

User-Centered Evaluation of Metadata Schema for Nonmovable Cultural Heritage: Murals and Stone Cave Temples

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Digitization provides a solution for documentation and preservation of nonmovable cultural heritages. Despite efforts for the preservation of cultural heritages around the world, no well-accepted metadata schema has been developed for murals and stone cave temples, which are often high-value heritages built in ancient times. In addition, the literature is scarce on the user-centered evaluation of metadata schemas of this kind. This study therefore aims to offer insights on developing and evaluating a metadata schema for organizing information of these historic and complex cultural heritages. In-depth interviews were conducted with a total of 30 users, including 18 professional and 12 public users, and interview transcripts were coded through a qualitative content analysis approach. Findings reveal the importance of specific metadata elements as perceived by the two groups of end users, which correlated with their cultural heritage information-seeking behaviors. In addition, the issues of standardization of cataloging of cultural heritage information and interoperability among metadata schemas have been raised by users for enhancing the user experience with digital platforms of cultural heritage information. The coding schema developed in this study can serve as a framework for follow-up evaluations of metadata schemas, contributing to the ongoing development of cultural heritage metadata.

INTRODUCTION

Cultural heritages are important records of human activities in history. Buildings, paintings, music, and language are

all examples of cultural heritages. Studies of these heritages are of significant importance for diverse subjects such as archaeology, history, anthropology, information science, linguistics, and religious studies. As some cultural heritages are nonmovable, people who like or need to observe these heritages must travel. More importantly, these heritages may undergo deformation due to natural and/or man-made causes. Digitalizing these heritages for documentation and preservation is considered to be one of the solutions to this problem (Garoufallou et al., 2008). Moreover, when numerous digital resources are produced, organization of and access to these resources become crucial, which in turn calls for reliable, high-quality metadata. Gradually, more and more information from cultural artifacts in physical form are digitalized and disseminated to users through the virtual world that transcends the boundaries of time and space. As well as professionals in information management and other fields, end users of cultural heritage information often also include members of the general public (Doerr, 2009) who rely to a large extent on museums, libraries, and archives for accessing cultural heritage collections (van den Akker et al., 2013). Metadata of cultural heritages is keenly needed in order to meet the information needs of both professional users and the general public who are interested in cultural heritages.

China is renowned for its rich historic and cultural background, yet digitization of nonmovable cultural heritages in China is at an initial stage. Organizations including academic libraries and research institutes are striving to develop fine practices, with major references given to the knowledge and experiences of other countries and international organizations. Murals and stone cave temples are two major

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categories of nonmovable cultural heritages identified in China¹ (UNESCO, n.d.). For instance, the Mogao Cave near Dunhuang, a remote city in northwest China, is a representative site with hundreds of stone cave temples decorated with numerous murals dating from 366 CE (Hu et al., 2017).

Despite the efforts spent on digital preservation of cultural heritages around the world, there is no metadata schema developed specifically for murals and stone cave temples. In addition, there is very little literature that evaluates metadata schemas of cultural heritages with a user-centered approach through which improvements on the schema can be made and sustained. In order to bridge this gap and improve research in this field, the study aims to create more insight into developing and evaluating metadata schemas for the purpose of digitalizing and preserving cultural heritages, with particular reference to murals and stone cave temples. This study also attempts to compare and contrast the experience and perceptions of different types of users according to their information needs and knowledge of the said heritage. A draft metadata schema was developed for murals and stone cave temples, with reference to a series of existing standards for cultural relics and museum collections. As the schemas are sufficiently similar, in this study we regard them as one schema for evaluation purposes. It is hoped that this schema may be useful for the murals and stone cave temples of China as well as those from other parts of the world. By evaluating the metadata schema, we aim to identify potential problems and make suggestions to improve the schema. In addition, by comparing the evaluation of professional and public users, this study has implications for personalized information services enabled by metadata design. Specifically, the following research questions are proposed:

RQ1: How do professionals and the general public seek and use information of murals and stone cave temples?

RQ2: Which metadata elements are important and useful to these two groups of users in the drafted metadata schema for murals and stone cave temples?

RQ3: Besides metadata elements, what other aspects of the metadata schema are relevant for users?

The first question mainly focuses on understanding how users, including professionals and the general public, access and use the information resources of murals and stone cave temples. As addressed by Abbas et al. (2016) under the framework of “information representation design” and in the spirit of user-centered design, understanding users’ information behaviors and their information needs is of utmost importance for the design of information systems. Users’ information-seeking behaviors could then inform their evaluation of the metadata schema, which is a crucial component of information systems. In the second research question, we set out to identify and explore metadata elements in the schema that may or may not be perceived as important or

useful by users, thereby making suggestions on modifications of the elements. The third research question investigates how users perceive the metadata schema as a whole, eliciting worthy issues at the schema level such as completeness, clarity, and interoperability (Ronzino, Amico, & Nicolucci, 2011). Deriving from the above research questions, the primary objective of this study is to evaluate the metadata schema for murals and stone cave temples so that suggestions can be made to inform the further development and improvement of the schema. Furthermore, the study also aims to provide a framework for the next stages of the evaluation.

RELATED WORK

Managing Cultural Heritage Information

Cultural heritage information access is a unique domain due to the complex nature of the resources. As stated by Moen (1998), cultural heritage resources include a variety of physical and digital objects such as physical artifacts and its digital derivatives, descriptive records designed for collection management, online tools such as thesauri and authoritative lists of artists’ names, and so on. Alternatively, Koolen et al. (2009) discussed the fundamental problems of information retrieval in cultural heritage, arguing that these challenges come from the highly structured and standardized data in cultural heritage institutions that make such data generally difficult and expensive to maintain. The uniqueness of cultural heritage resources and the related information organization and access process has attracted the attention of many researchers. For example, Liew (2005) identified 10 key information retrieval features among various online exhibition sites. These features mainly cover search and browse facilities and interactive functions. In another study, geographical information was identified as frequently used when searching for information on cultural heritage (Jones et al., 2001).

Metadata is an important basis for information organization and access (Haynes, 2004; Bhattacharya, 2006). Foulon-Neau and Riley (2008) emphasized that metadata was the key to interoperability, as metadata not only improved content sharing but also supported information exchange among and between electronic platforms and information repositories. According to Baca (2003), controlled vocabularies such as thesaurus and classification systems are required to populate metadata records, especially in the cultural heritage domain. Baca also addressed the development of local authority files and thesauri to enhance end user access, metadata mapping and crosswalks, and provide integrated access to diverse information resources. This has been reflected in the drafted schema evaluated in this study. Terms from thesauri are required or suggested for some elements such as “Object/Work Type” and “Grade.” Ontology-based metadata has also been widely studied, as it helps with the integration of entities and standardization of terminologies for the cultural heritage domain (Weinstein, 1998; Maedche & Zacharias, 2002; Schuurman & Leszczynski, 2006). With

¹There are five other categories of nonmovable cultural heritage: archeological sites, ancient architecture, ancient tombs, large stone carvings, and historical sites.

the help of computational technologies, several digital libraries and online repositories of cultural heritage sites have been established worldwide, including the Digital Dunhuang project,² HistoricPlacesLA,³ and Ancient Locations.⁴ These sites provide rich metadata for digital surrogates of nonmovable cultural heritages, such as the landscape and stories of historical sites (Hu et al., 2017).

Challenges for Metadata of Cultural Heritage Information

Creating metadata for cultural heritage information poses various and significant challenges. First is the question of the suitability of metadata for digitized cultural heritages. Cultural items that are born digital, such as video games, have already faced metadata creation difficulties (Lee et al., 2013), and digitized cultural heritage as derived from information objects may anticipate even more challenges. Existing metadata schema and standards might be suitable for original, physical items, but fall short for digitized surrogates of cultural heritage. For instance, Patel et al. (2005) pointed out that digital representations of physical artifacts required significant technical information (for example, parameters related to creation, storage, and manipulation) in the metadata in order to maintain and preserve these cultural objects.

Another challenge is that the metadata of cultural heritages needs to serve users from diverse backgrounds. It has been remarked that documentation of cultural heritage necessitates standardization that allows integration of cultural heritage information from multidisciplinary environments involving scholarly and professional users ranging from historians and conservators to sociologists and engineers (Ronzino et al., 2012). Standards of metadata are important not only for supporting efficient searches for cultural heritage information, but also for improving interoperability across resource platforms. In addition to scholars and professionals, metadata also serves users from the general public (Patel et al., 2005). Nontraditional users of metadata (that is, the general public) are recognized as having been adept at “creating, exploiting, and assessing” certain types of metadata of cultural heritage information (Gilliland, 2008, p. 1). Their potential contributions to such metadata justify the prominence of their opinions.

Many cultural institutions and national bodies have attempted to develop standards to address the wide-ranging metadata requirements of the cultural heritage sector. Well-known standards include the CIDOC Conceptual Reference Model (CRM) for museum documentation (CIDOC, 2003), the Europeana Data Model (EDM) for European cultural heritages (Doerr et al., 2010), the SPECTRUM coordinated by the Museum Documentation Association (MDA) (Grant & Cowton, 1997), the VRA Core for visual cultures (Library of Congress, 2014), the ICCD form in Italy (Corti &

Marcon, 2003), and the UK Historic Environment Data Standard (MIDAS Heritage) (Forum on Information Standards in Heritage, 2007). Ronzino et al. (2011) carried out an assessment and comparison of several national schemas and standards on cultural heritage assets including archaeological sites, museum objects, and architectonic elements. Their article highlights equivalencies and shortcomings of the schemas, and suggests that a more comprehensive standard for cultural heritage assets is needed. Smiraglia (2005) suggested that schemas should be derived with empirical understanding of the concepts to be represented, and metadata descriptions should be designed with the goal of facilitating retrieval.

Regardless of the complexity or the modernity of metadata schemas, they are often created based on resources at hand and existing standards, and the perspectives of end users might not have been taken into account. There is currently a lack of a standardizing metadata schema for murals and stone cave temples, and, more importantly, a user-centered evaluation of this metadata schema is required for improvements. It is hoped that the schema refined from user evaluation can contribute to meeting the aforementioned challenges to the creation of metadata schema for information and resources of cultural heritages, particularly murals and stone cave temples.

METHODS

With the aforementioned objectives, this study adopted a qualitative approach. Interview is considered a suitable method for this study, as there is little literature on this topic, thus making hypothesis inappropriate at this stage. Semi-structured individual interviews with 30 participants from different backgrounds were conducted in order to gain an in-depth understanding into current user practices in seeking information about murals and stone cave temples, and their evaluation of the draft metadata schema and its elements. The draft metadata schema was developed by referencing existing standards published by the National Cultural Relics Bureau of China, as well as internationally well-adopted metadata standards such as the CDWA (Categories for the Description of Works of Art, Getty Trust, 2014) and DCMI (Dublin Core Metadata Initiative, DCMI, 2012). The core elements and their definitions are presented in Table 1. Findings from this study can provide a framework to enable follow-up studies to adopt a quantitative approach.

Sample Selection

Thirty participants joined this study. Nineteen were female and eleven were male. The ages of participants ranged from 20–55, with most participants ranging from 25–30 years old. Participants were categorized into two groups: professionals ($N = 18$) and the general public ($N = 12$). The sample sizes are in line with previous studies on user-centered metadata evaluation, namely, 17 cultural heritage experts as interviewees in Amin et al. (2008), 14 users in different groups in Hu et al. (2017), and 33 survey respondents

²<http://www.e-dunhuang.com>

³<http://www.historicplacesla.org>

⁴<http://www.ancientlocations.net>

TABLE 1. Core elements and definitions.

Element name	Definition
Classification	Cultural heritage category (for example, mural, stone cave temple, etc.)
Title	Scientific and accurate names approved by authority, if available. For items without official names, use common names or the combination of the minimal administrative region name and “mural/stone cave temple”
Identifier	Unique identifier assigned by (national, provincial, or local) authority for nonmovable heritage
Current Location	The location of heritage, its geographical name, coordinates, and the organization it belongs to
Creation	The entity and era for the construction, design, production, of the heritage
Materials	Description on the main materials or texture of the heritage
Techniques	Description on techniques, process or methods of making the heritage
Measurements	The size, area, quantities, etc. of the heritage
Description	Free-text description of information relevant to the heritage
Inscriptions/ Marks	Inscriptions on the heritage, including: name, content, language, type, etc.
Object / Work Type	Faceted subjects including the physical attributes, style and era of the heritage; prioritizing values in “Chinese cultural heritage thesaurus”
Context	The temporal, spatial, and humanity information involved in the heritage
Grade	Heritage grade approved by authority (including “unrated” for items without an approved grade)
Current Condition	Description on the conditions of the heritage regarding its completeness, degree of damage, and loss
Environment	Description of the natural, socio-cultural environment of the heritage
Damage	Description on damages of the heritage caused by natural or social causes
Right	Intellectual rights and restrictions regarding the duplication, exhibition, and usage of the heritage
Related Works	Names of other heritage directly related to this heritage
Related Visual Documentation	Visual resources related to the heritage; used for identifying and displaying the digital images, anime, videos of the heritage
Related Knowledge	Names of knowledge related to the heritage, including the relevant people, events, archaeology, research, jargons etc.
Coverage	The orientation, space placement, and time of the heritage
Disposal History	The preservation and processing of the heritage in history
Type	The categories of murals or stone cave temples (for example, Buddhism murals, story murals, decorative murals, etc.)

in Zhang and Li (2008). The group of professionals included researchers and scholars in related fields such as art history, Buddhist study, and ancient architecture, as well as those who had jobs related to cultural heritage, such as teachers, journalists, graphic designers, and cultural heritage librarians. This group of users had information needs for murals and stone cave temples for job- or profession-related purposes. On the other hand, participants in the general public group were those who had no expert knowledge or job-related purpose in seeking mural and stone cave temple information. Examples of their occupations included nurses, bankers, and so on. This diverse user background was included for the purpose of collecting opinions from users with different information needs, so that implications can be used for informing how the metadata can serve different types of users. Participants in the professional group were recruited using a snowball sampling method in Hong Kong and mainland China where people are likely to be familiar with murals and stone cave temples in Dunhuang and other historical monument sites in China. It is important but difficult to identify and recruit experts in related domains, whereas snowball sampling can help obtain access to hard-to-reach populations (Berg et al., 2004). The group of the general public was recruited as a convenience sample, with efforts in diversifying participants’ age, gender, and professions.

Data Collection Through Interviews

Each interview was structured into two parts. The first was for collecting information-seeking behaviors of the

interviewees with regard to murals and stone cave temples. Interviewees were expected to answer the questions based on their past experiences in seeking related information. At the end of this part, to solicit users’ viewpoints of how such information could be provided in a more user-friendly way, interviewees were asked to give suggestions on what they needed most for improving access to mural and stone cave temple information. It is noteworthy that, at this stage, the draft metadata schema was still hidden from the interviewees and they may or may not mention any metadata-related issues. In the second part, the core elements in the draft metadata schema were introduced to the interviewees. They were asked to comment on the importance and usefulness of every core element of the metadata schema, as well as their opinions on the schema as a whole. The interview protocol is presented in the Appendix. The interviews were conducted either in-person or by phone, which allowed synchronous feedback and interactions between the interviewees and the interviewer (Dent, 2011). Each interview session lasted around 1 hour. The participants voluntarily joined the interviews with no remuneration provided.

Data Analysis

All audio recordings of interviews were transcribed and coded in a thematic content analysis approach. Excerpts were defined as units with independent meanings and usually an utterance. A grounded theory approach (Strauss & Corbin, 1994) was adopted. The codebooks were developed from the data through an iterative coding process and refined for multiple rounds of going through the data.

TABLE 2. Codebook for each metadata element.

Categories	Codes	Definition
Importance	Necessary	Element is important and must exist for identifying the heritage.
	Informative	Element is useful in learning more about the heritage but not necessary.
	Not interested	Interviewee is not interested in learning this information but does not mind having it.
	Redundant	Element overlaps with other elements.
Function (searching; browsing; organizing)	Useful	Element can be used in searching / browsing / organizing resources related to the heritage.
	Not useful personally	Element is not useful for oneself due to lack of knowledge or other reasons, but might be useful for others.
Issues	Not useful	Element is not useful in searching / browsing / organizing related resources.
	Confusing terminology	Element definition is unclear or hard to understand.
	Lack of cataloging standards	Element is problematic because it would need standard rules to catalogue, but it is unlikely that such standards exist.

TABLE 3. Codebook for general issues.

Categories	Definition
Interoperability	Interviewee mentions or implies working or integrating with other standards or systems.
Completeness	Interviewee mentions whether the schema covers enough information
Order arrangement	Interviewee mentions the ordering of the metadata element.
Usefulness in information retrieval	Interviewee mentions how the schema can (or cannot) sufficiently support information retrieval.
Difficulty in cataloging	Interviewee mentions the ease / difficulty of cataloging related resources
Terminology	Interviewee questions the naming of one or more elements in the schema.
Redundancy	Interviewee mentions there are overlaps or duplicate elements in the schema.

RESULTS

There were 1,119 excerpts extracted from the interview transcripts and 325 excerpts (29%) were double-coded. Cohen's kappa coefficient was calculated to measure the interrater reliability of the coding. The resultant kappa values ranged from 0.78–0.92 across the interview questions, implying an overall substantial to excellent level of agreement between coders (McHugh, 2012).

Current Practices of Information Seeking

In terms of the methods used to seek information on murals and stone cave temples, websites/databases (15 times) accounted for one-third of the total count of 45 responses from the professionals, while search engines (12) took this role among the 35 responses from the general public group. Comparing the two user groups, the remaining responses had similar counts and also included library catalogs (7 vs. 7), visiting targeted museums and exhibitions (5 vs. 5), visiting bookstores (2 vs. 3), and using personal contacts (3 vs. 2). These results showed that electronic resources were the predominant tools used in looking for information related to murals and stone cave temples. This predetermines users' potential in benefitting from digitized cultural heritage information as well as metadata schemas designed for digital information.

The most common type of cultural heritage information sought by the professional group was visual material (for example, images, videos) (9 out of 20 responses), whereas that by the public group was travel-related information

(9 out of 26 responses). Both groups looked for the historical or cultural background of cultural heritage (6 vs. 6), while reviews from other people were sought more by the public (5) than the professionals (1).

When asked about how information of murals and stone cave temples can be provided in a more user-friendly way to improve the information-seeking experience, more than half of responses (7) from the professional group indicated that resources should be available online (4), whereas more than one-third (4) of the general public participants (10) mentioned the same. High-quality catalogs (2 vs. 2) and the availability of search functions (1 vs. 1) were similarly demanded by both user groups. Metadata, as the backbone of catalogs and online searches, is therefore a potential requirement from users' perspectives. Meanwhile, the provision of a map of cultural heritage sites was suggested by the public (2) exclusively.

Codebooks for Metadata Evaluation

Two codebooks were developed from responses to different interview questions on the metadata schema. Table 2 presents the codes on individual metadata elements, including users' perceptions on its importance, its usefulness in searching, browsing, and organizing related information, and issues raised.

Participants were also asked to evaluate the proposed metadata schema as a whole, and identify issues the schema might have. Table 3 shows the codebook of main issues raised.

TABLE 4. Coded comments on element importance, from the professional user group ($N = 18$).

Element	Necessary (%)	Informative (%)	Not interested (%)	Redundant (%)	Total
Classification	2 (100%)				2
Title	5 (83%)	1 (17%)			6
Identifier	3 (43%)	3 (43%)	1 (14%)		7
Current Location	4 (80%)	1 (20%)			5
Creation	3 (60%)	1 (20%)	1 (20%)		5
Materials	4 (50%)	3 (37%)	1 (13%)		8
Techniques	1 (25%)	3 (75%)			4
Measurements	2 (40%)	2 (40%)	1 (20%)		5
Description	4 (50%)	1 (13%)		3 (37%)	8
Inscriptions/Marks	2 (50%)		1 (25%)	1 (25%)	4
Object / Work Type	2 (67%)			1 (33%)	3
Context	2 (29%)	1 (14%)	1 (14%)	3 (43%)	7
Grade	2 (50%)		2 (25%)		4
Current Condition	2 (50%)		1 (25%)	1 (25%)	4
Environment	2 (40%)	2 (40%)		1 (20%)	5
Damage	1 (13%)	1 (13%)	1 (13%)	5 (62%)	8
Right	2 (67%)		1 (33%)		3
Related Works	1 (25%)	1 (25%)	2 (50%)		4
Related Visual Documentation	4 (80%)		1 (20%)		5
Related Knowledge	4 (57%)	1 (14%)	1 (14%)	1 (14%)	7
Coverage	2 (50%)		1 (25%)	1 (25%)	4
Disposal History	2 (50%)		2 (50%)		4
Type	2 (50%)		1 (25%)	1 (25%)	4
Total	58 (50%)	21 (18%)	19 (16%)	18 (16%)	116

User Evaluation of Metadata Elements

There were 419 excerpts containing interviewees' views on individual metadata elements in the schema. Of these, 240 were about their importance, 146 concerned their usefulness, and 33 indicated issues of the elements.

Table 4 summarizes the distributions of the codes on element importance in the professional user group, as well as the percentages of the total of each element. "Title" (rated as "Necessary" or "Informative" 6 times, representing 100% of opinions on this element), "Identifier" (6, 86%), "Current Location" (5, 100%), and "Material" (7, 87%) of a mural or stone cave temple can be viewed as the most important among all elements. While most elements had only one to two responses of "Not interested" among the professional users, "Damage," "Context," and "Description" received the most "Redundant" ratings among this user group. They commented that "Damage" (5 times, 62%) overlapped with "Current Condition," while "Context" (3 times, 43%) and "Description" (3 times, 37%) might duplicate to some extent.

Distribution of codes on element importance in the general public user group is presented in Table 5. For this group of participants, the most important elements were "Current Location" ("Necessary" or "Informative," rated 5 times, 100%), "Description" (5, 87%), "Context" (5, 71%), and "Related Knowledge" (5, 71%). The public users rated some elements as "Not interested" more often than the sum of "Necessary" and "Informative," including "Measurements" (60%), "Related Visual Documentation" (57%), "Materials" (50%), and "Right" (43%). Similar to the professional

group, "Damage" was deemed redundant by the public users as well.

More than two-thirds of the excerpts were coded as "Necessary" or "Informative," by both groups of participants, indicating that most elements are considered important. Only 16% and 15% of the excerpts respectively in the two groups were coded as "Redundant". "Current Location," "Description," and "Related Knowledge" were perceived to be important by both user groups. However, in the group of professionals, "Description" and "Related Knowledge" were perceived more as "Necessary" than "Informative," while the case was reversed in the public group.

Tables 6 and 7 present the code distributions in the two user groups regarding their opinions on the capacity of each metadata element in supporting the searching, browsing, and organizing of information of murals and stone cave temples. The percentages were calculated against the total number of codes on each function (for example, searching) of each element. Elements considered useful for searching by both user groups included "Creation" (all opinions on this element were "useful" in both user groups), and "Title" (all opinions in the professional group and 67% in the public group were "useful"). "Current Location" received "useful" ratings (100%) from the public group but not the professional group, corroborating the importance of travel-related information to the public users. "Inscriptions/Marks" was viewed by the public as "useful" for searching (100%) but "not useful personally" by the professionals. Some interviewees in the general public group opined that users might remember inscriptions on some (famous) murals and use it for

TABLE 5. Coded comments on element importance, from the general public user group (*N* = 12).

Element	Necessary	Informative	Not interested	Redundant	Total
Classification	2 (67%)	1 (33%)			3
Title	3 (100%)				3
Identifier	1 (14%)	3 (43%)	3 (43%)		7
Current Location	3 (60%)	2 (40%)			5
Creation	2 (33%)	2 (33%)	1 (17%)	1 (17%)	6
Materials		3 (38%)	4 (50%)	1 (13%)	8
Techniques	1 (13%)	3 (38%)	2 (25%)	2 (25%)	8
Measurements	1 (20%)	1 (20%)	3 (60%)		5
Description	2 (33%)	3 (50%)		1 (13%)	6
Inscriptions/Marks		2 (50%)		2 (50%)	4
Object / Work Type		1 (100%)			1
Context	2 (29%)	3 (49%)		2 (29%)	7
Grade		3 (60%)	2 (40%)		5
Current Condition	1 (25%)	3 (75%)			4
Environment	1 (20%)	2 (40%)	2 (40%)		5
Damage	1 (10%)	5 (50%)		4 (40%)	10
Right		2 (29%)	3 (43%)	2 (29%)	7
Related Works		4 (100%)			4
Related Visual Documentation	1 (14%)	2 (29%)	4 (57%)		7
Related Knowledge		5 (71%)		2 (29%)	7
Coverage		3 (50%)	2 (33%)	1 (17%)	6
Disposal History	2 (40%)	2 (40%)		1	5
Type		1 (100%)			1
Total	23 (19%)	56 (45%)	26 (21%)	19 (15%)	124

TABLE 6. Coded comments on element usefulness, from the professional user group (*N* = 18).

Element	Searching			Total	Browsing		Organizing	
	Useful	Not useful personally	Not useful		Useful	Total	Useful	Total
Classification	1 (50%)	1 (50%)		2	1 (100%)	1		
Title	2 (100%)			2	1 (100%)	1		
Identifier	2 (50%)	2 (50%)		4	1 (100%)	1	2 (100%)	2
Current Location								
Creation	2 (100%)			2				
Materials		2 (100%)		2	2 (100%)	2		
Techniques		3 (100%)		3	1 (100%)	1		
Measurements		5 (83%)	1 (17%)	6	1 (100%)	1		
Description		1 (50%)	1 (50%)	2				
Inscriptions/Marks		1 (100%)		1	1 (100%)	1		
Object/Work Type		2 (100%)		2				
Context		1 (100%)		1				
Grade	1 (33%)	1 (33%)	1 (33%)	3	1 (100%)	1		
Current Condition	1 (25%)	3 (75%)		4	1 (100%)	1		
Environment		4 (100%)		4				
Damage		3 (100%)		3				
Right		2 (100%)		2				
Related Works		1 (100%)		1				
Related Visual Documentation	1 (33%)	2 (67%)		3				
Related Knowledge		3 (100%)		3				
Coverage		1 (100%)		1	1 (100%)	1		
Disposal History		1 (100%)		1				
Type		3 (100%)		3				
Total	10 (18%)	42 (76%)	3 (5%)	55	11 (100%)	11	2 (100%)	2

searching, which could further improve the popularity of the heritage. “Measurements,” “Techniques,” “Environment,” “Materials,” “Description,” and “Right” were viewed by both groups as not useful or not useful personally for searching. Some professionals (especially researchers) expressed

that elements such as “Measurements” were too technical and might only be useful to a specific group of “insiders” when conducting information search.

For browsing, “Inscriptions/Marks” was regarded as “useful” consistently by both user groups, indicating users’

TABLE 7. Coded comments on element usefulness, from the general public user group (N = 12).

Element	Searching				Browsing				Organizing	
	Useful	Not useful personally	Not useful	Total	Useful	Not useful personally	Not useful	Total	Useful	Total
Classification	3 (75%)		1 (25%)	4						
Title	2 (67%)	1 (33%)		3						
Identifier	2 (50%)	2 (50%)		4		1 (100%)		1	1 (100%)	1
Current Location	2 (100%)			2	2 (100%)			2		
Creation	3 (100%)			3						
Materials		1 (33%)	2 (67%)	3	1 (50%)		1 (50%)	2		
Techniques		2 (50%)	2 (50%)	4	1 (33%)	1 (33%)	1 (33%)	3		
Measurements		2 (67%)	1 (33%)	3						
Description		1 (33%)	2 (67%)	3		1 (100%)		1		
Inscriptions/Marks	2 (100%)			2	1 (100%)			1		
Object/Work Type	3 (75%)	1 (25%)		4	2 (100%)			2		
Context			1 (100%)	1						
Grade	2 (50%)	1 (25%)	1 (25%)	4		1 (100%)		1	1 (100%)	1
Current Condition	1 (50%)		1 (50%)	2						
Environment		2 (100%)		2		1 (100%)		1	1 (100%)	1
Damage	1 (50%)		1 (50%)	2						
right		1 (100%)		1		1 (100%)		1		
Related Works	2 (67%)		1 (33%)	3	1 (100%)			1		
Related Visual Documentation	1 (33%)	2 (67%)		3		1 (100%)		1	1 (100%)	1
Related Knowledge					1 (100%)			1		
Coverage										
Disposal History									1 (100%)	1
Type	2 (100%)			2						
Total	26 (47%)	16 (29%)	13 (24%)	55	9 (50%)	7 (39%)	2 (11%)	18	5 (100%)	5

need for textual content as a type of browsing surrogate of visual cultural objects. “Techniques” and “Materials” were also considered useful by the professional group but received diverse opinions from the public group. “Classification,” “Title,” “Identifier,” and “Current Condition” were exclusively considered by professionals to be useful for browsing, as they could yield information of research value. In contrast, only the general public group perceived “Current Location” and “Related Knowledge” as useful for browsing, which were related by this user group to traveling to cultural heritage sites. “Identifier” was, not surprisingly, considered useful for organizing related information by both groups.

In terms of issues for the elements, both groups of interviewees thought some elements were confusing with one another, such as “Object/Work Type” and “Type” (2 times by professionals and 1 time by public), “Creation” and “Disposal History” (2 vs. 1). The public users exclusively indicated that “Context” and “Related Knowledge” (2 times) were confusing, whereas professionals expressed confusion over more elements, including “Description” (3 times), “Inscriptions/Marks” (3), “Environment” (2), “Identifier” (1 time), “Grade” (1), “Current Condition” (1), and “Damage” (1). Another issue pointed out by the professional group was the lack of standardization in cataloging some elements such as “Description” (1 time), “Classification” (1), “Current Location” (1), “Creation” (1), and “Grade” (1).

User Evaluation on the Whole Metadata Schema

Only participants in the professional group commented on the metadata schema as a whole. They pointed out

concerns such as element redundancy (8 times), completeness (6), terminology (3), order arrangement (2), and variable usages for different user groups (2). Other issues, presented in Table 3, including interoperability and difficulty in cataloging, were each commented on once.

The issue of element redundancy was mentioned above. When interviewees talked about the completeness of the schema, the reflections were generally positive.

“I think there is nothing that has to be added because I think [the collection of elements] is pretty comprehensive.” (*Participant 7*)

There were also concrete suggestions made for further enhancement of the completeness of the schema:

“[The] uncovering process [of the heritage] could also be an integral part of cultural heritage; . . . I think digital resources should be categorized in more than just one simple element, there’s so much going on in the tech[nological] world. The schema needs to put potential future development into consideration as well; . . . I think some travel information might also be helpful in this schema.” (*Participant 30*).

When terminology was concerned, suggestions were raised to clarify terms by using modifiers:

“If I see elements such as ‘Creation’ and ‘Coverage,’ these names are very confusing. Maybe it can show ‘Creation’ first, then under which there would be ‘Creator,’ ‘Creation Time,’ ‘Creation Location,’ and so on.” (*Participant 8*)

Some participants mentioned that the schema may need to cater to different user groups:

“If various communities [of users] are using [the metadata], the information that concerns them would be different.

This might be a difference in terms of the use of the metadata.” (Participant 2)

Interoperability was raised as a suggestion for future development:

“The search engines are effective because people use the same or similar metadata. If we develop a new schema, it is hoped that it can also be used by other countries, so it [the schema] needs to be able to integrate with international standards.” (Participant 19).

One interviewee expressed her concern on the difficulty of cataloging:

“It [cataloging] needs both fundamental knowledge in organizing information, and professional knowledge [in murals and stone cave temple].” (Participant 12).

Discussion and Conclusion

Information-Seeking Behaviors Inform Metadata Requirements

Under the spirit of user-centered design and the framework of “information representation design” (Abbas et al., 2016), current information-seeking practices of potential users are informative for metadata requirements. The foremost preference of both user groups is electronic forms of cultural heritage information, better from online sources. Nonetheless, professional users opted for online databases rather than search engines that were more often used by general public users. This can be attributed to professionals’ familiarity with databases that store relevant cultural heritage information, such as Artstor,⁵ an online repository of images in arts, humanities, architecture, sciences, etc. This is consistent with findings from prior studies that found experts of cultural heritage preferred reputable online sources over search engines (Amin & Nispen, 2008). The distinctive purposes of seeking cultural heritage information and the types of information sought by the two user groups in this study necessitate a requirement of the metadata schema to support a variety of information needs in multidisciplinary environments for cultural heritage. Regarding the types of information being sought, the professionals’ needs for visualized materials imply that the metadata should contain elements describing related images and videos. On the other hand, participants in the general public group tended to search for travel information and were interested in other cultural heritage sites nearby when traveling. In addition, unlike their professional counterparts, public users tended to rely on online reviews to learn more about the heritage.

In view of these practices, the proposed metadata schema should facilitate information seeking of users with various information searching experience and information needs. Functions that the metadata schema could serve can include, but are not limited to, standardizing the way to locate online cultural heritage resources, providing a consistent and cross-disciplinary descriptive framework to manage properties of cultural heritage resources (for example, geographical

location, damage conditions, photos of the resources, etc.), categorizing the resources based on a well-defined taxonomy, facilitating resource ranking and sorting for customized user experience, etc. It is also prudent to seek the advice of and suggestions from researchers and professionals during the process of refining the metadata schema, owing to their exposure to the heritage in question, and their familiarity with online databases of cultural heritage information.

Metadata Elements for Information Retrieval

Users’ perceived importance or usefulness of specific elements in the metadata schema correlated with their information-seeking practices.

“Related Knowledge” is an important element to both groups of users. It can facilitate indexing and searching not only of the cultural heritage itself but also knowledge related to it (for example, related historic events, myths, and legends). This element was valued by the professionals as research and teaching materials. For the general public group, “Related Knowledge,” rated as informative and useful for browsing, can be learning resources to help further their understanding of a mural or a stone cave temple. In addition, both user groups perceived “Current Condition” as useful in supporting searching. A participant from the general public group (Participant 13) pointed out that the real condition of a mural or stone cave temple could be different from its digitized forms, which could have been edited or enhanced. On the other hand, a number of metadata elements were deemed not useful for searching, by both groups of users, including “Measurements,” “Materials,” and “Techniques.” While the general public thought these elements were uninteresting, some researchers in the professional group perceived them as very technical and would be useful only to certain groups of “insiders” in a specific field (for example, archeologists). “Object/Work Type” was regarded as problematic by both groups of users, in that it was ambiguously termed and could overlap with other elements such as “Classification” and “Type.” Common perceptions between these two user groups on specific elements imply that these elements necessitate immediate review and modification in terms of their terminology, definitions, and functions.

There were a number of noteworthy differing opinions between the two user groups. “Related Visual Documentation” was a necessary element to the group of professionals, attributable to their needs for visual materials. An example is the use of visuals by journalists in writing articles and news reports about cultural heritage sites. On another note, this is related to the tremendous contribution of visual materials to the promotion and preservation of cultural heritage, since visuals are powerful in demonstrating the values of tangible heritage (Waterton & Watson, 2010). It seems counterintuitive that the general public was uninterested in this element, but the terminology of “Documentation” may have sounded intimidating to them. “Classification,” “Title,” and “Current Condition” were regarded by the professional

⁵www.artstor.org

users as highly important elements in supporting their job-oriented searching and browsing activities.

Users in the general public group searched for cultural heritage information for more personal objectives such as planning trips to heritage sites. Therefore, “Current Location” was a popular element identified as important and useful for searching and browsing. “Context” was also held as an important element by the general public, as contextual information of a mural and stone cave temple, probably related to its historical background, could arouse the interest of visitors to the heritage sites. Although “Context” was perceived as less an important element for professionals, they still commented that it could help enhance the understanding of the general public group towards the heritage. This nevertheless implies that professional users were more knowledgeable about the relevant contextual information of murals and stone cave temples, and did not perceive it as a necessary element in the metadata. Another difference was found between the two groups in that the general public group was not too interested in “Right,” while researchers and professionals were less opinionated towards this element. Despite their disinterest in this element, these general public users still made comments involving copyrights, ownership, and duplication of heritage, reflecting their awareness of intellectual property issues involved in cultural heritage.

In terms of functions of the metadata elements, “Identifier” was seen as useful for organizing heritage information by the professionals, but it was regarded as not useful personally to the general public users. There is no doubt that professionals found “Identifier” largely helpful in facilitating heritage resource management, with some even valuing it as a unique ID contributing to the completeness of the metadata. Conversely, general users viewed themselves as “laymen” or “outsiders” who did not need, or even have concerns about, such information. One participant (Participant 18 from the public group) specified that “Identifier” would not be useful when traveling to the heritage site. Lastly, “Description” was shown to cause more confusion among professionals than public users, despite the fact that both groups pointed to its unclear definition. Professional users tended to be more critical in evaluating the metadata schema, as also shown from the fact that only this group of users commented on the schema as a whole in addition to each element.

Issues Identified in the Whole Schema

Improvements in the metadata elements informed by users’ information-seeking practices would also enhance the overall quality of the metadata schema as a whole. Following are the major aspects or concerns of the metadata schema raised from this study.

Based on the results, a clear definition of the proposed metadata elements and removal of redundant elements are suggested for minimizing confusion among users, especially when these elements cause confusion in both professional

and general public groups. Cataloging rules are necessary and integrated parts of metadata schemas, and need to be developed soon. Controlled vocabularies are also necessary for ensuring consistency in cataloging. The draft metadata schema refers to existing controlled vocabularies as much as possible. However, for cultural heritages such as murals and stone cave temples, more controlled vocabularies need to be developed and/or refined to describe their unique construction techniques, materials, and structures.

Interoperability allows different information systems or platforms to exchange and integrate data so that information resources can be shared and enriched under limited financial, technical, or human resources. A higher interoperability could enhance the experience of different types of users from the multidisciplinary environments of cultural heritage information. As some elements of the evaluated schema were created based on existing schemas, interoperability was taken into account from the beginning. Nonetheless, in further refinements of the schema, new elements specific to mural or stone cave temple heritages need to be carefully designed, including crosswalks and mappings to other existing standards.

Continuous Refinement

At this stage, there is still an ongoing effort to refine the draft metadata schema. It is advantageous to evaluate the schema along with its development process. The integrated process of development and evaluation is iterative, with considerations of the perspectives of both user groups. In fact, the findings of this study have been applied to revisions of the schema, resulting in several modifications that attempt to solve issues raised by both groups in this study:

1. “Object/Work Type” was renamed “Subject,” while the “Type” element was eliminated to avoid duplication.
2. “Related Visual Documentation” was extended to “Related Digital Resources,” to cover a broader range of digital derivatives, and to ensure its appeal to users from different backgrounds.
3. “Coverage” and “Disposal History” were eliminated to avoid overlaps with other elements (for example, “Damage,” “Description”).
4. “Damage” was renamed “Damage Cause,” to be further differentiated from “Current Condition.”
5. “Description” was modified to include information not covered by other elements, particularly “Context,” which emphasizes the spatiotemporal and social background of murals and stone cave temples.
6. New elements, “Shape” and “Structure,” were added to describe the unique construction structures of murals and stone cave temples.

Due to the complexity of cultural heritage resources, there could be more elements, sub-elements, and qualifiers added in the future. New elements and local rules would continue being declared to form the most suitable metadata schema. It is also essential for the schema to offer the

greatest flexibility for customization to users from multiple disciplines and backgrounds with different information needs.

Limitations and Future Work

As a qualitative study, this work was limited by the small sample of participants, and thus the results are not intended for generalization. Future studies will continue evaluation of the draft metadata schema. A larger-scale study with quantitative data (for example, surveys) is needed to obtain more generalizable findings. Feedback from a larger set of users in both mainland China and Hong Kong are being collected through questionnaires. Trial cataloging has been conducted with a sample of five images taken from one of the Mogao caves and will be continued for more samples. A prototype digital collection will then be built based on the results of trial cataloging and usability testing of the prototype collection will be conducted as a high-fidelity user evaluation approach. The metadata schema will be reviewed and refined based on the issues and challenges identified during the evaluation process. Further work will take reference from this study and consider more diversified groups of users, including those outside of the greater China region.

Cultural heritage metadata is an essential area of investigation due to the exigent demands of preservation. The growth of online platforms and virtual reality technologies allow all kinds of users to interact with digitized cultural heritage information via the Internet. Findings of this study are expected to serve as a framework for ongoing development and evaluation of cultural heritage metadata, contributing to the goal of improving the access to and usage of nonmovable cultural heritage resources.

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References

- Abbas, J., Baker, S.R., Huskey, S.J., & Weaver, C. (2016). How I learned to love classical studies: Information representation design of the digital Latin library. In Proceedings of the Association for Information Science and Technology, 53(1), 1–10.
- Amin, A., Van Ossenbruggen, J., Hardman, L., & van Nispen, A. (2008, June). Understanding cultural heritage experts' information seeking needs. In *Proceedings of the 8th ACM/IEEE-CS joint conference on Digital libraries* (pp. 39–47). New York: ACM.
- Baca, M. (2003). Practical issues in applying metadata schemas and controlled vocabularies to cultural heritage information. *Cataloging & Classification Quarterly*, 36(3–4), 47–55.
- Berg, B.L., Lune, H., & Lune, H. (2004). *Qualitative research methods for the social sciences* (Vol. 5). Boston: Pearson.
- Bhattacharya, S. (2006). Metadata harvesting. Retrieved from [http://ir.inflibnet.ac.in/bitstream/handle/1944/533/6\(cal%2006\).pdf?sequence=1](http://ir.inflibnet.ac.in/bitstream/handle/1944/533/6(cal%2006).pdf?sequence=1)
- CIDOC (2003). The CIDOC Conceptual Reference Model. 2003-10. <http://cidoc.ics.forth.gr>
- Corti, L., & Marcon, G. (2003). I beni culturali e la loro catalogazione. *Pearson Italia Spa*. Accessible at <http://www.iccd.beniculturali.it/>
- DCMI (2012). Dublin Core Metadata Initiative Metadata Terms. Available at <http://dublincore.org/documents/dcmi-terms/>
- Dent, V.F. (2011). *Qualitative research and the modern library*. Oxford, UK: Chandos Publishing.
- Doerr, M. (2009). Ontologies for cultural heritage. In *Handbook on ontologies* (pp. 463–486). Berlin, Heidelberg: Springer.
- Doerr, M., et al. (2010, August). The Europeana data model (EDM). In *World Library and Information Congress: 76th IFLA general conference and assembly* (pp. 10–15).
- Forum on Information Standards in Heritage (2007). *MIDAS Heritage*. Accessible at <http://heritage-standards.org.uk/midas-heritage/>
- Foulonneau, M., & Riley, J. (2008). *Metadata for digital resources: implementation, systems design and interoperability*. Oxford, UK: Chandos Publishing.
- Garoufallou, E., Siatri, R., & Balatsoukas, P. (2008). Virtual maps—virtual worlds: Testing the usability of a Greek virtual cultural map. *Journal of the American Society for Information Science and Technology*, 59(4), 591–601.
- Getty Trust (2014). CDWA List of Categories and Definitions. Available at http://www.getty.edu/research/publications/electronic_publications/cdwa/definitions.pdf
- Grant, A., & Cowton, J. (1997). *Spectrum: the UK museum documentation standard*. Museum Documentation Association.
- Gilliland, A.J. (2008). Setting the stage. In *Introduction to metadata*, Getty Information Institute: Los Angeles, CA, 3.
- Haynes, D. (2004). The five purposes of metadata. *Library+ Information Update*, 3(7/8), 30–31.
- Hu, X., Ho, E.M.Y., & C. Qiao (2017). Digitizing Dunhuang cultural heritage: A user evaluation of Mogao cave panorama digital library. *Journal of Data and Information Science*, 2(3), 49–67.
- Jones, C.B., Alani, H., & Tudhope, D. (2001). Geographical information retrieval with ontologies of place. In *Spatial information theory* (pp. 322–335). Berlin, Heidelberg: Springer.
- Koolen, M., Kamps, J., & de Keijzer, V. (2009). Information retrieval in cultural heritage. *Interdisciplinary Science Reviews*, 34(2–3), 268–284.
- Lee, J.H., Tennis, J.T., Clarke, R.L., & Carpenter, M. (2013). Developing a video game metadata schema for the Seattle Interactive Media Museum. *International Journal on Digital Libraries*, 13(2), 105–117.
- Library of Congress (2014). VRA Core. Accessible at <http://www.loc.gov/standards/vracore/>
- Liew, C.L. (2005). Online cultural heritage exhibitions: a survey of information retrieval features. *Program*, 39(1), 4–24.
- Maedche, A., & Zacharias, V. (2002). Clustering ontology-based metadata in the semantic web. In *Principles of Data Mining and Knowledge Discovery* (pp. 348–360). Berlin, Heidelberg: Springer.
- McHugh, M.L. (2012) Interrater reliability: the kappa statistic. *Biochemia Medica (Zagreb)*, 22(3): 276–282.
- Moen, W.E. (1998). Accessing distributed cultural heritage information. *Communications of the ACM*, 41(4), 44–48.
- Patel, M., et al. (2005). Metadata requirements for digital museum environments. *International Journal on Digital Libraries*, 5(3), 179–192.
- Ronzino, P., Amico, N., & Niccolucci, F. (2011). *Assessment and comparison of metadata schemas for architectural heritage*. In Proceedings of the CIPA. Czech Technical University in Prague in cooperation with CIPA: Prague, Czech Republic.
- Ronzino, P., Hermon, S., & Niccolucci, F. (2012). A metadata schema for cultural heritage documentation. V., Capellini (ed.), *Electronic Imaging & the Visual Arts: EVA*, Firenze University Press: Florence, Italy, 36–41.
- Schuurman, N., & Leszczynski, A. (2006). Ontology-based metadata. *Transactions in GIS*, 10(5), 709–726.
- Smiraglia, R.P. (2005). Content metadata—an analysis of Etruscan artifacts in a museum of archeology. *Cataloging & Classification Quarterly*, 40(3–4), 135–151.
- Strauss, A., & Corbin, J. (1994). *Grounded theory methodology*. *Handbook of Qualitative Research*, 17, 273–285.

- UNESCO (n.d.). *Cultural relics protection law of the People's Republic of China*, http://www.unesco.org/culture/natlaws/media/pdf/china/china_lawprotectionclt_entof
- van Den Akker, C., et al. (2013, May). From information delivery to interpretation support: evaluating cultural heritage access on the web. In *Proceedings of the 5th Annual ACM Web Science Conference* (pp. 431–440). New York: ACM.
- Waterton, E., & Watson, S. (Eds.). (2010). *Culture, heritage and representation: Perspectives on visuality and the past*. Farnham, UK: Ashgate Publishing.
- Weinstein, P.C. (1998, May). Ontology-based metadata: transforming the MARC legacy. In *Proceedings of the Third ACM Conference on Digital Libraries* (pp. 254–263). New York: ACM.
- Zhang, Y., & Li, Y. (2008). A user-centered functional metadata evaluation of moving image collections. *Journal of the Association for Information Science and Technology*, 59(8), 1331–1346.

Appendix: Interview Protocol

Questions on mural and stone cave temple information-seeking behaviors:

Q1. How do you seek information related to murals and stone cave temples?

Q2. What kinds of information related to murals and stone cave temples do you look for?

Suggestions on organizing mural and stone cave temple information:

Q3. How can information on murals and stone cave temples be better organized to improve users' information seeking experience?

Q4. What metadata elements are necessary for facilitating users' search?

Comments/reviews on metadata schema:

Q5. Evaluation of each element in the drafted metadata schema: for each element, how do you think about its importance for searching, browsing, and managing information of murals and stone cave temples?

Q6. Evaluation of the entire metadata schema: how do you feel about the schema as a whole?