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"Immersive Models and Methodological Proposals for Art Education through AR and VR: a case study on Caravaggio."

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Abstract

This article explores the use of immersive digital technologies—particularly Virtual Reality (VR) and Augmented Reality (AR)—applied to the teaching of art history, with the aim of enhancing learning processes, active participation, and student engagement during workshops or thematic lessons. The study seeks to highlight the potential, methodologies, limitations, and critical aspects of digital-based teaching, focusing especially on the interactive and engaging approach fostered by the sense of "immersion" within the artwork (the recreation of an original work designed specifically for this purpose). Finally, a pedagogical laboratory methodology is proposed for implementation in educational settings, structured into five phases: theoretical introduction, immersive experience, reflection, creative reworking, and presentation. The educational model, applicable to any artist or artistic movement, is illustrated through the case study of Caravaggio. The contribution aims to outline a model for teaching art history that integrates the pedagogical tradition of the laboratory with new digital technologies.

Keywords : virtual and augmented reality; art education; digital technologies; teaching art appreciation, Caravaggio

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2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

Introduction:

Research in cognitive neuroscience on visual perception and neural activation during aesthetic experience—combined with recent advances in digital and computational experimentation, as well as studies in psychology (Pallavicini, 2020) and the sociology of art—has profoundly transformed the relationship among the artist, the artwork, and the viewer. Findings from the last few decades—such as the discovery of mirror neurons and the theoretical development of *embodied cognition* and *embodied simulation* (Gallese, 2012b) as mechanisms capable of reproducing actions, sensations, and bodily emotions—have revealed the existence of a deep connection that transcends mere visual observation and involves the entire body. This relationship, while especially powerful in museum environments, can also become inclusive, formative, and emotionally engaging through the use of new digital technologies grounded in aesthetic, artistic, computational, and cognitive studies—such as the design of augmented and virtual reality spaces or AI-driven creative processes (D'Isa, 2024). While not empirically tested within the proposed educational activities, these neuroaesthetic references are employed as a conceptual and interpretive framework. (Chatterjee & Vartanian, 2014). Their inclusion is intended to illuminate the depth and complexity of the relationship that unfolds among the artist, the artwork, and the viewer, particularly in immersive and digitally mediated contexts, highlighting how aesthetic experience engages the body and mind beyond mere visual observation. (Belfi et al., 2019). A three-dimensional reconstruction designed for augmented and virtual reality, accessible through a headset, enables a sensory and immersive experience (Di Marino, 2021) that strengthens engagement by directly connecting the artist, the artwork, and the viewer. Beyond their potential for museums, research, and experimentation, digital artworks can also serve valuable educational and didactic purposes.

This study focuses on the use of immersive technologies—particularly virtual and augmented reality—as innovative pedagogical tools to foster learning, engagement, and active participation among students in art history education. The article is structured into several sections. The first, Immersive Models and Teaching in AR and VR, offers a theoretical and critical overview of immersive technologies applied in educational and museum contexts, highlighting their main advantages in terms of engagement, accessibility, and learning, as well as the challenges related to their implementation. The second section, Case Study: The Digital Reconstruction of Caravaggio's *Adoration of the Shepherds*, presents a research project developed at the University of Messina aimed at recreating Caravaggio's painting—preserved at the Regional Museum of Messina—in a virtual environment. This experience provides a meaningful example of how VR can be employed to support understanding, dissemination, and interactive appreciation of art. The third section, Studying Light through Digital Tools: Caravaggio's Chiaroscuro, examines the artist's use of light and shadow through digital reconstruction, showing how virtual tools

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

can become a means of exploration and knowledge. Finally, the methodological section proposes a structured approach for integrating VR and AR into art history education, useful for explaining and conveying complex concepts. The design of such educational reconstructions should be based on collaborative projects developed in response to the specific needs of schools and implemented in synergy with teachers, public institutions (museums, galleries, cultural organizations), private partners, agencies, and field experts.

Immersive Models and Teaching through AR and VR

In recent decades, the design of digital applications—originally developed and tested in the field of video games—has been successfully adopted in education and in the enjoyment of cultural heritage (Guazzaroni & Pillai, 2020). Immersive technologies have become increasingly accessible within educational environments, offering the potential to transform learning into an engaging, active, interactive, and effective experience (Luigini & Panciroli, 2019). Digital media represent an innovative tool for teaching, as the design of virtual environments can actively engage learners and facilitate understanding through interactive experiences. *"In particular, VR offers numerous advantages in terms of feedback, assessment, motivation, and the engagement of the entire class group, including students with specific learning disorders (SLD) or disabilities in general"* (Rossi & Toto, 2024, p. 116). A 2023 study by Guerra Tamez, based on a survey administered to 200 art and design students, highlights the effectiveness of learning through virtual reality. Specifically, it shows that *"VR is quickly becoming a powerful learning tool in schools. By immersing students in a 3D environment, virtual reality can help them develop a better understanding of difficult concepts and gain a deeper appreciation of the creative process"* (Guerra-Tamez, 2023, p. 13). Equally significant is an article by Invitto (2013), which demonstrates that *"in contexts related to the perceptual environment of museums and cultural heritage, studies in neuroaesthetics and the use of new technologies interconnected with recent neuropsychological discoveries, can become valuable supports for spaces in which individuals experience educational, artistic, and cultural contexts"* (Invitto, 2013, p. 35).

Viewing an artwork through augmented or virtual reality—thus accessing visual culture via new forms of imagery and vision (Pinotti & Somaini, 2016)—can be a highly rewarding educational experience. By "transporting" the viewer inside the digital environment, these technologies enable immersive learning, allowing for direct and active engagement with art. (Yu at al., 2025) The viewer can identify with the depicted characters, interact with them, and dynamically participate in a sensory exploration that stimulates knowledge and curiosity—also thanks to accompanying texts, sounds, and information provided by the device. However, it is important to acknowledge the limitations and challenges still present, primarily those related to accessibility, as the cost of necessary hardware remains a significant barrier. The following table summarizes the advantages and challenges of using AR and VR during an art history workshop or lesson.

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

Aspect	Advantages	Challenges
Engagement	Immersive experience that stimulates curiosity, attention, and motivation. Even less interested students may be encouraged through the use of new digital technologies.	Possible cognitive overload, especially among students less familiar with technology. (varying digital competence among learners)
Learning	Complex concepts become more intuitive and easier to understand. Promotes dynamic and experiential learning.	The experience must be carefully guided both technically and pedagogically, and properly contextualized in historical and cultural terms.
Accessibility	Enables the viewing of artworks that are geographically distant or no longer exist.	High costs (hardware accessibility), inadequate infrastructure, and potential risks related to immersive technologies (e.g., motion sickness). May require external experts for content creation.
Collaboration	Encourages participation and cooperation within the group, fostering a sense of shared purpose.	Complex management of time (depending on where the activity fits within the teaching unit) and of available school spaces.
Interactivity	Allows observation of the artwork from multiple perspectives and angles; promotes learning through immersion, supported by audio, narrative, and descriptive elements.	Difficulties in using VR headsets for some students.
Relationship with the Artwork	Enables a direct and dynamic relationship with the artwork, enhanced by active learning.	The in-person museum visit remains irreplaceable.

Tab1:?

Furthermore, while it is important to emphasize the potential of new technologies and their educational, formative, and communicative roles, it is almost superfluous to stress that viewing a work of art in VR or AR can never replace an in-person museum visit or the physical presence before the artwork itself. (Radianti et al., 2020) A digitally created work can, however, be experienced within museum spaces to complement or diversify traditional modes of art appreciation, offering interactive, immersive, formative, and multimedia experiences that engage the visitor in a more direct and participatory way.

By accelerating the conception of the museum as a technological, innovative, and multidisciplinary laboratory open to the community, digital tools can become valuable educational resources for enhancing the overall experience in terms of engagement, embodied emotion, and accessibility, contributing to new narrative forms of cultural heritage (Spallone, Lamberti & Ronco, 2021).

Today, the museum is both container and content: a place for critical and direct engagement with cultural objects, an ideal environment for aesthetic experience, a center for documentation and study, and a *"space dedicated to the development of learning"* (Ercolano, 2024, p. 65) as well as an *"active site of cultural promotion and production"* (Ercolano, 2024, p. 66). To ensure cultural inclusion for a wide range of

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

audiences—children, young people, adults, the elderly, persons with disabilities, and non-Italian citizens—*"the museum must, through conscious and innovative design, implement high-quality educational pathways"* (Ercolano, 2024, p. 37), where digital technologies can serve as key tools to adapt content, language, and modes of engagement to audience needs. It is therefore essential to design pathways that go beyond simple dissemination or communication of heritage, and that—through multidisciplinary approaches—create an inclusive and relational space (Caldarelli et al., 2023) in which learning arises from curiosity and direct experience with art.

Case Study: The Digital Reconstruction of Caravaggio's *Adoration of the Shepherds*

As part of a PON research fellowship within the Ph.D. program in Cognitive Sciences at the University of Messina (Department of COSPECS), a multidisciplinary team, in collaboration with a visual designer, developed a digital environment inspired by Caravaggio's *Adoration of the Shepherds* (1609), housed at the Regional Museum of Messina. The reconstruction project was carried out in collaboration with the University's HuM-HI (Human-Machine Hybrid Intelligence) Laboratory and the Regional Museum of Messina. The museum provided a high-definition image of the painting (Cadet et al., 2022), which served as the basis for creating a 3D environment that faithfully recreates the scene's setting—the hut or stable where the event unfolds—and its various figures, including animals. The modeling of the scene was performed in Blender, and the 3D model was then used to develop an application for the Meta Oculus Quest 3 headset using the Unity 3D engine. The choice of this device was driven by the goal of granting users freedom of movement within the virtual scene.

The decision to focus on the Adoration of the Shepherds—originally located in the Church of Santa Maria della Concezione in Messina, which, along with its convent, was managed by the Capuchin order—was motivated by multiple factors related to the painting's iconography, style, and technique.
From an iconographic perspective, Caravaggio depicts Mary lying directly on the bare ground, a young woman exhausted by childbirth, tenderly embracing her child amid poverty and simplicity. The Madonna's contact with the earth symbolizes her closeness to the poor and the humble, who bow down before the newborn Jesus. The tones are dark and earthy, with light emerging only from the straw and a white cloth among Joseph's carpenter tools. From a stylistic standpoint, the painting exemplifies the distinctive features of Caravaggio's late period. During his time in Sicily, and particularly in Messina, his style evolved away from that of his Roman years: the large canvases feature coarse textures and are often composed of multiple joined sections. Empty and dark spaces dominate the upper parts of the composition. His brushstrokes are violent and essential—an aspect consistently emphasized by his biographers. Caravaggio's mastery of chiaroscuro—his dramatic interplay of intense light and deep shadow—enhances the emotional and narrative power of the scene. Light sculpts the figures, imparting

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

volume and realism, while its directional use guides the viewer's attention toward key gestures, faces, and symbolic details. The resulting contrast heightens tension, mystery, and emotional intensity. In the digital reconstruction, the hut serves as an ideal enclosed environment that heightens the sense of immersion. The arrangement of the figures—Mary, the Child, Joseph, and the shepherds—guides the viewer's gaze along a harmonious curve. Details such as the ox, the donkey, the basket, and Joseph's tools encourage closer inspection and prolong the viewer's engagement with the scene. The meticulous digital reconstruction revealed elements that are often overlooked in traditional observation, offering an immersive environment accessible through both virtual and augmented reality. The VR version provides a fully immersive aesthetic experience, while the AR version enriches the viewer's real-world environment by integrating 3D models of the figures and setting. Although AR is less immersive, it allows the user to interact simultaneously with the digital and physical worlds. Designed to engage the viewer on a physical, sensory, and emotional level, the digital reconstruction is suitable for both museum and extra-museum contexts, as it offers accessibility to those unable to visit exhibition spaces in person (Campitiello, 2025).

The experience is enhanced by ambient sounds, an audio narration of the Gospel story of the Nativity, and layered explanations of the artwork—from general context to detailed analysis.

The project also serves an educational purpose: the digital work can be used in teaching environments such as schools, libraries, museums, and coworking spaces (Gee, 2013). Thanks to the three-dimensional visualization, learners can intuitively grasp complex artistic concepts—such as Caravaggio's use of light, chiaroscuro, and compositional depth—through direct and interactive observation. Following the 3D development phase, within the framework of Dr. Certo's doctoral dissertation, an experiment was conducted to compare levels of engagement (assessed through physiological, cognitive, and emotional responses) among three viewing modes: virtual reality, augmented reality, and high-definition projection in a classroom setting. The study involved a sample of 71 volunteer participants recruited among students of the University of Messina. The results indicated that virtual reality provided the most engaging and immersive experience for participants. The results indicated that virtual reality provided the most engaging and immersive experience for participants.

Studying Light through Digital Reconstruction: Caravaggio's Chiaroscuro

The three-dimensional reconstruction of the Adoration of the Shepherds was conceived as a true staging, not merely as a digitally lit environment for AR/VR, but as a set endowed with its own cinematographic direction—implicit framing, hierarchies of attention, and perceptual timing. Light operates as a silent form of direction: it arranges bodies, isolates the essential, and restrains the superfluous. This approach prompted a reconsideration of the widely held notion of a single light source

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

in Caravaggio's work. In this painting, light appears instead as polyphonic. Five distinct yet integrated components contribute to the unity of the overall effect:

1. a terrestrial light, low and warm, that structures the chiaroscuro;
2. the warm reflection from the straw and ground, which lifts the shadows without softening them;
3. a cooler return from light fabrics, keeping the mid-tones alive;
4. a subtle edge light entering from the hut's opening, defining contours at risk of merging;
5. and a light of revelation, devoid of any material source, illuminating the faces and rescuing them from pure naturalism.

These are not five lamps on a set, but rather five behaviors of light, translated into a three-dimensional environment and carefully balanced in intensity, temperature, and mutual incidence to preserve narrative coherence. The virtual setup was therefore executed with measured discipline. Light sources were placed following a theatrical logic, allowing materials to respond naturally—wood that gathers reflection in textured clusters, fabrics that faintly sparkle under grazing light, and skin that absorbs and returns illumination with moderation. Special attention was devoted to adaptation time: in VR, the scene does not burst open—it emerges. As when entering a dimly lit space, a few seconds allow the eye to learn a grammar of light, avoiding the automatic flattening that would otherwise diminish the experience.

The didactic value of the virtual medium lies precisely in its ability to explain the scene from within. The user can stand beside the characters, adopt their viewpoints, and perceive how relationships shift with minimal movements—relating light accents to gestures and directions of gaze. Through this traversal, it becomes clear that what appears in the painting as a single burst of light is, in fact, a complex architecture—a true cinematography of representation imbued with emotional charge. Thus, the virtual scene functions as a laboratory of visual direction: it does not replace the painting but clarifies its internal economy. When successful, the headset experience does not produce the impression of "perfect" lighting, but of an apparition: the figures are not only visible—they are made present. In this transition—from seeing to understanding, from understanding to feeling—three-dimensionality ceases to be a technical feature and, as in Caravaggio's own art, becomes once again a matter of light and the consciousness of vision.

Didactic Methodology in AR and VR for Art History Education

In 2024, the research group participated in the Festival of Philosophies held at the Regional Museum of Messina, and in 2025 at the VII Festival of Scientific Culture at the "Caminiti" High School

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

of Giardini Naxos, engaging with several classes from secondary schools in Messina and the surrounding area. During these events—through both theoretical sessions and hands-on workshops—it became evident that interacting with a digital artwork is not only an engaging and fascinating experience, but also pedagogically meaningful. The immersive and interactive nature of such experiences enables the immediate and intuitive transmission of complex concepts compared to traditional teaching methods. (Slater, 2018). The multichannel approach—combining images, descriptive texts, narratives, audio, and ambient sounds—adapts to various needs and learning styles, stimulating curiosity and attention while making abstract concepts tangible. The creation of digital artworks, accessible through virtual and augmented reality, allows students to approach art in a more direct and intuitive way, facilitating understanding of complex artistic concepts and terminology—such as Caravaggio's use of chiaroscuro—through visual and sensory exploration. Immersive experiences (Cummings & Bailenson, 2016) enable learners to observe how light shapes figures, revealing the plasticity and depth of the scene, thus making the artist's techniques and choices more accessible.

In a school setting, the use of AR and VR—either in the classroom or in a computer lab—can bridge the gap between the discipline and students, transforming passive learning into an active and engaging experience. Digital technologies can be integrated both during traditional lessons, to deepen specific topics, and within dedicated workshops, which naturally lend themselves to immersive exploration of artistic techniques. When designing a lesson that integrates digital technologies, after analyzing the class context and the chosen topic, it is necessary to consider potential spatial and logistical limitations, such as "constraints caused by the position of classmates" or "difficulty of movement due to classroom configuration" (Tassinari et al., 2023, p. 152), and to seek support from internal or external experts when needed.

Since schools may lack the specific technical skills required for implementation, it is advisable to involve specialized partners, such as public and private institutions (universities, museums, etc.), companies, and creative agencies. This collaborative approach allows the experience to take the form of a co-designed educational project, aligned with the school's learning objectives. Tailor-made digital content is therefore more effective than adopting commercial products intended for a broad and undifferentiated audience. The methodological framework of this proposal is grounded in the principles of participatory, flexible, and inclusive education, supported by active, cooperative, and relational learning approaches. These are in line with contemporary pedagogical perspectives that emphasize collaboration among educational actors—particularly between schools and museums (Pizzato, 2019)—to enhance teaching quality and employ technology as a means of facilitating knowledge construction, consistent with the principles of meaningful learning.

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

This article therefore proposes a methodological model for active and collaborative art education in AR and VR, articulated in five phases, in which a class group is guided by a teacher and, when appropriate, by an expert. The model integrates essential skills such as observation, critical thinking, communication, temporal and stylistic orientation in art history, and the proficient use of digital technologies.

Didactic Model: Phases for Teaching Art through AR and VR

Below is the proposed five-phase methodological model for an active and collaborative art education pathway using Augmented Reality (AR) and Virtual Reality (VR). Each phase integrates theoretical, experiential, reflective, and creative dimensions, fostering both individual and collective learning. The model is designed for a secondary school class, but it can also be developed within a museum education program, inside a museum, to integrate the live viewing experience.

1. Theoretical Phase

Duration: 10 minutes (brainstorming) + 20 minutes (lesson)

Description:

The teacher introduces the topic through a brief brainstorming session, followed by a structured lecture. The brainstorming encourages participation and activates students' prior knowledge, while the lecture deepens understanding of the historical and artistic context through slides, videos, textbook readings, and guided discussion.

Learning mode: *Knowledge acquisition*

Objectives:

- Activate prior knowledge
- Introduce the historical-artistic context
- Understand and deepen the chosen topic

2. Immersive Experience

Duration: 40 minutes

Description:

Students, divided into small groups, participate in a post-lesson workshop where they explore the three-dimensional artwork (created from a two-dimensional painting or sculpture) through VR and AR headsets. During the experience, they can access additional layers of information—such as descriptive audio, narrative commentary, and ambient sounds—that enrich understanding and engagement.

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

Learning mode: *Learning by doing* – immersive and multisensory experience

Objectives:

- Enter "inside" the artwork
- Observe and interpret technical and compositional details
- Understand the artist's visual and expressive language

3. Reflection and Discussion

Duration: 20 minutes

Description:

After the immersive session, students engage in a group discussion moderated by the teacher, sharing impressions, discoveries, and questions. This dialogical exchange fosters awareness and critical thinking.

Learning mode: *Learning through discussion* — brainstorming, collaborative learning, cooperative learning.

Objectives:

- Stimulate critical and reflective thinking
- Compare interpretations and experiences
- Consolidate understanding through dialogue

4. Reworking and Production

Duration: 30 minutes

Description:

In this creative phase, students individually or in groups produce thematic outputs such as slideshows, written reflections, portfolios, podcasts, or web pages (e.g., virtual exhibitions). This allows them to reinterpret the acquired knowledge through creative and exploratory process.

Learning mode: *Learning through inquiry, manipulation, and exploration.*

Objectives:

- Stimulate creativity and imagination
- Rework artistic content in personal and expressive forms
- Develop digital and media literacy skills

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

5. Presentation and Evaluation

Duration: variable (depending on class size and number of projects)

Description:

The projects are presented, shared, and evaluated under the teacher's guidance, with an emphasis on peer feedback and self-assessment. The process encourages cooperative learning and appreciation of group work.

Learning mode: *Cooperative learning*

Objectives:

- Value teamwork and collaboration
- Develop communication and presentation skills
- Reflect on the learning process through self-evaluation

Phase	Duration	Description	Learning Mode	Objectives
1. Theoretical Phase	10 min brainstorming + 20 min lecture	The teacher introduces the topic through a brainstorming session and a lecture using slides, videos, and readings.	Learning by acquisition	• Activate prior knowledge • Introduce the historical-artistic context • Understand and deepen the topic
2. Immersive Experience	40 min	Students in small groups explore a 3D artwork using VR/AR headsets, with audio narration and ambient sound.	Learning by doing (immersive and multisensory)	• Enter the artwork • Observe technical details • Understand the artist's visual language
3. Reflection and Discussion	20 min	Group discussion after the immersive session to share impressions and stimulate critical thinking.	Learning through discussion (collaborative learning)	• Stimulate critical thinking • Compare interpretations • Consolidate understanding through dialogue
4. Reworking and Production	30 min	Creative phase where students produce thematic outputs (slides, podcasts, virtual exhibitions).	Learning through inquiry, manipulation, and exploration	• Stimulate creativity and imagination • Rework artistic content personally • Develop digital and media literacy skills
5. Presentation and Evaluation	Variable	Students present and evaluate projects collaboratively, guided by the teacher and peer feedback.	Cooperative learning	• Value teamwork • Develop communication skills • Reflect through self-evaluation

Conclusion

This article has outlined a methodological proposal for integrating Virtual Reality (VR) and Augmented Reality (AR) into the teaching of art history—an approach particularly effective for explaining and conveying complex concepts. The proposed case study focused on Caravaggio, demonstrating how immersive technologies can enhance the understanding of artistic techniques such as chiaroscuro in Baroque painting.

During a lesson on light and shadow in Baroque art and Caravaggio's distinctive style, the use of VR and AR enables a three-dimensional immersion "within" the artwork. Through a headset, students

ISSN: 3035-062X
2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

can observe the distribution of light and shadow from multiple angles, directly perceiving the painter's technique. This immersive and active experience fosters more intuitive comprehension, making learning deeper, more engaging, and more enduring. Digital tools can thus be effectively employed in art history lessons or thematic workshops, as the experience of exploring a digital reconstruction of an artwork—following the study of the original—can stimulate critical observation and comparative reflection, going beyond the limits of traditional textbook or screen-based analysis.

The ultimate aim of this study is to propose a didactic methodology grounded in digital innovation, designed through collaborative projects that respond to the specific needs of schools and involve teachers, public institutions (museums, galleries, cultural organizations), private partners, agencies, and sector experts. This cooperative framework ensures that technology becomes not an end in itself, but a meaningful educational tool for enhancing the teaching and learning of art.

Conflict of interest statement *: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Author Contributions *:

A.N., F.P.C., V.C. and R.F. jointly conceptualized and authored the *Introduction* and *Immersive Models and Teaching through AR and VR* sections.

A.N., together with F.P.C., V.C., S.A. and R.F. developed and wrote the *Case Study: The Digital Reconstruction of Caravaggio's Adoration of the Shepherds*.

The section *Studying Light through Digital Reconstruction: Caravaggio's Chiaroscuro* was solely written by S.A.

The sections *Didactic Methodology in AR and VR for Art History Education* and *Didactic Model: Phases for Teaching Art through AR and VR* were co-authored by A.N. and V.C.

The *Conclusion* was collaboratively written by A.N., F.P.C., V.C., R.F.

All authors contributed to the critical revision of the manuscript and approved its final version for publication. The images were created by S.A.

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Preliminary Reports and Negative Results in Life Science and Humanities

Images

[image 1] Michelangelo Merisi, *Adoration of the Shepherds*, 1609, Messina, Regional Museum of Messina.

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2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

[image 2] A Three-Dimensional Reconstruction of Caravaggio's *Adoration of the Shepherds* by Saverio Autellitano

[image 3] Lighting Analysis of Caravaggio's *Adoration of the Shepherds* by Saverio Autellitano (The light beam has been deliberately accentuated to demonstrate how it could be visualized for educational purposes.)

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2025, 2(2)

Preliminary Reports and Negative Results in Life Science and Humanities

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2025, 2(2)

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2025, 2(2)

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[images 4, 5, 6, 7] Lighting Analysis of Caravaggio's *Adoration of the Shepherds* by Saverio Autellitano. The various images highlight the decomposition of light within the artwork. (The light beam has been deliberately accentuated to demonstrate how it could be visualized for educational purposes).