

## Research on Optimization of the Signage System of the Potala Palace Scenic Area in Tibet

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### ABSTRACT

Based on grounded theory, this study systematically analyzes the current status and challenges of the Potala Palace signage system in terms of its orientation, cultural transmission, and user experience. Through interviews with visitors, management personnel, and design experts, a three-stage approach using open coding, principal axis coding, and selective coding was employed to extract 73 concepts and 24 categories, which were summarized into three core dimensions: "Signage Status," "Signage Evaluation," and "Signage Optimization." The results indicate that the existing signage system has significant deficiencies in spatial coverage, cultural expression, multilingual adaptability, material weather resistance, and digital experience. To address this, this paper proposes systematic improvement strategies encompassing spatial layout optimization, deep depiction of cultural symbols, expansion of multilingual services, and integration of digital technologies. A practical and transferable optimization model is constructed, providing a theoretical basis and practical reference for upgrading the signage system of plateau cultural heritage sites.

**Contribution/Originality:** This study contributes to the existing literature by systematically analyzing the Potala Palace signage system using grounded theory. It is one of very few studies which have investigated cultural heritage signage optimization in a high-altitude context and documents a transferable theoretical model integrating functionality, cultural transmission, and visitor experience.

## 1. Introduction

The Potala Palace, located in Lhasa, Tibet Autonomous Region, China, is a symbol of Tibetan history and culture and a UNESCO World Heritage Site. Built in the 7th century AD as the royal palace of the Tubo Dynasty, it later became a religious center of Tibetan

Buddhism. Its unique architectural style, a fusion of traditional Tibetan culture, Buddhist art, and unique Tibetan religious symbols, not only bears witness to Tibetan history but also embodies the wisdom and artistic achievements of the Tibetan people. The Potala Palace's cultural significance and historical significance have made it a focal point for tourists and scholars worldwide.

As a significant cultural heritage site, the Potala Palace attracts a large number of domestic and international tourists. However, with the increasing number of visitors, the management and service of the Potala Palace face greater challenges. Providing a better visitor experience while preserving the uniqueness and historical value of this cultural heritage has become a core issue that needs to be addressed. Signage systems, as a key component of scenic area management, play a crucial role in improving visitor efficiency and cultural identity (Ruan et al., 2016). Signage design is particularly crucial in cultural heritage sites, as it not only needs to meet functional requirements, such as providing clear directions, but also convey the cultural connotations of the scenic area, helping visitors understand its history and cultural context (Shizhu et al., 2024).

The design of a scenic spot's signage system should be culturally relevant, conveying the site's core values and cultural significance through symbols, text, and patterns (Wu et al., 2025).

Although the signage system at the Potala Palace scenic area already provides a certain level of orientation, its shortcomings have gradually become apparent with the increasing number of visitors and the growing demand for cultural displays. First and foremost, the most prominent issue facing the existing signage system is its lack of functionality. While existing signs can guide visitors to major attractions, guidance between remote areas and scenic spots is unclear, leaving visitors frequently disoriented and lost. This issue not only impacts the visitor experience but also potentially affects visitor satisfaction and the scenic area's reputation.

Secondly, the existing signage system also has significant shortcomings in terms of cultural communication. As a historical heritage site steeped in cultural and religious significance, the Potala Palace's signage system fails to fully incorporate its profound cultural connotations and religious background. Existing signage primarily focuses on basic information transmission, neglecting how to effectively convey the Palace's cultural and historical significance through design elements such as symbols, colors, and patterns. Propose that signage systems are not only tools for directional guidance but also carriers of culture, enhancing visitors' understanding of the scenic area's culture through visual symbols (Shizhu et al., 2024). Regarding the visitor experience, the existing signage system also suffers from issues with readability and visibility. Some signs have small text and lack color contrast, making them difficult for visitors, particularly the elderly and foreigners, to read. Furthermore, while the Potala Palace signage system offers signs in Tibetan and Chinese, the existing language options are insufficient for visitors who speak other languages, such as English and Japanese, making it difficult to meet the needs of international tourists (Sha, 2025).

The existing signage system at the Potala Palace scenic area leaves much room for improvement in terms of functionality, cultural expression, and visitor experience. The core question of this study is how to optimize the signage design to not only enhance its functionality and aesthetics but also better showcase the unique charm of the Potala Palace through cultural expression.

## 1.1. Research Objectives

The core objective of this study is to systematically analyze the signage system of the Potala Palace scenic spot through the grounded theory, to identify its deficiencies in functionality, cultural transmission and visitor experience, and to propose reasonable optimization strategies. Specifically, this study aims to comprehensively examine the current design status of the existing signage system of the Potala Palace from the perspective of grounded theory, assess its deficiencies in terms of orientation, efficiency of information transfer, depth of cultural communication and visual design, and construct an optimization framework accordingly.

The objectives of this study specifically include the following:

- i. Assess the current situation of the signage system in the Potala Palace scenic area
- ii. Identify the deficiencies of the existing signage system of the Potala Palace in terms of functionality, cultural expression and visitors' experience, including the visibility, legibility, cultural transmission of the signage system, as well as its effectiveness, through interviews.
- iii. Propose optimization strategies based on grounded theory. Combining the cultural background, visitor needs and design aesthetics, through the coding process of grounded theory and in-depth analysis of the data, a feasible optimization strategy is proposed to ensure that the signage system enhances the visitors' orientation experience while better transmitting the cultural and historical values of the Potala Palace.
- iv. Constructing the grounded theory Framework. Based on the three-stage coding (open coding, axial coding and selective coding) of the grounded theory, the optimization theoretical framework applicable to the signage system of cultural heritage scenic spots is constructed, and theoretical support and methodological guidance are provided for the optimization of signage systems in similar scenic spots.

Through the realization of the above objectives, this study aims to fill the research gap in the existing literature on the optimization of signage systems in cultural heritage scenic spots, and to provide practical and theoretical support for the design of signage systems in the Potala Palace and other similar cultural heritage scenic spots.

## 1.2. Research Questions

In order to accurately implement the above research objectives, this paper proposes the following three progressive research questions based on the logical chain of "current situation diagnosis - method adaptation - cultural integration" of the Potala Palace scenic area sign system:

- i. What specific and key problems exist in the current Potala Palace scenic area sign system in the three core dimensions of guidance function, cultural transmission and tourist experience?
- ii. How to systematically analyze the problem data of the sign system through the three-stage coding of grounded theory (open coding, main axis coding, selective coding) and build an operational optimization framework?
- iii. In the unique context of the Potala Palace's "Tibetan Buddhist Culture + Plateau Heritage", how can we achieve a deep integration of the sign system and cultural elements (rather than superficial symbol stacking) through symbols, colors, images, and digital technology?

## 2. Literature Review

### 2.1. Overview of grounded theory

Grounded Theory (GT) has become one of the most influential theory generation methods in the field of qualitative research since it was first developed by Glaser and Strauss in the 1960s and generate theories (Mohajan & Mohajan, 2022).

#### 2.1.1. Basic Concepts and Methods of grounded theory

The analytic process of grounded theory is centered on a three-stage coding system, including Open Coding, Axial Coding and Selective Coding (Shrestha, 2025).

##### i. Open Coding

Open coding is a meticulous, sentence-by-sentence (line-by-line) analysis of the raw data, breaking down the data into separate conceptual units, assigning labels, and categorizing preliminary phenomena. This stage emphasizes maximizing the data's connotations and ensuring that theory and reality are closely aligned (Charmaz & Thornberg, 2021).

##### ii. Axial coding

Based on open coding, axial coding aggregates preliminary concepts into master categories by comparing, integrating, and correlating them to further sort out attributes, dimensions, conditions, and causal relationships among categories. This stage helps to reveal the structural logic and dynamic mechanisms behind the phenomena (Vollstedt & Rezat, 2019).

##### iii. Selective coding

Selective coding focuses on the core categories and their relationships with other categories, and integrates theories around the main phenomena, ultimately forming a theoretical framework that can explain the object of study. This stage requires constant backtracking of data to ensure theoretical saturation and refinement of the model (Vollstedt & Rezat, 2019).

grounded theory emphasizes the principle of theoretical saturation, which means that a theory is considered saturated and highly explanatory if no new categories or theoretical relationships emerge during the ongoing data collection and analysis process (Nelson, 2017).

### 2.2. Applicability and research value of grounded theory

The unique advantage of grounded theory lies in its strong theory generation power and high adaptability, which makes it particularly suitable for exploratory research in theoretically weak, emerging, or interdisciplinary fields (Nelson, 2017). Specifically, grounded theory demonstrates excellent applicability in the following areas:

### *2.2.1. Theoretically Under-Constructed Areas*

Grounded theory provides pathways for theoretical innovation in areas lacking authoritative theories or well-established models, e.g., cultural heritage management, tourism experience, user behavior, health care, etc. (Nelson, 2017).

### *2.2.2. Deep Description of Dynamic and Complex Phenomena*

Through continuous comparative method and theoretical sampling, grounded theory is able to grasp the dynamics, process, and multiple interactions behind social phenomena, which is well suited to study the real-world situation of complex systems interacting with multiple subjects (Timonen et al., 2018).

### *2.2.3. Interdisciplinary Application Ability*

Grounded theory has achieved wide application and methodological innovation in sociology, management, education, information systems, design, and other fields. In recent years, grounded theory has provided new perspectives for theory development and practice innovation in qualitative exploration in the fields of cultural heritage protection and tourist attraction signage design and optimization (Charmaz & Thornberg, 2021).

### *2.2.4. Integration of Theory and Practice*

Grounded theory not only generates descriptive concepts, but also focuses on the generalization and explanation of operational theories, which is important for guiding practical work and policy formulation (Chun Tie et al., 2019). For example, for cultural heritage tourism and scenic area signage systems, researchers analyze tourists' needs, cultural perception, and spatial cognition patterns through grounded theory, which provides theoretical basis and practical inspiration for scenic area management optimization, signage system innovation, and cultural inheritance (Chen & Pan, 2025).

## **2.3. Current status of the application of rootedness theory in the field of tourism and cultural heritage**

In recent years, grounded theory has shown great theoretical vitality and practical value in the fields of tourism management, heritage site interpretation, user experience, and spatial design (Hussein et al., 2020). Especially in the fields of signage systems, visitor experience at heritage sites, and cross-cultural information transfer, grounded theory not only helps to discover the real needs and behavioral patterns of tourists but also provides a theoretical framework for the optimization of signage systems, cultural information transfer, and innovative practices of digital experience design (Hussein et al., 2020).

Studies have shown that adopting the research method of grounded theory helps scenic spot managers to understand the real confusion of tourists in terms of information access, path selection, and cultural identity, and adjust the signage design and information organization mode accordingly to achieve the optimal balance between functionality and culture, personalization and universality (Jiang et al., 2025).

## 2.4. Research Status of Tourist Attractions Signage System

### 2.4.1. Research progress of domestic and foreign scenic spot signage system

As an important infrastructure for tourism service and management, the signage system of tourist attractions—its functionality, legibility, and cultural transmission ability—has become a hotspot of cross-disciplinary research in tourism management, environmental behavior, information design, and other disciplines in recent years (Ko, 2025).

Scholars both at home and abroad generally agree that a high-quality scenic area signage system plays an irreplaceable role in enhancing tourists' experience, safeguarding the order of the scenic area, and promoting the image shaping of tourist destinations (Zhang, 2021).

#### a) Functionality and Legibility Research

Functionality research mainly focuses on the information instruction, spatial navigation, and safety management roles of signage systems. An effective signage system should cover multiple functions such as directional guidance, information prompts, warning instructions, etc., to help tourists efficiently obtain the required information and make correct decisions in the complex scenic environment (Wan, 2024).

Readability research focuses on the intuitiveness of information expression, the legibility of graphic design, and multilingual adaptability (Suzuki & Heo, 2022). In recent years, multilingual signage systems, internationalized graphic symbols, and color contrast optimization have gradually become an important means of enhancing scenic accessibility and service quality, especially widely used in World Heritage Sites and internationally renowned tourist destinations (Wan, 2024).

#### b) Research on Cultural Transmission and Identity

In recent years, the function of the signage system as a medium for the interpretation of cultural landscapes and the dissemination of heritage values has received more and more attention (Salerno, 2023). Domestic scholars emphasize that the signage of scenic spots is not only the "first point of contact" in tourism services but also an important field for cultural confidence and value expression (Zhang, 2021).

Overseas studies have focused on the function of signage in translating cross-cultural information in different cultural contexts, emphasizing that visual language, symbols, and historical narratives help tourists from different backgrounds understand local culture and improve their sense of cultural closeness and identity. With the development of intelligent and digital design tools, new scenic area signage systems, such as interactive signs and AR guides, have been gradually promoted in Europe, America, and East Asia, greatly enriching the level of information delivery and forms of cultural expression (Shizhu et al., 2024).

### 2.4.2. Cultural significance of signage systems

The cultural significance of signage lies in its ability to serve as a tangible vehicle, directly reflecting a scenic area's historical and cultural heritage, ethnic characteristics, and values (Utami & Kharisma, 2025). Research has found that excellent signage systems, through

design elements such as fonts, colors, symbols, and images, convey the scenic area's unique cultural ambiance and historical narratives, thereby stimulating visitors' emotional resonance and cognitive interest (Zhang, 2021). In World Heritage and ethnic cultural sites, signage also serves the functions of "cultural interpretation" and "meaning generation." By cleverly incorporating local cultural symbols, folk totems, and religious imagery, signage not only helps visitors identify the space but also inspires exploration and respect for the scenic area's deeper culture (Wu et al., 2025). In recent years, academics have also called for signage systems to balance modern design standards with local aesthetic traditions, avoiding an imbalance between "internationalization" and "localization," and ensuring accurate cultural transmission and a sense of identity among visitors (Utami & Kharisma, 2025). Research on Chinese cultural heritage sites such as the Potala Palace, the Forbidden City, and the Old Town of Lijiang points out that only by combining local history and national spirit with modern information design can a signage system with both functionality and cultural significance be created, achieving the dual goals of heritage protection and tourism development (Shizhu et al., 2024).

## 2.5. Existing Research on Signage Design of Potala Palace Scenic Spot

As a representative cultural heritage site in China and even globally, the Potala Palace's signage design has garnered significant attention from both academic and industry circles. In recent years, with the surge in heritage tourism and the increasing diversity of visitor demands, the function and cultural value of the Potala Palace's signage have become a focus of research across multiple disciplines, including tourism management, environmental behavior, and visual communication (Deri et al., 2023).

### 2.5.1. Inadequate cultural expression and symbolic transmission

Existing research generally indicates that the Potala Palace's signage system still lacks significant cultural expression and in-depth interpretation. While some signs incorporate traditional Tibetan symbols and Buddhist elements, most designs remain superficial, lacking a systematic narrative of the Potala Palace's historical, religious, architectural, and spiritual core (Vetter, 2020). Visitors often only gain a superficial impression, struggling to gain a deep understanding of the Potala Palace's cultural context through the signage system. Furthermore, the monotony of cultural narratives and the homogenization of visual symbols diminish the uniqueness and cultural communication power of the scenic area's signage (Utami & Kharisma, 2025).

### 2.5.2. Functionality and Limitations of Information Transfer

Functional design is also the important short board of the Potala Palace signage system at present. Some studies have found that the signage layout lacks scientific spatial logic and navigation network, the information level is not clear, and tourists are prone to get lost and miss visiting points during peak hours. At the same time, the signage system lacks in multi-language adaptation, the friendliness of the elderly and international tourists, and the universality and inclusiveness of the information transfer is insufficient to meet the development trend of globalized tourism (Wan et al., 2022).

### 2.5.3. Deficiencies in visual design and digital innovation

At the visual design level, the existing Potala Palace logo generally exists in small font, color contrast is weak, indicative symbols recognition degree is not high. In addition,

compared with the international first-class heritage scenic spots, Potala Palace lags behind in the development of intelligent and digital signage applications, and has not yet realized interactive and multimedia experiences based on mobile Internet, AR guides and other technologies, making it difficult to meet the needs of the new generation of tourists for immersive information experiences (Koo et al., 2019).

#### *2.5.4. Optimization trends and future directions*

Academia and industry generally advocate a systematic optimization approach guided by 'deep cultural description + service experience.' This includes strengthening cultural narratives, building scientifically guided networks, introducing multimedia and multilingual technologies, and organically integrating digital innovation with traditional aesthetics to achieve a synergistic improvement in heritage preservation and tourism services (Khater et al., 2025). Future research should integrate more data on visitor perceptions and behaviors, employing qualitative methods such as grounded theory, to delve deeper into visitors' underlying needs and motivations for cultural experience, thereby promoting the iterative upgrade of scenic spot signage systems towards intelligent, user-friendly, and culturally relevant approaches.

### **3. Research design**

#### **3.1. Research methodology**

Grounded Theory (GT) is a systematic qualitative research method that aims to develop a theoretical framework from empirical data through inductive analysis (Chun Tie et al., 2019). Unlike traditional theory-verification methods, grounded theory emphasizes starting from the data to discover underlying patterns and theories. This gives it unique advantages in exploratory research, understanding complex phenomena, and theoretical innovation (Sharma et al., 2022).

This study employed a grounded theory approach to conduct an in-depth analysis of the Potala Palace signage system, identify areas for improvement, and propose practical improvement strategies for signage design. Grounded theory's three-stage coding process (open coding, axial coding, and selective coding) provided strong theoretical support for this study, helping researchers analyze the current status and challenges of the scenic area's signage system from multiple perspectives and ultimately constructing a practical optimization framework.

#### **3.2. Data collection methods**

In this study, the data collection method was designed and semi-structured interviews were conducted according to the research objectives. The interview outline was developed after based on relevant literature and revised and completed after pre-interviews with three tourists. The interviews were completed independently by the authors who have experience in qualitative research and mastered certain interviewing techniques. The interviews were preceded by communication with the study participants, who were given an informed consent form detailing the purpose, content and methods of the study. The research subjects were informed that the study would be strictly voluntary and confidential, and that they had the right to withdraw and terminate at any time during the interview. Interview data were anonymized and numbered to protect the privacy of the participants. Interviews were conducted in a separate, quiet office with a prior

appointment, and were recorded with a tape recorder after obtaining the consent of the interviewee; each interview lasted 30-60 min, and when 15 people were found to have produced no new valuable information, the interview was continued with 7 people as a theoretical saturation test.

### *3.2.1. Sampling strategy: theoretical sampling*

This study employed theoretical sampling as its primary sampling strategy, aiming to dynamically select samples based on the research's analytical needs, ensuring that the sample complements or challenges existing theoretical concepts, thereby advancing the depth of the research and theoretical refinement (Ligita et al., 2020). Unlike traditional random sampling, theoretical sampling emphasizes flexible adjustments to sample selection based on the coding process of grounded theory. This approach allows for the selection of respondents who can delve deeper into new questions or expand existing theories based on the results of preliminary analysis.

In this study, theoretical sampling was implemented as follows:

A total of 22 relevant personnel were interviewed in this study, including 4 art directors, 3 Potala Palace scenic area managers, 5 tourism experts and scholars, 5 visual communication designers and related experts, and 5 tourist representatives to ensure the diversity of the sample and the theoretical saturation of the research.

Three Potala Palace scenic area managers: Scenic area managers were directly involved in the design and implementation of the signage system and are key personnel in its operation. Interviewing scenic area managers provided insights into the actual operational performance of the signage system, including its effectiveness and feedback from visitors (Zhang, 2021). Managers also provided firsthand data on visitor behavior, helping researchers understand the challenges and issues of signage operation, such as balancing functional design with visitor experience.

Five tourism industry experts and scholars: These tourism industry experts and scholars possess extensive industry knowledge and academic backgrounds, enabling them to analyze the design trends and development directions of the Potala Palace signage system from a macro perspective. Their perspectives contribute to understanding the positioning of scenic area signage within global tourism trends, particularly regarding best practices in signage design for cultural heritage sites.

Five visual communication designers and experts in related fields: Visual communication designers are responsible for integrating functionality and aesthetics in signage design, ensuring that signage not only provides orientation but is also visually appealing (Zhou et al., 2024). They can provide research on how to effectively incorporate cultural elements of the Potala Palace into signage design to enhance cultural communication. The involvement of designers will contribute to research on how visual design can enhance the visitor experience and make signage more appealing and accessible.

Five scenic area visitors and representatives of target tourist groups: Scenic area visitors are the ultimate users of the signage system, and their feedback is a key component in evaluating the effectiveness of the signage system. By interviewing scenic area visitors, researchers were able to gather direct feedback on the signage system's visibility, understandability, and wayfinding function (Su et al., 2022). Furthermore, visitors'

cultural awareness and understanding can help evaluate the cultural transmission effectiveness of the signage system and provide design references tailored to the needs of tourists from diverse cultural backgrounds.

The advantage of theoretical sampling is that it can dynamically adjust sample selection, ensuring comprehensiveness and depth of data, and promoting theoretical development in research (Ligita et al., 2020). By drawing on feedback from diverse groups of respondents, this study was able to conduct a comprehensive analysis of the Potala Palace signage system from multiple perspectives, providing more precise recommendations for optimization.

### *3.2.2. Interview method: semi-structured interviews*

This study utilizes a semi-structured interview methodology that aims to guide interviewees through open-ended questions for in-depth discussion. Semi-structured interviews provide flexibility and allow the researcher to adapt the questions at the right time based on the respondents' answers in order to dig deeper into the respondents' perspectives and experiences (Ruslin et al., 2022). This approach is particularly suitable for grounded theory research as it allows the researcher to discover new concepts during the data collection process and provides primary sources for subsequent theory building. The interview guide was designed around the following core dimensions:

**Accessibility and legibility:** whether visitors are able to quickly understand what the signage system is indicating, and whether there are any difficulties in understanding or getting lost.

**Cultural transmission:** the effectiveness of the signage system in conveying the cultural background, history and religious connotations of the Potala Palace, and whether visitors are able to feel the cultural depth of the Potala Palace from the signage.

**Visitor experience:** the overall experience of visitors when using the signage system, whether the signage system improves the efficiency of visitors' visit, and whether it generates positive emotional feedback to visitors.

These questions were refined during the pre-testing phase to ensure the clarity and relevance of the question design so that it could cover all dimensions of the optimization of the signage system in the Potala Palace scenic area.

### *3.2.3. Interview implementation process*

The data collection process began in March 2025 and continued through June, totaling three months. Interviews were conducted using a combination of online and offline methods, depending on respondents' preferences and availability. Face-to-face interviews were conducted mainly in Lhasa, Wuhan, Beijing and Guangzhou, the cities where the Potala Palace is located, while online interviews were conducted with participants from other regions through a secure online meeting platform. This approach not only ensured maximum sample coverage, but also guaranteed interview quality and efficient communication. Each interview lasted approximately 30 to 60 minutes, and all interviews were audio-recorded with the consent of the interviewee and transcribed into text using transcription software. All audio recordings and transcribed text will provide primary data to support the subsequent analysis of grounded theory. Interviews were

conducted using open-ended questions to ensure that interviewees were able to express their views freely and thus obtain detailed feedback.

#### *3.2.4. Data recording and transcription*

All interviews were fully audio-recorded to ensure the completeness and accuracy of the data. Interview recordings were transcribed immediately after each interview and the original words of the interviewees were strictly retained to ensure the authenticity and reliability of the data. The transcribed text will retain the original context of the interview, including details such as tone of voice and emotional expression. To ensure accurate transcription of the data, the research team used high-quality transcription software and proofread the transcribed text several times. During the interview transcription process, the researcher ensured that the linguistic style, emotional expression, and cultural context of all interviews were fully reflected. The transcribed data will be systematically analyzed according to the open coding stage of grounded theory to identify key concepts and themes that influence the signage system of the Potala Palace scenic area.

### **3.3. Data analysis methods**

All interview data were systematically organized in the form of audio recordings and transcribed texts and analyzed in conjunction with the three-stage coding method (open coding, axial coding, and selective coding) of Zagan's theory. The open coding stage will initially extract key concepts, axial coding categorizes these concepts and identifies relationships between them, and selective coding integrates the core categories to construct a comprehensive framework for optimizing the marking system. This process provides systematic theoretical support for this study and promotes the signage system of the Potala Palace scenic area. Rooted theoretical data collection and analysis were conducted in parallel, with preliminary analysis of the information from each interview to adjust the interview outline in a timely manner. Within 24 h after each interview, the researcher converted the audio recordings into an initial script to form textual data. The coding process was conducted using manual coding combined with Nvivo 14.0 software. The data analysis process was conducted by writing a reflective memo to ensure as much objectivity as possible in the interpretation of the data. Optimizing the construction of the theoretical framework.

## **4. Data analysis and coding**

### **4.1. Open coding**

During the open coding phase, the research team analyzed the text of interviews with 22 interviewees, including tourists, scenic area managers, and design experts (data source: semi-structured interview transcripts from the Potala Palace Scenic Area from March to June 2025). They analyzed each sentence's semantics and extracted key information. Ultimately, they identified 73 initial concepts (such as "basic path guidance," "religious etiquette reminders," and "sun resistance"). Through concept clustering, these concepts were integrated into 24 categories (such as "way signs," "behavioral signs," and "material durability"), covering core dimensions such as sign function, user experience, cultural expression, and environmental adaptation. The specific correspondence between these initial concepts and categories is shown in [Table 1](#).

Table 1: Open coding

Text Extract	Initial Concept	Scope
Base orientation indicators.	a1 base path orientation	A1 Guiding Signs
At the beginning of entering the Potala Palace place, there is a general plan of the scenic area, and for example, like a fork in the road, it will have a sign to indicate.	a2 overview and fork in the road guide	
You, for example, in some of our rest areas, including toilets, including some entrances and exits. The signage is still relatively clear.	a3 Service Node Guidance	
Then there is also a scenic that place, it will have an explanation of the sign.	a4 Scenic Spot Explanation Board	
Then there is a part of the explanation about us is a part of the electronic explanation with a QR code.	a5 electronic explanation code	A2 information sign
A general introduction to a character on Buddhism.	a6 character background introduction	A3 Behavioural signs
There will be reminders, such as you enter the Potala Palace inside to remove the hat, to remove sunglasses, this kind of tips.	a7 Religious etiquette tips	
That's really too much, the first one above the guide is the sign that prohibits taking photos, to use it, right? You must be, this is one that also has a generic sign that everyone can see, which I don't know if there is a sign for taking off your hat.	a8 Taboo Behaviour Reminder	
There should also be, because some some about some religious places, to have some. And then there's the don't use your fingers kind of thing.	a9 Photography restriction signs	
Generally, there are signs that prohibit photography.	a10 main road signs coherent	A4 Main Road Coverage
Now is probably is after I went to the Potala Palace, feel the road is marked.	a11 Main road coverage is sufficient	
Basically, it can cover the main routes of the tour.	a12 corner setting is perfect	
I think it is covered to every place corner, what will have obvious signs.	a13 Lack of signage on paths	
There's still a lot of those little places actually. No, what, can't actually see much of any of those little places, and then they don't have any signs, so they don't pay much attention to it.	a14 Sparse signage in isolated areas	A5 Lack of signage on the slip roads
For example, some of the places where there is no open space, or some of the places where people seldom go over, it's a signage density arrangement is not so proper.	a15 Signs are easily covered	A6 Cultural Orientation
Some signs are hidden in places that are less likely to be noticed.	a16 Guiding cultural awareness	
I think these design concepts of the Potala Palace are definitely intended to guide our visitors to deeply understand the cultural connotation of the Potala Palace.		

<p>I want to explore the Potala Palace, that is, all the traditional culture related to the Potala Palace.</p>	<p>a17 Showing the traditional heritage</p>	
<p>So its logo in the design, including the setting contains some of the Tibetan cultural elements in it. For example, trace, such as text and its colour.</p>	<p>a18 Integration of national symbols</p>	
<p>...</p>	<p>...</p>	<p>...</p>
<p>... The overall structure or what it is. That is, since I have opened it up as an attraction, then uh, the proper signage needs to be there. But still can't destroy some of its overall ecology, should I think ecological band BR, other unimportant unimportant.</p>	<p>... ... a62 Landscape Coherence</p>	
<p>I feel a bit out of place if it is placed inside.</p>	<p>a63 Environmental integration</p>	<p>A21 style unity</p>
<p>Then again unity I would like to be able to see me walk in from the outside, all the signs are the same, that is, do not say that the outside is this, the inside is that is he is going to be to cut off the type of thing. But I obviously the whole scenic area it is a holistic, we can do the logo also style unification, can reflect our professionalism.</p>	<p>a64 system visual unity</p>	
<p>Like the more traditional Tibetan colours as the main tone, and then look are more harmonious. You don't look so ugly, with a certain degree of this aesthetic.</p>	<p>a65 colour harmony a66 Appearance aesthetics</p>	<p>A22 aesthetic harmony</p>
<p>It is having fine lines and unique colour presentation. It can increase that artistic feeling we have about the logo.</p>	<p>a67 Artistic expression</p>	
<p>But if used for a period of time, for example, after a long period of summer sunshine, then the sun will certainly appear damaged.</p>	<p>a68 sun resistance performance</p>	
<p>Can go one is to replace its material, so that it has a certain resistance to high temperature, that is, resistance to its day and night temperature difference of this change.</p>	<p>a69 Temperature difference resistance</p>	<p>a23 material durability</p>
<p>Our ordinary materials are prone to fading, aging, or brittle when pressed, affecting its clarity and service life.</p>	<p>a70 Anti-aging ability</p>	
<p>Then when you are in this mainland of ours, you don't need to apply sunscreen, ultraviolet rays are very strong, after you get over here, it's this skin may have a certain amount of this burning, is or some of this to these signage systems of ours, and also surely also need to go to some of this kind of a protection.</p>	<p>a71 Ultraviolet resistance</p>	<p>A24 Climate Adaptation</p>
<p>Let's say it's raining or snowing, it's going to cause the lettering on ours to wear off or something like that.</p>	<p>a72 Rain and snow resistance</p>	

In the summer, we have heavy rain and strong winds, and I think it's important to take these environmental factors into consideration for our signage needs. To make sure that we are able to use it in all bad conditions. When we are travelling, it will increase the demand for this signage system during the peak season.

a73 Responding to extreme weather

## 4.2. Axis Coding

Based on the 24 categories derived from open coding, the logical connections between categories were analyzed using the constant comparison method (for example, "way-signage," "information signage," and "behavioral signage" all belong to the basic component types of the sign system and can be integrated into the principal category of "type composition"). Ultimately, the 24 categories were summarized into 10 main categories, which were further clustered into three core categories: "Signage Status," "Signage Evaluation," and "Signage Optimization." The hierarchical correspondence between the core categories, main categories, and original categories is shown in [Table 2](#).

Table 2: Axis Coding

Core categories	Main categories	Scope
C1 Status of labelling	B1 Type Composition	A1 Orientation Signs A2 Information Signs A3 Behavioural signs
	B2 Spatial Configuration	A4 Main road coverage A5 Branch road omission A6 Cultural orientation A7 User Orientation A8 Path guidance
	B3 Design Sources	A9 Messaging A10 Content Interpretation A11 Status Maintenance
	B4 Effectiveness	A12 Font Adaptation A13 Colour recognition A14 Language coverage A15 Symbolic representation
C2 Signage assessment	B5 Readability	A16 Hierarchical clarity A17 Path clarity A18 Precise information
	B6 Readability	A19 Element Integration A20 Contextual embodiment A21 Unity of style
	B7 Practical Orientation	A22 Aesthetic harmonisation A23 Material Durability
	B8 Cultural Orientation	A24 Climate adaptation
C3 Signage optimisation	B9 Formal expression	
	B10 Environmental response	

This table presents the "hierarchical integration logic" of axial coding—with three core categories (C1-C3) as the top-level framework, 10 main categories (B1-B10) as the intermediate hubs, and 24 original categories (A1-A24) as the bottom-level foundation. It clearly shows the logical connection of the identification system from "current situation description" to "evaluation feedback" to "optimization direction", providing structural support for the construction of the theoretical framework of selective coding.

### 4.3. Selective Coding

During the selective coding phase, we used the dynamic interaction of "Sign Status - Sign Evaluation - Sign Optimization" as the core logical thread to analyze the internal mechanisms between the three core categories and clarify how each category influences and supports each other (e.g., "Sign Status" provides a realistic basis for "Sign Evaluation," and "Sign Evaluation" provides a direction for "Sign Optimization"). The typical relationship structure and connotations of these core [Table 3](#).

Table 3: Selective Coding

Typical relationship structure	Connotation of relationship structure
C1 Signage status quo ↔ C2 Signage assessment	The type, spatial distribution and cultural orientation of the existing signage system form the basis for visitors' perception and use, and the assessment process reveals its functionality, recognisability and effectiveness in conveying information, and reflects the limitations of the current situation.
C2 Signage Assessment ↔ C3 Signage Optimisation	The results of the evaluation of the signage in terms of path guidance, message delivery and cultural understanding will provide design direction for subsequent optimisation; and the optimised design should respond to the problems revealed in the evaluation in order to enhance the overall experience.
C1 Signage Status ↔ C3 Signage Optimisation	The current situation of the signage system in terms of structural composition, cultural implantation and user orientation provides the basic pivot point for optimisation; and the optimised system form in turn promotes the systematic updating and improvement of the signage image and function of the scenic spot.

This table reveals the "core logic chain" of selective coding—the "bidirectional arrows (↔)" reflect the dynamic interactive relationship among the three core categories, rather than a one-way linear relationship. This not only illustrates the constraining effect of the current situation on evaluation and optimization, but also emphasizes the value of evaluation and optimization in improving the current situation. Ultimately, it constructs a closed-loop theoretical framework of "current situation diagnosis - problem assessment - strategy optimization," providing a theoretical basis for the proposal of "optimization strategy" in Section 7.2.

## 5. Saturation test

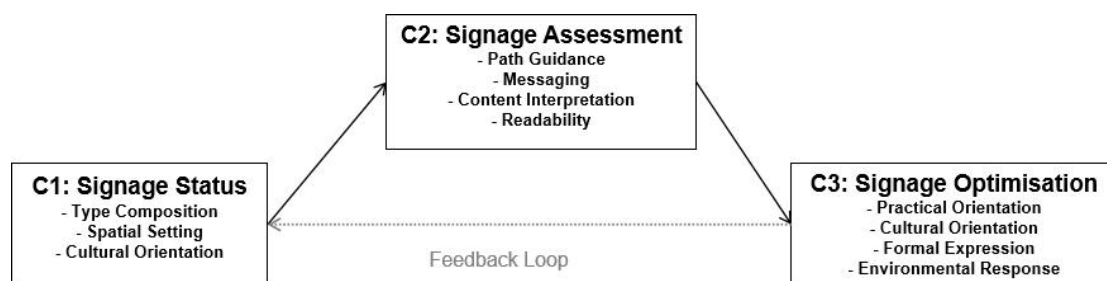
### 5.1. Description of Theoretical Framework

Guided by grounded theory, this study systematically analyzed interview transcripts on the Potala Palace tourist signage design system, constructing a theoretical framework encompassing three dimensions: current status, evaluation, and optimization. During the

open coding phase, 73 initial concepts were extracted from the data and organized into 24 categories, covering core issues such as wayfinding, behavioral cues, cultural communication, message clarity, and material durability. The axial coding phase further integrated these categories, forming the three core categories of "signage current status," "signage evaluation," and "signage optimization."

This theoretical framework (Figure 1), based on three levels: functional construction, user perception, and design enhancement, reveals the interactive logic of tourism signage systems in terms of spatial configuration, user feedback, and cultural communication. It also clarifies the specific path and theoretical basis for optimizing scenic area signage systems. The resulting model not only demonstrates practicality in tourism scenarios but also responds to the systematic needs of regional cultural display and information services.

Figure 1: Theoretical Framework of Potala Palace Scenic Area Signage System Optimization Based on Grounded Theory



Functional Construction Layer: Corresponding to the "signage current status (C1)" dimension, including sub-elements such as "type composition (B1: wayfinding signs, information signs, behavioral signs)" and "spatial configuration (B2: main road coverage, branch road gaps)" derived from axial coding. User Perception Layer: Corresponding to the "signage evaluation (C2)" dimension, including sub-elements such as "effectiveness (B4: path guidance, information transmission)" and "readability (B5: font adaptation, color recognition)" reflecting user experience feedback. Corresponding to the "signage optimization (C3)" dimension, including sub-elements such as "practical orientation (B7: clear paths, accurate information)" and "cultural orientation (B8: element integration, contextual reflection)" pointing to improvement strategies. C1: Signage Current Status (bottom layer, data foundation) – derived from 24 categories (e.g., A1 wayfinding signs, A5 branch road gaps) summarized in open coding.

C2: Signage Evaluation (middle layer, problem diagnosis) – connects C1 and C3, reflecting the evaluation results of C1 from the perspective of user needs (e.g., "inadequate branch road signs in C1" leads to "low path guidance effectiveness in C2").

C3: Signage Optimization (top layer, solution output) – proposes targeted strategies based on C2's evaluation results (e.g., "improve path guidance effectiveness in C2" leads to "strengthen branch road sign coverage in C3"). Bidirectional arrows between C1↔C2, C2↔C3, and C1↔C3 indicate dynamic interaction (e.g., C3's optimized strategies update C1's status, forming a closed-loop iteration).

Figure 1 transforms the abstract coding results (73 initial concepts, 24 categories, 3 core categories) into a visual hierarchical framework. It solves the problem of "abstract

theoretical logic" in the text, allowing readers to quickly grasp the relationship between "raw interview data → categorized information → core theoretical dimensions" and understand how the study constructs the signage system optimization framework from bottom-up (data-driven) rather than top-down (hypothesis-driven).

**Data and Theoretical Support:** The elements in [Figure 1](#) are all derived from the study's empirical process: the 24 categories in the "signage current status (C1)" layer come from open coding of interview transcripts; the "signage evaluation (C2)" layer is based on user feedback (e.g., "difficulty reading small fonts" leading to "low readability"); the "signage optimization (C3)" layer responds to the evaluation results and combines the Potala Palace's cultural characteristics (e.g., "Tibetan cultural symbol integration" in B8). This ensures the framework's authenticity and avoids "theoretical disconnection from data."

**Connection to Coding Results:** [Figure 1](#) visually confirms the logical consistency of the three-stage coding process (open → axial → selective), supporting the discussion in Chapter 4 ("Data Analysis and Coding") that "coding is a systematic process of data aggregation."

**Support for Core Findings:** It directly underpins the core findings in Chapter 7.1 (e.g., "inadequate spatial coverage of the signage system" corresponds to "branch road gaps (A5)" in C1 of [Figure 1](#); "superficial cultural transmission" corresponds to the lack of depth in "cultural orientation (B8)" in C3).

The "design enhancement layer" in [Figure 1](#) clearly points to the six optimization strategies in Chapter 7.2 (e.g., "practical orientation (B7)" supports "spatial coverage optimization"; "environmental response (B10)" supports "material upgrade and environmental adaptation"), ensuring that the strategies are not arbitrary but rooted in the theoretical framework.

**Practical and Transferable Value:** [Figure 1](#) is not only specific to the Potala Palace but also provides a replicable framework for other cultural heritage scenic areas. For example, the "three-level (functional-user-design) + three-dimension (status-evaluation-optimization)" structure can be applied to scenic areas such as the Forbidden City or Lijiang Ancient Town, where only the sub-elements (e.g., cultural symbols, climate-adapted materials) need to be adjusted. This realizes the "transferable value of the optimization model" mentioned in the abstract.

## 5.2. Saturation Test Satisfaction

The saturation test indicates that the research has achieved a unity of depth and breadth in understanding the key issues, and the research structure is stable and the theoretical structure is complete. In the later stage of coding, it is specifically reflected in the following aspects:

### a) Reproducibility of new data

In the later stage of the study, paragraphs from the later interviews were randomly selected for verification. These added materials did not generate new initial concepts or categories, and their content had been effectively covered by the established framework, indicating that the coding had reached information saturation.

#### b) Completeness of the theoretical framework

The existing framework has built a complete chain of tourism signage system elements, from type composition to spatial configuration, from information readability to cultural adaptability, to material and ecological factors, with no thematic omissions or structural gaps.

#### c) Internal consistency and clear logical structure

The relationship between the three core categories is stable and logically self-consistent. For example, the current situation supports the evaluation dimension, the evaluation conclusion points to optimization suggestions, and optimization feedback updates the current situation. The categories present a hierarchical and mutually supportive system structure.

#### d) External applicability and migration value

This theoretical framework is not only applicable to the Potala Palace scenic area, but also provides a systematic approach for the evaluation and optimization of signage design for other tourist attractions with cultural heritage characteristics. It has strong transferability and theoretical explanatory power.

In summary, this study has achieved theoretical saturation based on existing data, with a complete theoretical structure and stable logic, and has good research depth and application breadth.

Based on grounded theory, this study constructed a theoretical model for the status quo assessment, problem diagnosis, and optimization path of the guide system in the Potala Palace scenic area through systematic interviews and three-stage coding.

The main conclusions are as follows:

a) The basic functions of the signage system are basically complete, but there are deficiencies in spatial coverage, detailed services, etc. The layout of the signs for the main tourist routes and service nodes in the Potala Palace scenic area is relatively complete and can meet basic guidance and information needs. However, there are still problems such as insufficient sign density and unclear path guidance at forks in the road, remote areas, intersections, and peak traffic lines, which affects the barrier-free tour experience of tourists in the entire area.

b) The cultural connotations lack depth and innovation, and the Signage forms tend to be homogenized. Although the current signage system incorporates some Tibetan colors and Buddhist symbols, it lacks a systematic cultural narrative and diverse visual expression, and fails to showcase the unique historical heritage and spiritual value of the Potala Palace. There is still much room for improvement in the cultural experience.

c) Insufficient readability, visibility and multilingual adaptability. Some signs have small fonts and low color contrast, which makes them easy to blend in with the environment and are particularly unfriendly to the elderly and international tourists; multilingual information is mainly in Chinese, Tibetan, and English, and lacks the supplement of

international mainstream languages such as Japanese and Korean, making it difficult to meet the needs of diverse tourists.

d) The weather resistance and daily maintenance of the material need to be strengthened. Plateau climate signs are easily affected by extreme weather such as ultraviolet rays, wind and snow, and fading and damage occur frequently. Existing materials and maintenance mechanisms are in urgent need of upgrading, which affects the durability and aesthetics of the sign system.

e) Lack of digital and interactive experience methods. The guide system primarily relies on traditional physical forms. Modern technologies like digital interpretation, QR codes, and AR guides have yet to be widely adopted, failing to meet the expectations of a new generation of tourists for multimedia information and personalized services. In summary, the Potala Palace scenic area's guide system faces the need for a triple upgrade in "function, culture, and experience," requiring comprehensive optimization through a systematic approach.

## 6. Coding Discussion

This study focuses on the theme of "Optimization Path of Tourism Signage Design System in Potala Palace Scenic Spot", and combines the systematic coding process with the grounded theory, and ultimately refines three core categories: current status of the signage, signage evaluation, and signage optimization. This structure systematically reveals the dynamic relationship between the current situation, functional feedback and improvement strategy of the tourist logo, reflecting the deep interactive logic between culture, functionality and user experience in tourist logo design.

Signage Status Describes the basic composition, spatial setting and cultural orientation of the signage system of the Potala Palace scenic spot, covering multiple types of signage forms such as guidance, information, behavior and service, and reveals that its main tour paths are better covered by signage, while branch paths, corners and cultural area signage are still missing. In addition, the signage design is generally constructed according to the national standard, and although it has a certain Tibetan cultural style, it is still insufficient in the expression of characteristics.

Signage evaluation is the direct feedback from visitors to the signage system based on their experience, focusing on such dimensions as path guiding, information conveying effectiveness, and depth of cultural content interpretation. This category integrates three types of structural feedback, namely effectiveness, legibility and ease of reading, and points out key problems such as too small fonts, poor color recognition, limited language coverage, and difficulty in comprehending cultural symbols, which directly affects the ability of tourists to obtain information and perceive culture.

Signage Optimization reflects the improvement paths proposed in response to the above feedback. It covers the four directions of practical orientation (e.g. clear paths and precise information), cultural orientation (e.g. integration of elements and contextualization), formal expression (e.g. stylistic unity and aesthetic harmonization), and environmental response (e.g. durability of materials and climatic adaptation). The core scope emphasizes that the optimization work needs to establish a balance between functional enhancement, cultural heritage and ecological adaptation, and promote the deep integration of the signage system with the scenic environment.

Through the coherent analysis of the three core categories, this study constructs a closed-loop theoretical model, revealing the evolutionary path of tourism signage system from “seeing problems - evaluating and reflecting - designing and improving”, aiming at providing a set of signage design ideas and theoretical basis for the plateau cultural heritage scenic spots. It aims to provide a set of operational, cultural and adaptive signage design ideas and theoretical basis for plateau cultural heritage scenic spots.

## 7. Conclusions

Based on the grounded theory, this study constructs a theoretical model of the current situation assessment, problem diagnosis and optimization path of the signage system of the Potala Palace scenic spot by means of systematic interviews and three-phase coding. The main conclusions are as follows:

The basic function of the signage system is basically perfect, but there are shortcomings in spatial coverage and detailed services. The main tour routes and service nodes of the Potala Palace scenic area have a relatively complete signage layout, which can meet the basic orientation and information needs, but there are still problems of insufficient signage density and unclear path guidance on the branch roads, remote areas, turnoffs and peak flow lines, affecting the tourists' all-area barrier-free visiting experience.

Cultural connotation transfer lack of depth and innovation, sign form tends to homogenization. Although the current signage system integrates some Tibetan colors and Buddhist symbols, it lacks systematic cultural narrative and diversified visual expression, and fails to show the unique historical heritage and spiritual value of the Potala Palace, and there is still much room for improvement in the level of cultural experience.

Insufficient readability, visibility and multilingual adaptability. Some of the signs have small fonts, low color contrast, easy to assimilate with the environment, and are especially unfriendly to elderly and international tourists. The multilingual information is mainly in Chinese, Tibetan and English, and lacks the supplement of mainstream international languages such as Japanese and Korean, making it difficult to cover the needs of diversified tourists.

Weather resistance of materials and daily maintenance need to be strengthened. Plateau climate signs are vulnerable to ultraviolet rays, wind and snow and other extreme weather effects, color fading, breakage phenomenon occurs from time to time, the existing materials and maintenance mechanism needs to be upgraded, affecting the durability of the signage system and aesthetics.

Lack of digitalization and interactive experience means. Signage system is mainly for the traditional physical form, digital interpretation, two-dimensional code, AR guide and other modern technology has not been widely used, failing to meet the new generation of tourists on multimedia information and personalized service expectations. To sum up, the signage system of Potala Palace scenic spot is facing the demand of “function-culture-experience” triple enhancement, which needs to be optimized in a comprehensive way with systematic thinking.

Combining the theoretical model and empirical analysis, the following system optimization path is proposed:

a) Spatial Coverage and Node Optimization. Strengthen the coverage of the main and secondary paths and branch signs, focusing on enhancing the clarity of the orientation of remote, forked roads and cold attractions, so as to realize barrier-free access for tourists. Significant reminders are added at important nodes, such as entrances, exits, ticketing, restrooms, transfer and other places, adopting a unified style and highly recognizable design to reduce information blind spots.

b) Cultural depiction and visual innovation. Deeply excavate and integrate local cultural elements to enrich the cultural connotation of the signage through multi-dimensional narratives such as architecture, murals, religious stories and folklore symbols. Promote the diversity of logo styles and the unity of scene aesthetics, maintain national characteristics and pay attention to modern aesthetics, and avoid the homogenization of symbols and a sense of fragmentation.

c) Readability of information and diversified inclusion. Appropriately enlarge fonts and improve color contrast to enhance the recognition friendliness of the elderly and special groups. Expanding multilingual information services, increasing the number of major international languages such as English, Japanese and Korean, and adopting common graphic symbols and intuitive guidelines to improve the level of internationalized services.

d) Material upgrading and environmental adaptation. Adopts new weather-resistant and environmentally friendly materials to enhance the signage's ability to resist ultraviolet rays, high temperatures, wind and snow, and improve the service life and clarity of information. Improve the regular inspection and maintenance mechanism, and clarify the inspection and replacement cycle of the signs at each node, so as to ensure the long-term good operation of the system.

e) Digitalization and interactive experience. Comprehensively promote the digital upgrade of the signage system, such as the addition of two-dimensional code electronic explanation, multimedia interactive signage, mobile navigation and AR guide service, enriching the information level and tour experience. Promote the construction of intelligent scenic spots, continuously optimize the layout and content of signs in combination with visitors' behavioral data, and realize dynamic updating and intelligent management.

d) Management Mechanism and Tourist Participation. Establish a full life cycle management mechanism for the signage system, including design, construction, evaluation, maintenance, feedback and upgrading, so as to improve systematicity and responsiveness. Encourage tourists and multiple parties to participate in feedback and co-creation, and collect opinions through online and offline channels to promote continuous iteration and self-improvement of the signage system.

The analysis of interviews with visitors, managers, designers, and tourism experts revealed a multifaceted set of strengths and weaknesses in the Potala Palace Scenic Area's signage system. Overall, the current system fulfills its most basic navigational functions but exhibits substantial gaps in spatial coverage, cultural depth, accessibility, and adaptability to modern visitor expectations.

First, spatial coverage is uneven. While the main tourist routes and key service nodes—such as entrances, exits, ticketing areas, and restrooms—are generally well marked, signage along branch roads, in remote sections, and at less-visited attractions is sparse or

absent. This deficiency reduces orientation clarity and disrupts the continuity of visitors' experiences, especially during high traffic periods or when navigating less familiar pathways.

Second, cultural representation within the signage is shallow and stylistically uniform. Existing signs incorporate certain Tibetan colors and Buddhist motifs but lack an integrated narrative capable of communicating the site's historical, architectural, and spiritual significance. Stakeholders noted that this superficial treatment limits visitors' opportunities to engage meaningfully with the cultural heritage and diminishes the uniqueness of the scenic area's visual identity.

Third, readability and multilingual inclusivity are insufficient. Interviewees frequently cited small font sizes, low color contrast, and visual blending with the background environment, which create accessibility challenges for elderly visitors and those with visual impairments. Language offerings are largely confined to Chinese, Tibetan, and English, excluding other major international languages such as Japanese and Korean. This limits the system's capacity to serve a growing and diverse international audience.

Fourth, material durability and maintenance are problematic in the high-altitude climate. Exposure to intense ultraviolet radiation, temperature fluctuations, strong winds, and seasonal precipitation leads to fading, breakage, and other forms of degradation. Current materials and maintenance cycles do not adequately prevent or address these issues, reducing both the functional lifespan and the aesthetic quality of the signage.

Finally, the system shows limited adoption of digital and interactive technologies. Visitors expressed interest in modern enhancements such as QR codes, augmented reality guides, and multimedia interpretation, yet these features remain largely absent. The lack of digital integration constrains opportunities to provide richer, personalized, and dynamically updated information.

Collectively, these findings highlight the need for a comprehensive, multi-dimensional optimization strategy that addresses the functional, cultural, aesthetic, and technological dimensions of the signage system. Strengthening spatial coverage, deepening cultural storytelling, enhancing accessibility and inclusivity, upgrading materials for environmental resilience, and incorporating interactive technologies will be critical to improving the overall visitor experience and ensuring the long-term sustainability of the Potala Palace Scenic Area's signage.

This study contributes to the existing literature by systematically analyzing the Potala Palace signage system using grounded theory. It is one of very few studies which have investigated cultural heritage signage optimization in a high-altitude context and documents a transferable theoretical model integrating functionality, cultural transmission, and visitor experience.

### **Ethical Approval and Consent to Participate**

The researchers followed the research ethics guidelines set forth by the Universiti Teknologi MARA (UITM) Research Ethics Committee. All procedures performed during this study involving human participants were in accordance with the ethical standards of

the institutional research committee. Informed consent was obtained from all participants in accordance with the Declaration of Helsinki.

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### **Conflict of interest**

The authors declare no conflicts of interest.

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