accurate documentation, preservation, and dissemination of cultural assets. Furthermore, the integration of artificial intelligence and machine learning optimises data acquisition, semantic segmentation, and reconstruction processes, improving efficiency while enabling sustainable documentation strategies. Scholars increasingly recognise the importance of combining technical precision with critical and ethical reflection to ensure that digital innovation aligns with social responsibility and long-term preservation goals.

The methodology section details the implementation of a scan-to-HBIM workflow and the use of NURBS and CAD techniques to model complex architectural geometries. Machine learning algorithms, such as PointNet and PointNet++, are employed to automate semantic segmentation and classification of heritage point clouds, addressing challenges related to irregular forms and incomplete datasets. This multi-layered framework supports accurate digital reconstruction and fosters interoperability between geometric and semantic data. The mixed-method approach—combining theoretical instruction, digital tool training, and field-based experimentation—was tested through higher education modules involving 3D modelling, photogrammetry, and virtual collaboration.

The results demonstrate that blended learning significantly improves students' comprehension of theoretical principles and their ability to apply digital tools in real-world contexts. Participation in citizen science and collaborative projects enhanced students' sense of responsibility towards heritage conservation and encouraged interdisciplinary problem-solving. The integration of cultural astronomy and digital reconstruction projects allowed students from the arts, humanities, and STEM disciplines to apply specialised knowledge to heritage challenges, strengthening their critical, creative, and communicative skills. Feedback confirmed that this

pedagogical model cultivates ethical awareness and adaptability—key competencies for contemporary heritage professionals.

The study concludes that the holistic integration of new technologies and sustainability within heritage education bridges the gap between technical expertise and cultural understanding. By combining virtual and experiential learning, this approach prepares students to engage critically with digital tools, address ethical and environmental challenges, and contribute to inclusive and accessible heritage preservation. The findings support the European Commission's emphasis on digital heritage and the need for interdisciplinary, future-oriented education models that connect technological innovation with cultural sustainability.

Key words: Digital heritage; Blended learning; Sustainability; HBIM; Immersive technologies

1. Introduction

The growing importance of technology and sustainability in cultural heritage education (Zhang & Shen, 2024) is driving higher education institutions to adopt evolving pedagogical paradigms (Havenga et al., 2023). The professional profile now requires specialists who combine theoretical understanding, practical skills, and a critical awareness of the social and environmental value of heritage (Sibilla & Kurul, 2019). A comprehensive educational approach must train graduates in advanced digital tools as well as critical reflection on ethical and environmental implications. Hybrid pedagogical models, which combine virtual and experiential learning (Achille & Fiorillo, 2022), are essential for navigating the complexity of digital heritage, promoting technological literacy and sustainability. The digital transformation of the sector depends on expertise in technologies such as 3D printing, virtual reality, and collaborative robotics (Casciani & Chkanikova, 2023; Gaspari et al., 2024). The COVID-19 pandemic accelerated this adoption, strengthening the role of interdisciplinary frameworks to apply diverse skills to heritage challenges (Liritzis et al., 2021; Kirkegaard & Riis, 2024). Finally, the integration of digital tools fosters knowledge sharing and connectivity through virtual platforms (D'Orazio et al., 2024).

2. Literature Review

The review focuses on the application of digital technologies in art history and heritage, emphasizing blended learning. The digitization of cultural assets, such as 3D models, creates immersive learning experiences (Lobovikov-Katz, 2017) and overcomes geographical and temporal barriers (Münster et al., 2021). Extended Reality (XR) applications, which include VR, AR, and MR (Zhang et al., 2024), offer deep and emotionally resonant interactions (Lin et al., 2025) with heritage, democratizing access to inaccessible sites and facilitating personalized learning experiences (Anwar et al., 2025; Antón-Sancho et al., 2024; Li et al., 2023). These immersive environments enable interactive, gamified learning (Zhao et al., 2025; Schwaiger et al., 2024) and transform passive observation into active participation (Cipriani et al., 2019). The integration of HBIM and procedural modeling (Massafra et al., 2020) facilitates the creation of high-fidelity digital twins (Imbesi et al., 2023; Bagnolo et al., 2021), which are crucial for academic research and public engagement. This methodological flexibility allows for the accurate representation of complex structures, integrating with game engines and enriching the semantic interpretation of heritage elements (Banfi et al., 2021). By transforming point cloud

data into parametric objects, the limitations of conventional BIM are overcome, ensuring precise documentation and preservation of cultural assets (Murphy et al., 2017; Rubens et al., 2022).

3. Methodology

The development of comprehensive digital models requires a robust methodological framework focused on the scan-to-HBIM workflow (Oreni et al., 2017), which converts point cloud data into detailed 3D models (Luggo et al., 2019). Complex or irregular geometries often require advanced techniques such as Non-Uniform Rational B-Splines (NURBS) and the combination of BIM software with 3D CAD or mesh modeling (Banfi, 2019; Brumana et al., 2017). The methodology includes compiling historical documentation, vectorizing plans, and logically organizing BIM databases for comprehensive data integration (Ferdani et al., 2020). Laser scanning is used for its high precision and reliability, which are essential for characterizing surfaces and structural components and reflecting the irregularities of historical objects (Monchetti et al., 2023; Sammartano et al., 2021). Managing irregular geometries in heritage often requires customized segmentation algorithms (Haznedar et al., 2023). Recent developments have leveraged machine learning, particularly semantic segmentation techniques (Moyano et al., 2021; Zhao et al., 2023), to optimize the scan-to-BIM process, speeding up the classification of architectural elements and reducing manual effort (Ji et al., 2021). Deep learning frameworks such as PointNet and PointNet++ improve point cloud segmentation (Croce et al., 2023; Matrone et al., 2020). However, there are challenges, since these models are often trained on manufactured objects with regular geometries, which limits their effectiveness for historical architecture (Battini et al., 2023). This highlights the need for domain-specific datasets, such as the ArCH benchmark, to train robust AI models (Miky et al., 2024; Croce et al., 2021). Given the high cost of manual annotation, semi-supervised learning approaches are being explored for the preservation and digitization of cultural heritage (Cao & Scaioni, 2021).

4. Results

The implementation of the mixed methodological approach confirms that combining online learning modules with practical training significantly improves students' theoretical understanding and practical skills (Achille & Fiorillo, 2022; Hess et al., 2017). Participation in citizen science and crowdsourcing initiatives fosters a sense of responsibility and awareness toward heritage conservation (Agersnap et al., 2025). The interdisciplinary nature of the activities is essential, allowing students from diverse backgrounds (Arts, Humanities, and STEM disciplines) to apply their expertise to heritage challenges (Mortensen et al., 2023; Steenberg & Círklová, 2024). For example, integrating 3D game engines with archaeoastronomy enabled computer science students to link Blender with Stellarium, strengthening their programming and cultural skills (Baik & Alitany, 2018). This pedagogical model cultivates key competencies, including critical thinking, communication, digital literacy, and organizational skills (Kwee & Santos, 2022). By transcending traditional disciplinary boundaries, the framework trains heritage professionals with

Competence	Activity	Observations / Results
Theoretical understanding	Online modules	Improved comprehension of complex concepts
Practical skills	3D modeling / photogrammetry	Direct engagement with material culture and digital
Interdisciplinarity	Astronomy projects + Blender	Encourages collaboration between CS and Humas
Critical thinking	Crowdsourcing and citizen science	Develops a sense of responsibility and ethical
Digital literacy	Apps and cloud platforms	Enables self-learning and democratization of tools
Creativity	Integration of game engines + heritage re-	Increases motivation and exploration of innovative so

Figure 1. Impact of blended learning (online + practical) on student competencies.

5. Conclusion

This holistic educational approach ensures that graduates are not only technically competent, but also ethically informed and capable of navigating the complex landscape of digital heritage (Tucci et al., 2018). By combining theoretical knowledge with practical experience, the pedagogical framework fosters a deep understanding of both the potential and the limitations of emerging technologies (Hess et al., 2018). Future research is recommended to evaluate the long-term effectiveness of these integrated curricula in fostering critical thinking, adaptability, and the ability to transfer training to real-world applications. It is crucial to investigate the impact of these interventions on the practices and policy development of heritage organizations, as well as to develop multidisciplinary networks for the scientific validation of digital documentation processes (Mortensen et al., 2023; Kirkegaard & Riis, 2024). Future developments should consider improving interoperability between HBIM reconstructions, archival databases, and virtual platforms to create interconnected digital ecosystems (Castellazzi et al., 2023). The use of open-source software and global collaborative research initiatives can expand the accessibility and applicability of these technologies (Araújo et al., 2019). Immersive technologies offer dynamic and interactive learning environments that deepen engagement with complex historical contexts (Li et al., 2023). This approach aligns with the European Commission's focus on digital heritage, bridging the gap between non-IT disciplines and IT-oriented specialists. atrimonio (Olesen, 2024).

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Digital humanities for preventive conservation of cultural heritage: Advanced visualisation of historical data through multidimensional maps and interactive graphics

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Digital transformation has driven a significant evolution in the way cultural heritage (CH) is approached, integrating advanced technologies that allow not only its physical conservation, but also the comprehensive management of its information and context. Furthermore, by making heritage information accessible and transparent, it encourages greater public participation, strengthening the sense of belonging and collective responsibility toward cultural preservation.

Museum catalogs and inventories serve as essential tools in CH management by documenting and preserving the rich array of cultural assets, enabling efficient management and promoting accessibility to these resources. Historically, these catalogs functioned as specialized technical documents, primarily intended for experts familiar with the specific terminologies and classification systems used in cultural heritage management. Documentation is a fundamental aspect of managing cultural heritage, as it lays the groundwork for monitoring, conservation, and management of heritage sites and items. It involves methods such as digitalization to enhance sustainability and management capabilities (Tobiasz et al., 2019).

The key question is: how can we convert cultural data into computationally readable information without losing its interpretive richness?

The integration of digital technologies into the strategic management of museums is crucial for adopting a visitor-oriented approach, enhancing communication with the public, and promoting the collections in engaging ways (De Bernardi et al., 2019). The digital life cycle of CH collections, facilitated by knowledge management architectures, supports the challenges of managing, preserving, and visualizing digital collections. This approach includes collaborative management of information, breaking language barriers, and providing structured data to users and machines (Dragoni et al., 2017).

The advent of digitization has transformed these records into publicly accessible resources, yet this shift has not fully resolved the challenges related to accessibility and usability. Despite the availability of digital data, users often encounter epistemological barriers, such as the difficulty in locating relevant information, and technical barriers, including complex interfaces or insufficient contextualization that hinder interpretation. Moreover, the effective dissemination of cultural heritage information requires more than mere data availability; it demands presentation strategies that are comprehensible, engaging, and tailored to diverse audiences with varying levels of expertise.

From the perspective of digital humanities (DH), this shift towards semantic reconfiguration represents a transformative approach to CH preservation and interpretation. Rather than treating digitization as a mere technical conversion, it invites the creation of dynamic, layered

knowledge systems that embed context, meaning, and relationships directly into the digital artifacts themselves. By incorporating interpretive metadata and ontologies, cultural documentation becomes more than static records; it evolves into interconnected networks of information that reflect the complexities and nuances of historical and cultural narratives. This enables scholars to explore heritage materials through multiple lenses and facilitates the discovery of new insights by linking previously isolated data points.

The incorporation of digital visualization techniques in the humanities, also known as 'visual digital humanities,' is expanding the scope of research by focusing on pictorial rather than just textual data. These techniques are increasingly applied in fields like art history, archaeology, and museology, enhancing the understanding and interpretation of visual culture (Münster & Terras, 2019).

By integrating computational tools with traditional humanistic methods, DH significantly enhance the analysis and interpretation of cultural data. The Semantic Web technologies demonstrate high potential for managing cultural data, as they allow for reusable methodologies and tools adaptable to the needs of digital heritage (Bikakis et al., 2021). Moreover, the use of Linked Data in Digital Cultural Heritage offers new paradigms for modeling digital collections to be more accessible and inclusive. By focusing on Intangible Cultural Heritage, these methods address the need for detailed and semantically informed documentation, thus supporting the preservation and accessibility of a broader range of cultural expressions (Ziku, 2020).

The combination of digital technologies and humanistic approaches broadens the ways in which CH is documented, analyzed, and engaged with by the public. This interdisciplinary approach not only supports the preservation and dissemination of cultural knowledge but also fosters greater public accessibility and interaction with cultural heritage, ensuring its continued resonance in contemporary society.

Within the scope of the DH, the integration of data science (DS) and data visualization (DV) offers transformative possibilities for presenting large CH datasets information. These disciplines enable the extraction, management, and representation of complex information, facilitating the understanding and dissemination of CH over time.

Data visualization not only serves as a means to represent complex information in an accessible way, but also becomes an essential component for the comprehensive management of CH in the digital age.

It transforms complex datasets into intuitive graphics, making them accessible to a broad audience, including researchers, policymakers, and the general public. This improved access aids stakeholders in making informed decisions regarding the management, conservation, and promotion of heritage sites by visualizing trends and assessments (Park, Bekemeier, et al., 2021; Qin et al., 2019).

One major benefit is the ability to manage and analyze large volumes of cultural data, allowing researchers to detect patterns and relationships that were previously difficult to uncover. This is particularly evident in the preservation and promotion of CH, where digital tools offer innovative solutions for documentation and accessibility (Siliutina et al., 2024). Other benefits include

enhanced understanding of CH data, improved communication of heritage narratives, and support for data-driven decision-making. Visualization tools help engage and educate the public through formats like interactive maps and infographics. They also help prioritize preservation by visualizing the state and changes over time in heritage sites (Park, Flaxman, et al., 2021; Wang et al., 2017).

These systems leverage spatial databases and infrastructures for processing large volumes of data to model and interpret changes over time, addressing real-world problems associated with cultural preservation (Alam et al., 2022). DV adds a layer of interpretability by presenting information in interactive and engaging formats.

Additionally, in museum exhibitions, data visualization provides interactive and educational experiences (Lurie & Mason, 2007; Muskan et al., 2022). Enhances CH management by increasing accessibility, fostering awareness, supporting informed decision-making, and enabling interdisciplinary collaboration. It provides a common visual language that bridges different fields, making it an indispensable tool in the digital age (Kim et al., 2016; Viégas & Wattenberg, 2007).

Ultimately, this evolution in digital humanities supports a more holistic and participatory understanding of heritage, bridging gaps between disciplines and communities while enhancing the preservation, accessibility, and relevance of cultural information in the digital age.

In this sense, data visualization is a technique that allows complex information to be represented graphically, making analysis and communication easier. In the context of digital humanities, it is not just about displaying numbers, but about revealing cultural patterns, historical relationships, and social structures. From William Playfair (1786) to today's interactive dashboards, visualization has evolved as a form of visual storytelling. In cultural heritage, this involves: historical maps, timelines of artistic styles, or networks of influence between authors and works.

However, visualization is not neutral: graphic design influences interpretation. That is why, within digital humanities, critical visualization is encouraged, one that recognizes its biases and fosters reflection. One of the most important aspects of this discipline is the transformation of data into the visual (aesthetic) properties that make up a chart. These properties, such as position, color, shape, or size, depend largely on the type of data being represented.

Technologies such as the STMaps system, an ontology-based visualization tool, enable the display of spatiotemporal data on interactive maps. This approach allows for the exploration of silk heritage projects, demonstrating STMaps' flexibility in representing information from diverse domains, as long as the datasets contain relevant spatiotemporal information (Sevilla et al., 2021).

In this way, these innovative techniques go beyond conventional interfaces, diversifying how information about CH is presented. Different types of visualizations, such as interactive visualizations and stack zooming for multi-focus interaction, facilitate a deeper understanding of temporal datasets. These innovations serve both casual users and researchers, providing serendipitous and generous interactions with CH data (Windhager et al., 2019). Additionally, semantic technologies are increasingly used to enhance DV by offering more precise search capabilities and recommendations on cultural portals. When combined with graph databases

and RDF models, these technologies can personalize user experiences when navigating and efficiently presenting vast CH data collections (Li & Bikakis, 2023).

Overall, the synergy between DS and DV has great potential for managing and showcasing large CH datasets. These capabilities not only facilitate the preservation of cultural assets but also enhance public engagement and education by revealing the rich diversity of cultural history through temporal analysis and visualization.

With that, data visualization has emerged as a key tool in the field of CH, enabling new ways to explore, interpret, and communicate the historical and artistic richness of societies. Various international projects have demonstrated the potential of these technologies to transform how cultural information is accessed and understood. Below are some outstanding examples that illustrate this trend.

One of the most representative cases is *Historia Hispánica* (Real Academia de la Historia, n.d.), an interactive chronological map that allows users to explore the lives and works of significant historical figures within the Spanish context. This platform combines biographical data with geospatial and temporal representations, facilitating a deeper understanding of the connections between characters, events, and places throughout Spain's history.

In the urban sphere, the *imagineRio* project (Imaginerio, n.d.) offers a visual reconstruction of the evolution of the city of Rio de Janeiro over time. Using historic maps, 3D models, and georeferenced data, this initiative enables users to navigate different periods and observe the morphological, social, and architectural changes of the city, making it a valuable tool for both researchers and the general public.

From a historical perspective, *ORBIS* (Stanford Geospatial Center, n.d.) is a simulation of the transportation system of the Roman Empire. This digital model allows for the calculation of routes, travel times, and costs between different cities of the empire, taking into account variables such as seasons of the year and modes of transport. *ORBIS* not only offers a rigorous academic tool but also provides an immersive experience that facilitates the understanding of logistics and connectivity in antiquity.

In the context of colonial American art, the *ARCA Project* (TED-Ed, 2013, 1:00) is dedicated to cataloging and visualizing viceregal painting. Through the use of enriched databases and interactive maps, *ARCA* makes it possible to trace the circulation of works, artists, and styles between Europe and the Americas, revealing the transatlantic dynamics that shaped colonial art.

Finally, *Expofinder* (Exhibitium, 2018) is presented as a platform for visualizing exhibitions held in Spain. This system allows for chronological and geographical exploration of art exhibitions, facilitating the analysis of curatorial trends, recurring themes, and the territorial distribution of exhibition activity.

Taken together, these projects demonstrate how data visualization, supported by digital technologies and principles of the semantic web, can significantly enrich the documentation, research, and dissemination of cultural heritage. These projects not only present data, but also

generate new questions: Who is represented and who is not? Which styles predominate in which periods? How is art distributed geographically?

Based on these principles, the ClioViz project is rooted in the line of research initiated by SILKNOW (SILKNOW, n.d.), a project funded by the European Commission that focused on the preservation and promotion of silk textile heritage through the use of computing systems. Later, the SeMap project (SeMap, n.d.) was dedicated to improving access to the digital catalog CER.es (Online Collections of the Spanish Museum Collections Digital Network) via space-time maps with semantic features. By refining CER.es data with the CIDOC-CRM ontology, SeMap managed to simplify complex terminologies and effectively geolocate objects. However, during SeMap's research, several challenges were encountered in visualizing the historical data aggregated into the CER.es repository.

The case of CER.es, the Digital Network of Spanish Museum Collections. It brings together more than 366,000 cultural objects and 643,000 images from 121 museums. Although it offers advanced search options, it poses challenges for visualisation like geographic heterogeneity (locations are expressed as place names or coordinates), temporal granularity (Centuries, decades, or exact dates) and ambiguity (multiple attributions or imprecise periods). From the DH, this is addressed through Data Normalization, unifying formats and scales; digital curation, manual and automated review of records; and Semantic Modeling, representing uncertainty and ambiguity. Furthermore, not all museums are integrated into CER.es, which limits interoperability. Each institution decides which software to use, fragmenting the digital ecosystem.

With all this in mind, ClioViz has been developed, an experimental project that applies DH principles to explore CER.es data through interactive visualizations. With the goal of extracting and synthesizing information from large CH datasets into visual forms that integrate scientific visualizations and interactive maps, the objectives of the ClioViz Project are to assess the reusability of cultural data, overcome barriers to automated interpretation, and transform technical records into accessible visual representations. ClioViz enables users to navigate the history of Spanish art through multidimensional maps and interactive graphs. It is a tool that connects technology with cultural sensitivity, opening up new possibilities for education, research, and civic engagement. From an academic perspective, ClioViz represents an epistemological laboratory: a space where forms of digital knowledge are experimented with, structural errors are identified, and solutions are proposed for a more inclusive computational culture. Focusing on the visualization of complex multispatial and multitemporal variables, it investigates the application of visualization strategies from Geographic Information Systems (GIS) and scientific visualizations inherent to DV and DS. The implementation of DV techniques and tools in the GLAM sector is considered essential to enhance understanding, appreciation, and protection of CH (Targa et al., 2025).

In conclusion, preventive conservation of cultural heritage involves not only protecting physical objects, but also ensuring that information about them is accessible, understandable, and useful. The digital humanities provide tools to achieve this by combining technical rigor with interpretive sensitivity. Data visualization, far from being just a simple graphic technique, becomes a way of thinking, a method of organizing and communicating cultural knowledge. Projects like ClioViz

demonstrate that, with creativity and method, it is possible to transform databases into meaningful visual narratives, and to open up new paths for interpretation, education, and engagement with cultural heritage.

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Digital humanities as a driver of museum transformation: from management to service to society

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Abstract

The digital transformation of museums is a strategic imperative that extends beyond cataloging and online presence. This article examines the evolution of the museum concept, emphasizing its shift toward social engagement and the need for a cross-cutting digital strategy aligned with the new ICOM museum definition (2023). This vision is contrasted with pioneering yet limited initiatives in Spain, such as the Strategic Plan of the State Museums Network (2004–2008). Finally, it explores Digital Humanities tools that enable deep and transformative digitization in three key areas: collection management, visitor interpretation and experience, and research and collaboration.

Keywords: cultural heritage; digital humanities; collection management

1. Introduction: The context of digital transformation in European and Spanish museums

The approval of the new museum definition by the ICOM Extraordinary General Assembly in Prague (August 24, 2023) marks a turning point.

"A museum is a non-profit, permanent institution in the service of society that researches, collects, conserves, interprets, and exhibits tangible and intangible heritage. Open to the public, accessible, and inclusive, museums foster diversity and sustainability. With the participation of communities, museums operate and communicate ethically and professionally, offering varied experiences for education, enjoyment, reflection, and the exchange of knowledge" (ICOM, 2023).

Comparing this with ICOM's 1974 definition of a museum, in which "a museum is a permanent institution, not for profit, at the service of society and its development, open to the public, which acquires, conserves, researches, communicates, and exhibits material evidence of people and their environment for the purposes of study, education, and enjoyment" (Brulon Soares, 2020); and with the widely used definition that remained in force until only a few months ago, approved in 2007 by the 21st General Conference held in Vienna, Austria, which stated that "a museum is a permanent, non-profit institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates, and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study, and enjoyment," (Brulon Soares, 2020) we find that accessibility, inclusion, the promotion of diversity,

and sustainability are the major transformational changes with a socializing character toward which museums are now increasingly oriented.

For these purposes and given that the rapid growth of technologies has significantly impacted all aspects of cultural management, museums seek to renew their own institutional identity through museological planning, programs, or strategic plans that specify the definition of their mission, the articulation of their strategies, and the objectives to be achieved (Hurtado Jarandilla, 2020).

In order for communication resources and platforms to provide broader, more accessible, and participatory cultural dissemination, thus fostering the new values of identity embraced by the institution, helping these to be perceived by the public, and, in line with the new identity project, moving the institution toward higher quality services (Valdés Sagüés, 1999), the most cutting-edge museological plans or strategic plans, such as the Strategic and Action Plan of the Museu Nacional d'Art de Catalunya (Museu Nacional de Catalunya, 2022), include digital strategies. These are understood as the way in which museums plan the implementation of new technologies within their walls (Hurtado Jarandilla, 2020).

In fact, one of the most prominent professionals in Spain when it comes to digital culture and museological planning is Conxa Rodà, head of strategy and digital transformation at the Museu Nacional d'Art de Catalunya, which we referred to earlier, who asserts that “it is absolutely necessary to have that digital strategy, and of course it should be integrated within the museum's overall strategy” and that “the digital dimension is transversal to the entire organization” (Hurtado Jarandilla, 2020). This quote from Conxa Rodà leads us to highlight the importance of policies aimed at virtualization and digitization in museums. However, the legislative aspect regarding digital transformation is relatively recent. It was not “until the last decade of the 20th century that capturing digital images for the management and dissemination of cultural heritage became of primary importance in museum institutions and in the heritage conservation and preservation industry” (Alberch, R., 2009).

In recent years, and with greater emphasis today, the European Commission has been especially promoting actions aimed at the digitization of heritage elements, making available online what it has defined as “cultural objects”: images of books, archival documents, photographs of buildings, paintings or sculptures preserved in museums, videos, etc. (Alberch, R., 2009), thus contributing to the consolidation of initiatives such as Europeana or MICHAEL (Multilingual Inventory of Cultural Heritage in Europe).

Regarding MICHAEL, its main objective was the creation of a multilingual inventory of European cultural heritage, based on sharing the data from national and regional inventories, alongside the development of a software platform for the creation, sharing, and dissemination of this data. By focusing on digital collections, it sought to become an inventory of both Europe's digital cultural heritage and digitized European cultural heritage, with digital collections at the core of the project.

Likewise, in this regard, Recommendation 2011/711/EU (Unión Europea, 2011) to the Member States established a series of general measures for the digitization and accessibility of European cultural material, in whose conclusions we find the priority actions to be carried out for the period from 2012 to 2015:

- By the end of 2012, consolidate digitization objectives and maintain or, if necessary, increase the priority given to digitization.
- Enhance the monitoring of digitization progress to achieve a comprehensive national overview and contribute to a Europe-wide perspective.
- By the end of 2013, contribute to the Commission's assessments of digitization and digital preservation progress at the European level.
- Strengthen the organization of digitization and secure funding, particularly through public-private partnerships.
- Ensure that public domain material remains in the public domain after digitization, fully respecting intellectual and industrial property rights.
- Encourage voluntary agreements and other mechanisms that facilitate the digitization and online access of works no longer in commercial circulation.
- Urge cultural institutions, publishers, and other rights holders to provide access to their digitized materials via Europeana, considering the indicative minimum content supply targets outlined in Annex II of Commission Recommendation 2011/711/EU.
- Make a diverse range of culturally and historically significant works and objects available through Europeana, including masterpieces selected by each Member State.
- By the end of 2012, finalize plans to publish content online in Europeana, in line with the conclusions of the 2010 Council, while ensuring the inclusion of relevant material already digitized.
- Promote national-level aggregation by establishing or strengthening national aggregators and facilitating the creation of cross-border aggregators for Europeana.
- Encourage the adoption of common digitization standards and the systematic use of permanent identifiers.
- Advocate for the broad and free provision of metadata by cultural institutions to Europeana for reuse and innovative applications.
- Promote and enhance long-term digital preservation strategies and implementation plans. Exchange information on strategies and action plans for long-term digital preservation.
- Implement necessary legal measures regarding the deposit of digitally created material to ensure its long-term preservation.
- Consider the existing situation in other Member States when developing or updating policies and procedures for the deposit of material originally created in digital format, to avoid excessive divergence in deposit measures.
- Ensure the production of sufficient descriptive and technical metadata and permanent identifiers as an integral part of digitization processes or when material is originally created in digital format.
- Establish the necessary legal conditions for long-term digital preservation concerning the multiple copying and migration of digital cultural material by public institutions for preservation purposes, in full compliance with international and European Union legislation on intellectual and industrial property rights (Unión Europea, 2012).

However, thanks to the analysis conducted by Ciro Lluca on this topic in 2016, we know that: Regarding the planning and evaluation of digitization plans, Spain mentions the annual call by the Ministry for digitization projects, resulting in more than half a million objects already

incorporated into Europeana; however, when it comes to public-private partnership actions for digitization and access, Spain mentions Telefónica's sponsorship of the National Library of Spain, but makes no mention of the Google Books project with the Complutense University of Madrid and various institutions such as the Library of Catalonia or the agreements of state museums with Google Art Project.

Regarding actions leveraging European structural funds for digitization and access, as well as the establishment of economies of scale in digitization programs, Spain does not appear to have participated nor does it provide data on this.

Concerning the digitization and online access to public domain material, Spain mentions public funding that includes instructions against the use of watermarks; and regarding the online publication of these materials once digitized, Spain is among the countries that build consensus to carry out actions to make this possible (Llueca, 2016).

Regarding Europeana and the goal of digitizing 30 million objects by 2015, Spain performed 120% above its target; however, in terms of the presence of European masterpieces in the public domain, Spain was not among the leading countries. (Llueca, 2016).

As for the promotion of national aggregator portals, Spain presented Hispana. Regarding the use of Europeana's metadata standards, Spain requires the use of these standards as a condition for its annual grants; and concerning the dissemination of the Europeana portal to the general public, Spain reports a school campaign held in the second half of 2014, but there have been no further results. As for digital preservation, the progress of long-term digital preservation strategies in Spain is unknown; likewise, in terms of forecasts for copying and migrating objects, Spain is not among the leading countries, and the same applies to the technical development of platforms to ensure digital deposit and web page capture. Thus, it seems clear that significant progress has been made in the adoption of the 2011 recommendations, yet there is still a considerable gap compared to the reality demanded by the European agenda. (Llueca, 2016).

Thus, "many heritage centers and institutions have made a decisive commitment to digitization, to the incorporation of multimedia, in order to provide services and access to their collections via the internet," (Alberch, R., 2009), but it should be kept in mind that the digital transformation of museums, as well as the digital cataloging of their collections, presents a complex scenario not only at the European level, but also within our own country.

In Spain, according to the 2020 census, there are 1,510 registered museum institutions. Of these, the museum and collections statistics published by the Ministry of Culture indicate that "67% are publicly owned, 31% are privately owned, and 2% are owned by other entities. Public administrations (the General State Administration, Autonomous Community Administrations, and Local Administrations) establish their own museum policies in accordance with their legal regulations, normative principles, and economic resources" (Martínez García, n. d.).

It is within the General State Administration that we can already find proposals aimed at facilitating the integration of museums into the digital world. In Spain, the Ministry of Culture approved the first document in 2004 as part of the development of a digital strategy plan for state museums, the Strategic Plan for the State Museums Network (2004-2008) (Ministerio de

Cultura, 2004). This plan included a multitude of objectives organized around six areas of action (institutional; human resources; collections; dissemination and communication; and cooperation and coordination), all of which each state museum was to take into account when drawing up their respective plans. Among these were already some objectives relating to new technologies such as computerized inventories (DOMUS), the Digital Network of Museums (CER.es), accessible websites, automated ticketing, and audio guides.

2. Digital Humanities tools that enable deep and transformative digitization

While pioneering, these measures focused on cataloging and basic online presence, falling short of today's standards for deep digital integration and the use of Digital Humanities (DH) tools.

DH has evolved significantly from initial basic online cataloging to a comprehensive digital integration across academia. Originally aimed at digitizing and visualizing archives, DH now includes advanced tools like hypermedia, data visualization, text mining, and digital mapping, fostering interdisciplinary studies (Sun & Li, 2020). This evolution has reshaped research methodologies, organizing materials, and analyzing and publishing findings across the humanities (Gardiner & Musto, 2015).

Current digital tools offer flexibility and support traditional research practices while enabling new methods through tool development and data preparation (Given & Willson, 2018). Nowadays, the field of digital humanities is offering significant insights and techniques that can be seamlessly incorporated into museum practices. This integration not only enriches the academic and operational dimensions of museums but also opens up innovative avenues for engaging with cultural heritage and historical stories.

One critical area where digital humanities intersect with museum practices is through the use of digital visualization techniques. Museums increasingly employ these techniques to enhance the presentation and understanding of their collections. This approach aligns with the concept of "visual digital humanities," which encompasses research methods that utilize pictorial, rather than textual, information. This method is prevalent in art history, museology, and archaeology, allowing museums to present their collections in innovative and engaging ways (Münster & Terras, 2019).

Digital curation, a burgeoning field within digital humanities, also plays a crucial role in museums. The curation process involves managing digital data to maximize its current and future value. Museums can leverage digital curation practices to manage and present digital artifacts, making their collections more accessible to the public and researchers. This practice is especially important as museums seek to reach broader audiences and foster new research questions (Poole, 2017).

The interactive and performative capabilities of digital technologies present another significant connection between digital humanities and museums. For instance, digital historiography and performance studies illuminate how digital tools can be used to document and present historical events. Museums can implement these methodologies to create immersive and interactive

exhibits, allowing visitors to engage with history in innovative ways, such as the example from the Decision Points Theater at the George W. Bush Presidential Museum and Library (Bay-Cheng, 2016)

Furthermore, the collaboration between digital humanities scholars and museums can lead to better tool development and adaptive methodologies. As the digital humanities encompass interdisciplinary collaboration and the development of bespoke digital tools, museums can benefit from these practices to tailor exhibits and manage collections in more dynamic ways. This also fosters collaborative projects that expand the museum's educational outreach and engagement with the public (Given & Willson, 2018).

Over the past three decades, cultural management in museums has evolved to prioritize active dissemination of culture, reflecting broader societal shifts toward democratization and cultural democracy. Museums have transitioned from static repositories of artifacts to dynamic cultural spaces that foster dialogue, education, and community involvement. This transformation underscores a commitment to accessibility and inclusivity, aligning museum missions with democratic values that emphasize equal cultural rights and representation.

In this context, museums increasingly serve as spaces where personal and collective identities intersect, and where memory and history converge. They now present narratives that engage visitors on personal and emotional levels rather than merely showcasing objects (Crane, 2000). Accessibility has become central, positioning museums as alternative learning spaces that offer equal opportunities to all individuals, regardless of physical or health conditions (González-Herrera et al., 2023)

Furthermore, museums play formative roles in shaping socio-cultural relationships. Discussions on audience inclusion and exclusion are essential to understanding how museums function as platforms for shared narratives within complex cultural frameworks (Coffee, 2008). Strategic management for visitor-oriented museums emphasizes attracting diverse audiences and developing services tailored to their needs, fulfilling museums' social mandates as public institutions (Reussner, 2003).

The integration of digital tools redefines organizational structures, curatorial practices, and educational programs. Digital transformation serves as a catalyst for innovation, ensuring museums remain relevant in a digitally connected world. Key technologies include:

- Digital rights management and blockchain: Safeguarding digital content and cultural relics through secure preservation and authorization mechanisms (Wang et al., 2021).
- Visitor-oriented approaches: Enhancing engagement through two-way communication and interactive experiences (De Bernardi et al., 2019).
- Extended Reality (XR): AR, MR, and VR provide immersive, multisensory interactions that enrich cultural content and extend museum experiences beyond physical walls (Silva & Teixeira, 2022).
- Information and communication technologies (ICT): Reshaping the museum value chain by integrating online and onsite experiences into hybrid models (Simone et al., 2021).
- Human-Centered Design (HCD): Prioritizing visitor experience and fostering co-creation in digital cultural heritage design (Mason & Vavoula, 2021).

Moreover, the integration of new technologies has been pivotal in extending museums' reach and improving operational efficiency:

- Online exhibitions, virtual tours, and digital archives have expanded audiences and created dynamic, accessible experiences (Bakhshi & Throsby, 2012). Consequently, museums have become vibrant cultural spaces that actively engage communities, contributing to local development and reinforcing their educational role (Bertacchini et al., 2018).
- Also, rapid advancements in digital and communication technologies have profoundly transformed institutional identity and strategic planning:
- Virtual and augmented reality (VR/AR), online exhibits, and immersive experiences enhance accessibility and visitor engagement (Tsitseklis et al., 2023). These innovations have fueled a growing digital museum services industry, supporting a digital heritage economy (Hijazi & Baharin, 2022).
- Social media and metaverse-based strategies have emerged as essential tools for maintaining engagement in a contactless culture shaped by the COVID-19 pandemic, fostering hybrid communication models that blend physical and virtual interactions (Sánchez-Amboage et al., 2023).
- Gamification in VR museums is also being explored to balance educational value with entertainment, enriching both hedonic and eudaimonic visitor experiences (Sangamuang et al., 2025).
- Artificial intelligence (AI) further enhances personalization, interactive content, and real-time information access, while improving data analytics for curation and audience engagement (Rani et al., 2023).

3. Conclusions

Despite these advancements, challenges persist due to limited digital training and engagement policies, as highlighted during the pandemic. Nevertheless, initiatives promoting community participation and self-expression have proven highly effective (Morse et al., 2022). Overall, digital technologies act as relational tools that humanize museum interactions, enabling co-created experiences that align institutional objectives with visitor expectations (Marini & Agostino, 2021).

However, financial constraints, institutional pressures, and lack of coordination remain significant barriers. Addressing these challenges requires strategic management and interdepartmental cooperation to fully integrate digital strategies (De Bernardi et al., 2019). Digital storytelling and creative narratives further strengthen museums' societal roles by fostering emotional connections with audiences (Marini & Agostino, 2021; Visual Computing for Cultural Heritage, 2020).

Digitalization is fundamental for museums to fulfill their social mandate of accessibility, diversity, inclusion, and sustainability. A comprehensive digital strategy—integrating advanced technologies such as 3D digitization, NLP, LOD, AR/VR, and AI—is essential for transforming collection management, interpretation, and research.

Although Spain has a legal framework and early initiatives, true transformation requires moving beyond inventories toward immersive, interactive experiences that make cultural heritage more accessible and engaging for all.

Finally, the integration of digital technologies not only expands museums' reach but also necessitates a strategic rethinking of their societal role. While challenges remain, the potential for digital innovation to enhance museum experiences is vast and continues to evolve.

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This volume, *Cultural Heritage at a Crossroads: Sustainable Development and Digital Transformation*, emerges directly from the collaborative spirit of the European FORTHEM Alliance. It captures the rich academic dialogue of a Blended Intensive Programme that brought together the expertise of scholars and students from the University of Palermo, the University of Burgundy, the University of Valencia, and Lucian Blaga University of Sibiu. Together, they confront a central question of our time: How can we responsibly steward our most valuable and vulnerable cultural assets towards a sustainable future?

Through theoretical frameworks and practical case studies, the contributors explore how digital tools are revolutionizing preservation and access, while also addressing the policies needed to build resilience. This volume is an essential guide for students, professionals, and anyone invested in shaping a future where our shared past is not only protected but actively enriches contemporary society.



Co-funded by
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