A Review of the Functions of the Cultural Heritage of the Mogao Caves at Dunhuang

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ABSTRACT

The Mogao Caves, also known as the "Caves of a Thousand Buddhas," were first constructed in the early 4th century and gradually expanded to more than 700 grottoes by the Yuan dynasty. Preserved within are extensive wall paintings, sculptures of Buddhas, bodhisattvas, and arhats, along with the invaluable Dunhuang manuscripts, encompassing Buddhist scriptures, Daoist texts, Confucian writings, and secular documents. This unique cultural complex is not only an unparalleled artistic and religious treasure but also a dynamic medium for cultural transmission and moral education. Historically, the Mogao Caves have functioned as a space for Buddhist devotion, while also carrying a didactic function that warns and instructs through visual narratives. In the modern context, their significance extends beyond religious and historical value to encompass heritage preservation, aesthetic appreciation, and even sustainable commercial development through tourism and digital dissemination. As such, the Mogao Caves represent a multidimensional cultural heritage site whose enduring relevance lies in the intersection of spiritual devotion, cultural memory, and contemporary socio-economic engagement.

Keywords： Mogao Caves; Moral and Didactic Function; Heritage Preservation; Aesthetic Value; Commercial Value

Introduction

The Mogao Caves, also known as the "Caves of a Thousand Buddhas," are located at the eastern foot of the Mingsha Mountains in Dunhuang, Gansu Province, China. The caves were first excavated in 366 CE during the Former Qin dynasty, when the monk Lè Zūn, inspired by a vision of golden rays and myriad Buddhas, vowed to carve a sanctuary into the cliff. Over the subsequent centuries, the Mogao complex underwent continuous expansion across multiple dynasties—including the Northern Liang, Northern Wei, Western Wei, Northern Zhou, Sui, Tang, Five Dynasties, Song, Western Xia, and Yuan—culminating in a monumental ensemble of 735 caves, more than 45,000 square meters of wall paintings, over 2,000 painted sculptures, and an extensive body of manuscript remains. Today, the Mogao Caves constitute the largest and best-preserved repository of Buddhist art in the world.

The artistic achievements of Mogao are exceptionally diverse. Its murals, often described as an "encyclopedia on the walls," represent the pinnacle of Dunhuang art and reflect over a millennium of religious, social, economic, and cultural developments. The paintings encompass a wide array of subjects, including Jātaka tales, avadāna narratives, depictions of the Buddha's life, sutra illustrations (jingbian), donor portraits, architectural landscapes, and scenes of everyday life. In addition to the murals and sculptures, the caves gained worldwide prominence with the discovery of the so-called "Library Cave" (Cave 17) in 1900, where more than 50,000 manuscripts were found. These texts include Buddhist scriptures, Daoist writings, Confucian documents, as well as treatises on astronomy, calendrics, medicine, literature, music, and dance—making Dunhuang an indispensable source for the emergence of "Dunhuang Studies."

Beyond their religious significance, the Mogao Caves function as a comprehensive repository of global art, history, and culture. Their murals and sculptures fulfilled critical roles in religious instruction and ritual devotion, while also transmitting historical memory, moral education, and didactic warnings. As a UNESCO World Cultural Heritage Site, the Mogao Caves embody the shared responsibility of humanity to safeguard and transmit cultural legacies. In recent decades, their aesthetic value has drawn

sustained attention from scholars and visitors worldwide, rendering them a focal point for art historical research and cross-cultural appreciation. Moreover, in the context of contemporary tourism and digital technologies, the caves' commercial and communicative potential has become increasingly prominent. A systematic review of the cultural functions of the Mogao Caves not only illuminates their historical significance but also provides critical insights for the future of cultural education and heritage preservation.

Moral and Educational Functions of Dunhuang's Digital Heritage: Warning Value in Contemporary Dissemination

The story of "The Deer and the Snitch", adapted from the wall paintings of Cave 257 at the Mogao Grottoes, has become one of the most vivid examples of how Dunhuang heritage can be mobilized for contemporary education. Recently released as an animated short film through the "Traveling in Dunhuang" WeChat mini-program, it brings the ancient tale to life for younger audiences in a culturally accessible medium (Du & Zhang, 2023; Du & Zhao, 2024). The narrative centers on the Nine-Colored Deer, a resplendent creature shimmering in nine hues, living along the Ganges River. When a man falls into the rushing waters, the deer leaps in to save him at the risk of its own life. In gratitude, the man bows and swears loyalty. The deer, however, issues a stern admonition: "Do not betray me; if you do, divine punishment will follow." Later, when the queen dreams of the deer's beauty, the king offers a reward to anyone who can reveal its whereabouts. Tempted by greed, the very man once saved betrays the deer's refuge. Yet, when the king and his soldiers surround it, their arrows disintegrate mid-air. The deer then recounts the betrayal, and the king, moved and angered, punishes the informer and orders eternal protection for the Nine-Colored Deer. The story thus becomes a timeless warning: never betray gratitude, and uphold honesty and loyalty. Through digital media, this tale now functions as a moral parable to guide adolescents, instilling values of integrity, fidelity, and the consequences of betrayal.

The educational power of Dunhuang art is not confined to narrative retellings. Within the Dunhuang VR Project, serious games are designed that merge entertainment with cultural learning. By transforming visual elements of murals into interactive, three-dimensional environments, students and general users can both "play" and "study." They may construct a virtual grotto, select correct roof types, identify decorative motifs, or virtually restore damaged architectural sections of murals. Such tasks, framed as puzzles and interactive missions, not only impart knowledge about Buddhist art and architectural styles but also strengthen problem-solving skills and foster appreciation for historical aesthetics (Liu, 2025). The playful immersion of VR environments thus reactivates heritage as a dynamic medium of cultural training, extending the murals' traditional 警世作用 ("warning and instructive function") into digital pedagogy.

At the institutional level, universities are increasingly integrating Dunhuang-inspired creative cultural products into curricula. These include textbooks enriched with mural details, panoramic images, digital museums, and multimedia teaching resources. Courses often feature high-resolution digital reproductions of wall paintings, lectures on painting techniques, and even dynamic presentations of mural replication processes. Exhibitions within universities highlight the stylistic development of mural art across dynasties, while special seminars explore themes such as the intersection of murals with music and dance, or their adaptation in modern design and visual arts (Chong, 2025). Such integration has expanded Dunhuang heritage from a preserved relic to an active cultural resource within higher education, enabling students to experience its history not only visually but also experientially.

The visual narrative function of the murals is particularly significant. They frequently employ serial, almost comic-like structures to depict Buddhist stories—whether the Jataka tales of the Buddha's previous lives, illustrations of Amitabha's Pure Land, or transformation tableaux of the Lotus Sutra. By reconstructing these murals in three-dimensional digital spaces, users can virtually roam within the caves, observing donors' portraits, ritual practices, and cosmic visions of the Pure Land. Zhao (2023) emphasizes that such immersive media convert murals from "static relics" into "dynamic educational media," allowing learners to establish emotional and cognitive connections by situating themselves within simulated Buddhist environments. This expands not only the intellectual grasp of religious philosophy but also strengthens moral reflection through embodied experience.

The public aesthetic perception derived from Digital Dunhuang further illustrates the pedagogical potential of immersive heritage. The project's high-definition images, 3D reconstructions, and interactive navigation allow viewers to zoom into mural details—the serene facial expressions of

Buddhas, the delicate gradations of pigments, or the elegance of brushstrokes. Unlike a passive museum visit, audiences engage in multimodal narratives through textual annotations, audio explanations, and guided interactions. In this process, the aesthetic experience of murals is fused with moral-philosophical learning, enabling reinterpretation of Buddhist concepts such as harmony, compassion, and cosmic order (Chen, 2025). Thus, Digital Dunhuang does not merely conserve; it actively reshapes public understanding of religion and art.

The musical dimension of Dunhuang culture adds another pedagogical layer. Dunhuang songs are characterized by both "rustic simplicity" and "refined delicacy." Their melodies, rhythms, and role-played performances embody regional traditions shaped by desert geography, Silk Road exchanges, and ethnic hybridity. The "Dunhuang Opera Spontaneous Music Class", introduced in schools, exemplifies how local tunes and operatic styles are taught as living traditions rather than antiquated curiosities. By incorporating these elements into classroom activities, educators link music to local identity and historical memory, affirming cultural continuity and safeguarding intangible heritage (Bai, 2023).

Heritage education also extends into hands-on workshops and intangible art training. "Mogao Cave mural copying courses" allow students to practice brush techniques, line drawings, and color mixing directly inspired by original frescoes. Dance and music classes adapt Dunhuang rhythms and movements, while crafts workshops, often led by heritage inheritors, teach mural construction, polychrome sculpture, and embroidery. These activities emphasize not only technical skills but also the ethos of craftsmanship, fostering cultural confidence and identity. As Lian (2024) notes, intangible cultural arts from Dunhuang serve as a "cultural calling card" in international dialogues, symbolizing both local rootedness and global relevance.

Beyond formal education, public engagement strategies ensure that Dunhuang heritage reaches broader audiences. Museums and heritage institutions organize exhibitions, lectures, and cultural exchange activities to disseminate knowledge of the Mogao Caves' history and artistic value. Digital exhibitions, virtual tours, and online platforms further democratize access, enabling audiences worldwide to participate in cultural appreciation. Xu et al. (2024) highlight that sustainable management requires not only technical preservation but also clear policies, cross-departmental collaboration, and resource planning. Public education thus becomes part of the heritage protection system itself, ensuring that audiences are not passive recipients but active interpreters and participants.

Taken together, these initiatives underscore how Dunhuang heritage continues to embody Moral and Didactic Function—a moral and warning function—through diverse contemporary media. From the parable of the Nine-Colored Deer to immersive VR experiences, from academic curricula to community-based music programs, the Mogao Caves transcend their original religious context to become multi-layered platforms for moral instruction, cultural identity, aesthetic education, and social engagement. The historical mandate of Dunhuang art—to guide, to warn, and to inspire—thus finds renewed vitality in the digital era, shaping not only cultural appreciation but also ethical consciousness for future generations.

Heritage Preservation Value of the Mogao Caves

The murals of the Mogao Caves are not merely works of art; they constitute a visual archive of religious doctrine, ritual performance, and cultural memory. One of the most remarkable artistic devices employed in these murals is the synoptic narrative. Within a single frame or adjacent registers, episodes from different points in time are juxtaposed to present an entire causal chain of events in condensed form. Repetition of figures within a single image allows the depiction of progression—such as the Buddha's life stories or episodes from sutras—while occupying minimal pictorial space. Many caves adopted compositional systems that corresponded directly to sutra passages or liturgical sequences, using horizontal registers or square compartments to separate narrative scenes. Distinct visual signifiers such as halos, lotus thrones, or the transmutation of weapons into ashes conveyed divine attributes, causal relationships, and moral lessons. As dynasties shifted and restoration projects were undertaken, the color schemes and stylistic nuances of these murals also evolved, providing an invaluable record of the aesthetic, doctrinal, and technical transformations across centuries (Kong, 2025).

However, this cultural treasure faces unprecedented challenges due to the fragility of its medium. The influx of large-scale tourism threatens to create irreversible damage to both the murals and the cave micro-environments. To mitigate this, the Dunhuang Academy has adopted a strategy of zoning, visitor flow control, and capacity limits. Access to the caves is strictly regulated: visitors must book in advance, and tours are scheduled according to the carrying capacity of each section. This policy

minimizes physical strain on the caves while balancing the demand for cultural access. Complementing these restrictions, digital initiatives such as Digital Dunhuang and Cloud Dunhuang provide virtual access through VR reconstructions, panoramic imaging, and 3D modeling. These platforms allow global audiences to explore the Mogao Caves online, reducing pressure on the physical site while amplifying educational and cultural outreach.

Preservation also relies on continuous environmental monitoring and scientific conservation techniques. Sensors track humidity, temperature, CO_2 concentration, and visitor density to ensure environmental conditions remain within safe thresholds. Preventive conservation is complemented by interventions such as structural reinforcement, consolidation of pigments, and restoration of faded colors. International collaborations, exhibition exchanges, and scholarly publications further extend the preservation mission by integrating advanced technologies with cultural communication. Artistic reinterpretations, educational projects, and contemporary creative practices bring Dunhuang's legacy into dialogue with modern life (Xu, Zhang, Du, & Seong, 2024).

A landmark achievement in digital preservation is the Mogao Caves Panorama Digital Library. Through high-resolution photography, 3D reconstruction, and panoramic stitching, this platform has created an immersive virtual archive of the caves. Users can freely navigate cave interiors, zoom into mural details, and engage with embedded annotations, audio guides, and scholarly commentary. Beyond replicating the physical experience of visiting the caves, the system provides layered interpretive content, enabling a deeper understanding of the murals' religious significance, historical context, and artistic techniques. By transcending geographical and temporal boundaries, the platform democratizes access to Dunhuang's heritage and fosters international cultural exchange. With multilingual support and open access, it marks a crucial transition from "physical protection" to "digital inheritance" (Hu, Ho, & Qiao, 2017).

The Dunhuang VR Museum extends this concept by combining high-fidelity 3D modeling, panoramic video, and multimodal interaction. Visitors equipped with VR headsets can not only visualize the restored hues and textures of murals but also experience the soundscapes of ancient Dunhuang through reconstructed music. Gesture recognition and handheld controllers allow users to "touch" murals, trigger interactive storylines, and follow virtual pilgrimage routes. By simulating the journey of a Silk Road traveler, visitors gradually unlock layers of Dunhuang's artistic and religious world. Such immersive experiences are particularly effective in education, as they inspire curiosity among younger generations while instilling a heightened awareness of heritage conservation. Crucially, VR provides a sustainable alternative to on-site visits, reducing human impact while broadening public engagement (Lu, 2019).

A notable example of this innovation is the reconstruction of Cave 61's Mount Wutai Pilgrimage Mural. Here, 2D mural fragments are combined with 3D-rendered architectural elements to create a hybrid immersive space. Buildings are modeled with authentic geometric depth, while painted figures retain their original flat aesthetic. The integration of concave cave walls, portals, and skyboxes generates a spatial sense of movement. This reconstruction allows viewers not only to observe the mural but to "walk into it," following pilgrims through reconstructed temples, landscapes, and divine encounters. Fragmented pictorial data is thus woven into a coherent narrative, transforming passive viewing into embodied storytelling (Mu, 2024).

High-precision scanning, modeling, and panoramic stitching further ensure the digital immortality of the Mogao Caves. Gigapixel photography preserves the finest pigment particles, cracks, and brushstrokes, while spherical panoramas allow users to rotate perspectives freely. Interactive "hotspots" embedded in the panoramas provide textual explanations, audio commentaries, or related historical materials, enhancing interpretive depth. When displayed on large screens, details such as mudras or miniature narrative scenes can be magnified, allowing both experts and lay audiences to study them in unprecedented detail (Hu, 2015; Hu, 2018).

The Getty Conservation Institute (GCI), in collaboration with the Dunhuang Academy, has developed a systematic conservation framework encompassing mural stabilization, environmental regulation, material analysis, and protective infrastructure. Measures include natural and assisted ventilation systems to reduce humidity fluctuations, filters to minimize dust, and controlled low-intensity lighting to prevent photo-oxidation of pigments. Non-invasive techniques such as X-ray fluorescence (XRF) and infrared spectroscopy are employed to analyze pigments and substrates, ensuring the scientific selection of conservation materials. In cases where micro-samples are extracted,

stability and chemical reactivity tests guide long-term preservation strategies. Structural monitoring of cave walls and pigment adhesion is conducted periodically to evaluate conservation efficacy and optimize future interventions.

Equally important is the integration of "hard energy" and "soft energy" in preservation. While structural reinforcements, chemical stabilizers, and environmental controls constitute the hard energy of conservation, public education, digital communication, and cultural dissemination embody the soft energy. Transparent protective barriers prevent direct human contact with murals, while multimedia installations inform visitors about preservation challenges and cultural values. Visitor routes are optimized to minimize environmental stress, ensuring sustainability of conservation work. This holistic approach reflects a high-dimensional model of heritage protection that unites scientific rigor with public participation and cultural consciousness (Getty Conservation Institute & Dunhuang Academy, 2023).

Through these multilayered strategies—spanning physical conservation, digital reproduction, immersive education, and public engagement—the Mogao Caves stand as a global exemplar of heritage protection. They illustrate how ancient cultural treasures can be safeguarded against environmental and human threats, while simultaneously being revitalized through innovative technologies. This dual focus ensures that Dunhuang's legacy continues to function not only as a religious and artistic treasure but also as a dynamic site of cross-cultural dialogue, technological innovation, and moral education for generations to come.

Appreciation Value of Dunhuang's Mogao Cave Murals

The Mogao Caves murals are not merely artistic decorations; they function as a visual text, narrating Buddhist scriptures, moral principles, and aspects of social life through highly developed pictorial storytelling. This visual text takes form in the so-called bianxiang (transformation tableaux), such as the Amitabha Sutra Transformation and the Lotus Sutra Transformation. These murals unfold the chapters and episodes of Buddhist sutras in sequential frames, much like illustrated storyboards. By arranging complex doctrines into comprehensible narrative scenes, the murals transformed the cave walls into a "visualized scripture." This was particularly powerful in a society where literacy was limited, as even the illiterate masses could grasp the essence of Buddhist teachings by viewing these pictorial renderings. The murals thus operated as a democratized medium of education and spiritual cultivation, bridging textual tradition and visual pedagogy (Kong, 2025).

The visual text of Dunhuang murals was further enriched by a sophisticated symbolic system that carried precise religious meanings. Hand gestures (mudrās) communicated different aspects of the Buddha's teaching and blessing; the lotus throne symbolized purity, enlightenment, and rebirth in the Pure Land; the halo radiating behind Buddhas or bodhisattvas signified divine illumination; while the celestial apsaras (flying deities) embodied joy, offering, and celebratory devotion. Through these symbols, viewers engaged in a process of "visual reading." Eye contact between figures, the positioning of hands, and the structuring of pictorial space guided the audience psychologically into the unfolding sacred narratives. In this sense, the murals functioned as an early form of immersive reading, not unlike today's concept of "immersive storytelling." In some caves, inscriptions or excerpts from scriptures were painted alongside the images, further clarifying the doctrinal points and enhancing the murals' didactic function. Importantly, the composition of the murals followed a religious hierarchy: the central wall often depicted the Buddha or major deities, while surrounding panels included disciples, devotees, or historical scenes, reinforcing both doctrinal centrality and social order.

One illustrative case is Cave 323, built during the early Tang dynasty. Though relatively small, with its front chamber constructed with a flat ceiling and the rear chamber capped with a dome, the cave encapsulates the full richness of Dunhuang mural tradition. High-resolution scanning, three-dimensional modeling, and detailed textual documentation have revealed its layers of meaning. The murals depict Buddhist scriptures and ritual scenes, including central Buddha images, guardian deities, disciples, and celestial beings. Through digital reconstruction, the cave has been transformed into a navigable entry in databases, allowing scholars and the general public to explore its artistic details. Beyond religious worship, the murals function visually as tools for education, imparting moral lessons, cosmological ideas, and cultural values.

With the advancement of digital technology, 3D virtual tours of Mogao Caves like Cave 323 have become central in scholarship, education, and public dissemination. Virtual navigation allows users to rotate perspectives freely, zoom into intricate details, and experience the cave's spatial arrangement. This provides not only aesthetic pleasure but also a deeper sense of proportion, scale, and composition

within the cave space. Scholars benefit by conducting detailed research remotely, while students and global audiences gain opportunities to experience Dunhuang heritage without being physically present. Such platforms demonstrate how virtual heritage effectively integrates research, teaching, and cultural outreach, greatly amplifying the appreciation value of the Mogao Caves (University of Washington Libraries, 2024).

A major innovation in the digital preservation and appreciation of Dunhuang art is the "AI for Dunhuang" project, one of the largest and most comprehensive mural datasets in the world. Containing over 10,000 mural images, it provides resources for training and evaluating restoration models. Through deep learning and computer vision, the project assists in digitally repairing murals damaged by environmental erosion, historical wear, or human interference. By reconstructing missing segments at the digital level, AI contributes to restoring the integrity of these artworks, enabling audiences to appreciate them closer to their original state (Yu et al., 2022).

The dataset also includes 3,455 images covering murals from different historical periods, thereby documenting stylistic evolutions from the Northern Wei through the Sui, Tang, Song, and Yuan dynasties. This provides art historians with a systematic basis for studying the transformation of iconography, techniques, and stylistic conventions across centuries. Furthermore, the dataset contains 6,147 tagged images annotated with attributes such as figures, Buddhist scenes, decorative elements, and color schemes. This allows researchers to quickly retrieve, for instance, all depictions of Avalokiteśvara (Guanyin) or specific transformation tableaux. Such rapid and precise access dramatically improves both the efficiency and the accuracy of Dunhuang studies, moving the field toward data-driven scholarship.

Beyond restoration and research, "AI for Dunhuang" also plays a pivotal role in digital dissemination and education. Its dataset supports the development of immersive experiences using virtual reality (VR) and augmented reality (AR). These technologies enable global audiences to engage interactively with Dunhuang art in museums, classrooms, or even personal devices. At the same time, the initiative fosters cross-disciplinary collaboration among computer scientists, art historians, archaeologists, and scholars of religion, illustrating how cultural heritage preservation increasingly relies on interdisciplinary innovation (Yu et al., 2022; Lian, 2024).

In parallel, the E-Dunhuang panoramic exhibition and virtual navigation platform exemplifies how digital heritage enhances appreciation. Based on 360-degree high-resolution panoramic images, it reproduces the interiors of caves, including murals, sculptures, and architectural layouts, with remarkable fidelity. Through intuitive controls, users can rotate, zoom, and shift their perspective, accessing every detail of the caves. Information layers are integrated into the interface: when clicking a specific area, supplementary annotations, high-definition images, or audio guides pop up. Its logical navigation system enables exploration by historical era, religious theme, or artistic style. The experience is enriched with scholarly commentaries, audio tours, and multimedia references, offering learners multi-sensory understanding.

For instance, while exploring the mural of the Western Pure Land Transformation, the system synchronizes sutra explanations with artistic analysis, helping users grasp both the doctrinal background and stylistic features. Interactive "learning prompts" embedded in the platform pose reflective questions to the viewer, encouraging critical engagement rather than passive observation. As Hu (2018) emphasizes, this platform is not merely a display of cultural heritage but an innovative pedagogical tool, significantly advancing global cross-cultural education in Dunhuang studies.

Together, these initiatives reveal the multifaceted appreciation value of Dunhuang murals. At the artistic level, they exemplify the pinnacle of ancient Chinese religious art, blending narrative clarity, symbolic sophistication, and aesthetic harmony. At the cultural level, they serve as visual scriptures, making Buddhist philosophy accessible to broader audiences across literacy levels and cultural backgrounds. At the technological level, they inspire innovations in digital heritage preservation, AI-based restoration, and immersive education. Finally, at the pedagogical level, they encourage interdisciplinary dialogue, cross-cultural appreciation, and ethical reflection.

Ultimately, the murals' appreciation value lies not only in their visual splendor but in their capacity to connect past and present, text and image, tradition and innovation. Whether viewed within the cave's dim interior, through a panoramic digital interface, or reconstructed via AI algorithms, Dunhuang murals continue to inspire awe, provoke moral thought, and foster cross-cultural understanding. In this sense, the Mogao murals are not only relics of the past but also living texts,

perpetually reinterpreted in the light of new technologies, new audiences, and new educational paradigms.

Commercial Value of the Mogao Caves

The commercial value of the Mogao Caves is not merely a question of economic benefit but rather a multidimensional concept that connects cultural heritage, tourism management, digital technologies, and global communication. In recent years, scholars and practitioners have increasingly examined how frameworks from psychology and consumer behavior can illuminate the mechanisms by which heritage sites generate sustainable cultural and economic returns. Among these frameworks, the Stimulus–Organism–Response (SOR) model has proven particularly relevant for understanding the visitor experience at the Mogao Caves.

The SOR model conceptualizes human behavior as a process in which external stimuli (S) affect an organism's internal states (O), which in turn generate behavioral responses (R). When applied to cultural tourism, this framework explains how visitors' exposure to heritage narratives influences their perceptions and behaviors.

In the case of the Mogao Caves, the stimulus (S) refers to the historical and narrative dimensions of the site: the murals and sculptures, the stories they represent, the evolution of artistic styles, accounts of cross-cultural exchanges along the Silk Road, and the biographies of historical figures associated with Dunhuang. These elements are communicated through exhibitions, guided tours, multimedia platforms, and storytelling techniques that bring the caves to life for contemporary audiences.

The organism (O) represents the visitors' internal cognitive and affective processes. After encountering these narratives, tourists construct mental images of the destination, form evaluations of its cultural and artistic significance, and assign personal value to the experience. This stage mediates between stimulus and response by shaping the overall impression and perceived value of the visit.

The response (R), finally, manifests as behavioral outcomes such as satisfaction, willingness to recommend the site, or the intention to revisit. Crucially, the decision to return—or to advocate for the site through word-of-mouth—depends on how strongly the stimuli (narratives, visual impressions, cultural depth) translate into perceived value and emotional attachment. Research suggests that by carefully curating historical storytelling and emphasizing cultural symbolism, heritage managers can enhance destination image and foster long-term visitor loyalty (Yuxin, 2024).

The SOR framework highlights the importance of stimuli, but in practice, heritage managers must also consider how these stimuli are framed and communicated. Here, the concept of impression management becomes crucial. Impression management refers to the deliberate control of information and imagery by institutions to shape public perception. For the Mogao Caves, impression management is both a branding strategy and a heritage preservation paradigm.

Digital media plays a central role in this process. High-resolution mural photography, before-and-after restoration comparisons, and detailed images of motifs such as apsaras or Buddha figures are disseminated via platforms such as Weibo, WeChat, Facebook, and Twitter. These visual materials are often accompanied by explanatory texts—short essays explaining the symbolic meaning of particular figures, online lectures on Buddhist art, or video documentaries of conservation work. Social media hashtags invite visitors to share their experiences, while livestreams and VR/AR virtual tours offer behind-the-scenes access to conservation laboratories or immersive explorations of cave interiors.

Through such strategies, the Mogao Caves are presented not only as a tourism destination but also as a transparent, living institution of cultural preservation. Visitors perceive conservation efforts as open and participatory, which strengthens trust and public engagement. Moreover, by highlighting restoration processes and academic research, impression management communicates that Dunhuang is not only a site of visual splendor but also a locus of scientific rigor and cultural responsibility.

The integration of impression management with social media has generated a new form of digital heritage marketplace. On platforms like Weibo and WeChat, the Dunhuang Academy and affiliated institutions continuously release updates about Digital Dunhuang, online exhibitions, and conservation results. Three distinct dimensions can be identified in this communication strategy:

1. Aesthetic orientation: By emphasizing mural colors, composition, and artistic beauty, digital content appeals to the public's sense of visual appreciation, reinforcing Dunhuang as an unparalleled art treasury.
2. Academic authority: Through online lectures, digital catalogues, and scholarly exhibitions, the site projects an image of intellectual seriousness, encouraging the public to recognize its heritage value

beyond mere tourism.

3. Narrative intimacy: Storytelling, user-generated content, and shared visitor experiences foster emotional closeness between the site and its audiences. By inviting participation and encouraging dialogue, Dunhuang establishes itself as part of personal and collective identity.

In international communication, managers emphasize the Mogao Caves as a "shared heritage of humanity" rather than overemphasizing national identity. This inclusive framing enables global audiences from diverse cultural backgrounds to establish emotional resonance with the site, thereby enhancing its international cultural capital (Jinsha, 2025).

The commercial success of heritage tourism inevitably brings challenges: overcrowding, environmental risks, and concerns about authenticity. Effective impression management must therefore include crisis communication. Proactive responses to visitor complaints, concerns about mural damage, or reports of environmental degradation are crucial for sustaining credibility. For example, when issues arise, official platforms often feature interviews with conservation experts or site managers, providing transparent explanations that reassure the public.

This strategy is reinforced by multilingual outreach. Tweets, posts, and videos in English, Japanese, and other languages highlight Dunhuang's role in Silk Road cultural exchange, positioning it as a bridge between civilizations. By monitoring metrics such as traffic volume, likes, shares, comment sentiment (positive vs. critical), and follower growth, managers can evaluate the effectiveness of impression management strategies and adjust communication policies accordingly.

Beyond descriptive communication, the commercial value of Dunhuang is increasingly linked to big data analytics. Scholars have begun to retrieve and clean social media data—for example, Weibo posts and comments containing the keyword "Digital Dunhuang." After removing noise and stopwords, high-frequency terms are analyzed to construct co-occurrence networks. Findings reveal that words such as "cultural art," "virtual experience," "technology," and "heritage protection" frequently appear alongside "Digital Dunhuang," indicating strong associations with innovation and cultural appreciation. In contrast, terms like "restoration," "environmental monitoring," or "conservation management" appear less frequently, suggesting that while the public values digital visualization, technical conservation is less visible in discourse (Liu, 2025).

Sentiment analysis further demonstrates that most online discussions are positive or neutral, with users praising the immersive experiences and cultural dissemination achieved through digital platforms. This indicates that digital heritage communication enhances not only visitor experience but also brand equity, which in turn strengthens the site's commercial sustainability.

Toward a Sustainable Commercial Strategy

The commercial value of the Mogao Caves thus lies in its capacity to integrate heritage preservation, tourism development, and digital communication into a coherent system. By combining the explanatory power of the SOR model with impression management strategies and data-driven insights, Dunhuang demonstrates how heritage sites can balance economic sustainability with cultural authenticity.

The final step in this process is adaptive policy-making. Feedback from media platforms—traffic flow, likes, shares, comment quality, and sentiment trends—enables managers to adjust commercial strategies in real time. For example, if user data indicates high interest in virtual exhibitions but concern about on-site overcrowding, the institution can prioritize investments in VR development while tightening physical visitor limits. Similarly, if international audiences respond more positively to narratives of cultural exchange than to nationalistic framing, managers can recalibrate their communication accordingly.

CONCLUSION

The Mogao Caves illustrate that commercial value in heritage contexts is not synonymous with commodification. Rather, it represents the sustainable circulation of cultural meaning, educational engagement, and economic return. Historical narratives function as stimuli that shape visitor impressions and perceived value; impression management strategies enhance the site's image and emotional connection; and digital analytics provide feedback loops for continuous adaptation.

In this sense, Dunhuang's commercial value emerges as an intersection of heritage, education, and commerce. By leveraging digital technologies, storytelling, and participatory communication, the site transforms itself into a global cultural brand while safeguarding its fragile treasures. As digital

platforms evolve and audiences diversify, the Mogao Caves will continue to stand as a model for how cultural heritage can be both preserved and reimagined for the future.

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