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Design Science as a methodology for the development of Knowledge Organization Systems in museological entities

Abstract
Information overload has brought marked changes in the way people search for information and, in turn, has reshaped society. Today, people want well-communicated, efficient information to help them accomplish tasks on the Internet, especially in digital information environments, such as digital libraries, digital repositories and digital museums. The aim of this article is to present a design method for creating a technological artifact, understood as a digital environment, hosting a digital museum that supports an optimized knowledge organization system based on human rather than subject-based aspects. It is an epistemological, bibliographic study, in which we suggest a theoretical reference based on Design Science Research for research and development of information systems with efficient knowledge organization in the digital environments of museological entities, and consequently efficient information retrieval. In general, the organizational structure of information appropriation in different contexts and media in digital environments of museological entities demands a re-contextualization of the museum object when it is transformed from the physical to the digital context. In this process, the interface is the locus where the interaction of the individual with the museum objects and the knowledge organization content of this digital environment take place. This interface should, therefore, be based on the principles of Design Science to provide quality solutions and innovations.

Introduction
Information overload has brought about marked changes in the way people search for information and, in turn, has reshaped society. Today, people want well-communicated, efficient information to help them accomplish tasks on the Internet, especially in digital information environments, such as digital libraries, digital repositories and digital museums. On the other hand, there is an exponential growth in the number of museum websites with diverse modes of knowledge and information organization based on traditional subject-based knowledge organization tools, which may be, at times, frustrating and fail to meet the demands of information society.

The aim of this article is to present a design method for creating a technological artifact, understood as a digital environment, hosting a digital museum that supports an optimized knowledge organization system based on human rather than subject-based aspects. Thus, the suggestion of this study is that digital museum environments be organized considering human aspects such as the reason for information search, cognitive functions and meaningful experiences, influence of social and technological aspects on knowledge growth, etc.

Method
This is an epistemological, bibliographic study, in which we suggest a theoretical reference based on Design Science Research for research and development of
information systems with efficient knowledge organization in the digital environments of museological entities, and consequently efficient information retrieval.

This study is justified since, according to the strategic map of museums, the issues related to preservation, diffusion and access, as well as social function, education and research comprise at least 50% of the museum's strategic actions (Ibram Management Report [IBRAM] 2016). Contemporary museology has faced challenges, leading to new study perspectives, without concern for specific themes and privileging diverse contributions, as well as focusing on themes that go beyond communication processes and museum spaces.

The museum is a place where: "sensations, ideas and ready-made images radiated by objects and gathered references together illuminate essential values for the human being. A fascinating space where one discovers and learns, in it one widens knowledge and deepens awareness of identity, solidarity and sharing" (Santos 2014, online, our translation). Wagensberg (2005) proposes a definition conceptualized as Total Museology; for the author, the museum is a tool for individual change and therefore for social change. Reality is built from both objects and phenomena, and the role of the museum is to stimulate.

The museum object is an actor and also an information agent. Through the stories told by these objects, memories arise for visitors, often from a past time. It is from contemplation or immersion that the visitor constructs narrative discourses. We can say that there is a museological temporality in the exhibitions. The museum objects are coated with the reality, meanings and cultural manifestations of man and it is in this perspective that the visitor builds networks of intentionality, through memories and recollections. In this sense, the perceptual act arises from the direct contact with the memory and from the encounter relationship of the subject with the object. In this scenario, understanding the visitors and their expectations is imperative to organizing the communicative strategies properly.

**Museum communication**

The discussions of new museological perspectives have also provoked the development of new approaches in the literature; not only as a result of the discussion of existing museum practices, but several attempts to renew or develop a brand-new museum frame were also presented (Alsford 1991; Bearman 1995; Anderson 1997; Scweibenz 1998; Hodge 2011; Campos et al., 2011). By considering museological digital environments, conceptualizing some terms in the context of museums is deemed necessary.

The term communication, according to Lasswell's general model (1948), is understood as the action of transmitting information between one or more emitters (E) and one or more receivers (R), through a channel (C). This conception has a wide range
of applications, encompassing not only human processes, but also communication processes across machines. The model proposed by Lasswell (1948) may be a reciprocal phenomenon (E↔C↔R) with interactive characteristics, or even a unilateral phenomenon (E→C→R), and in this way communication operates in time and not only in space, named transmission (Debray 2000).

The function of museum communication includes a wide range of activities (Mensch 1992), of which the main ones include exhibitions, scientific publications, educational programs and events. The "Interactive Experience Model", based on the perspective of the visitor, was proposed by Falk and Dierking (1992) and is based on interaction within three contexts: personal context, social context and physical context. The personal context embodies a variety of experiences, including visitor knowledge, which includes individual interests, motivations, and concerns. The perspective of each visitor is strongly influenced by the social context; individuals visit the museums in group, or alone, and invariably, get in contact with other visitors and museum staff. The physical context includes the architecture and "feeling" of the building as well as the exhibitions contained in the physical environment. In the proposed model, all three contexts are considered.

ICOM (2008) applies the term "communication" in a more complex way and includes the exhibition, publication and education functions of the museum in the museum communication process: "the museum […] acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment." This logic presents a more general museological communication process, observed in the PRC (Preservation - Research - Communication) process proposed by Reinward Academi from Amsterdam, which includes the functions of exhibition, publication and education exercised by the museum in the process.

We realize that research has advanced to understand communication in museums through user research and visitation studies. Usually the research responds to how the individual “uses” the museum, and although they bring important issues, these studies point out to perspectives limited to certain contexts.

This new way of thinking about museum communication and studies with visitors also meant a breakthrough with some traditional approaches to museums, therefore provoking a conflict between old and new generations of museum scholars (Candlin 2012; Kidd 2011; Johnson 2005; Marwick 1995). Perhaps because new approaches often involve interdisciplinary work and consultation of experts from other areas of knowledge, as Janes (2013, p. 15) points out:

> The reluctance to use consultants and knowledgeable outsiders to tap different, and perhaps contradictory, perspectives to stimulate internal rethinking may be the result of professional conceit or insecurity among senior staff, but the consequences are the same - the loss of untapped internal
knowledge and creativity with which to build institutional renewal.

It is important to consider other communication means, in addition to the exhibitions, presented as the most important means and communication process for museums. Therefore, exploring new ways of thinking through interdisciplinary research and the use of communicational creativity in museums is desired. One of the tasks of the contemporary museum is to provide different types of learning for different audiences that can provide meaning, entertainment and possible knowledge construction through interactivity.

As new technology is introduced, new artifacts are created, interaction through digital environments develops rapidly, and many museums are embracing these new media as part of their communication (Tsichritzis and Gibbs 1991; Hornecker and Stifter 2006; Tsitoura 2010; Campos, et al. 2011; Hodge 2011). There are relatively few studies on the ways in which individuals interact with exhibitions in museums and galleries, and even fewer studies on the form of collaboration and participation of subjects interacting with new forms and interactive media in museums.

In this way, some of the new perspectives that the museums have been facing involve the new media. Below, we present a structure that proposes to identify the problems and solutions for the development of knowledge organization systems in museological entities through Design Science Research.

Design Science Research

Design Science Research was introduced by R. Buckminster Fuller in 1957. The author defines research in design as a systematic way of planning and designing, whether for medicine, architecture, product design, graphic design, information systems, etc. The term was later used in Gregory’s book (1965) at the Conference on Methods in Design, when the author distinguished between scientific method and design method. Herbert Simon (1968) in his lectures on "Karl Taylor Compton" used and popularized these terms in his argument for the scientific study of artificial information systems.

Contemporaneously, a design research framework developed by Hevner et al. (2004) combines two paradigms of research: the paradigm of behavioral science and the paradigm of design science. Behavior science develops and verifies the needs of the digital system/environment, whereas design science produces an efficient and effective technological utility to solve the problem (Hevner, et al. 2004; Hevner 2007). The constructive activity in Design Science Research can be understood as human cognitive (e.g., complexity, creativity, control) and social (collaboration) activities, which contribute to the design and development of mediating objects, with the possibility of enhancing knowledge and information organization of information systems according to the context and human needs (Hevner, et al. 2014).
The framework and the conceptual guidelines used in the present proposals are presented in Figure 1 and 2, respectively.

Figure 1: Framework for Design Research in Information Systems (IS)

Source: Adapted from (HEVNER, et al. 2004, p. 80, and HEVNER 2007, p. 2)

Simon (1996) points out that Design Science Research is motivated by the introduction of new artifacts and the processes that allow construction and innovation from these artifacts. According to the research developed by Hevner (2007), three research cycles are identified.

To understand the framework, the definitions and meanings of each of the cycles is presented. The environment defines the space of the problem (Simon, 1996) where the phenomena of interest reside, in addition to defining the business needs, it is where the relevance cycle is found. The knowledge base provides the raw materials through which research in information systems is performed. The knowledge base is composed of scientific foundations and methodologies for investigating the problem. The methodologies provide guidelines used in the justification/assessment phase of the problem situation. In behavioral science, the methodologies are typically rooted in data collection, empirical analysis techniques, case studies, and experimental simulations.

According to Hevner (2007, p. 3):

the relevance cycle initiates design science research with an application context that not only provides the requirements for the research (e.g., the opportunity/problem to be addressed) as inputs but also defines acceptance criteria for the ultimate evaluation of the research results. Does the design artifact improve the environment and how can this improvement be measured?
The result of scientific design research should be applied in the environment specific to the context which is found for study and assessment in the application and/or information system. The study field of the artifact can be carried out through appropriate methods of technology transfer assessment, such as action research (Jarvinen 2007).

Rigor Cycle connects the Design Science activities with the knowledge base of scientific foundations, experience and expertise that bring information about the entire research project and the state of the art in the context of the research object. Through this knowledge base, specific knowledge is provided. This should ensure the development of an innovation in the field of knowledge the research is contributing.

Design Cycle, located in the center of the framework, iterates and interacts across the main activities of constructing and assessing the artifacts and across the processes that involve the research project of the artifact in question. The three cycles should be present and clearly defined in a research project in Design Science.

Design Science is inherently a problem-solving process. One of the fundamental principles of Design Science Research is based on the knowledge and understanding of a Design problem and its solution, the guidelines developed by Hevner, et al. (2004) were based on these principles and are described in Figure 2.

According to Hevner, et al. (2004) the guidelines are meant to assist stakeholders to understand what an effective design-science research comprises. The authors are against a strict use of guidelines, as they believe researchers, reviewers and editors should use creative skills and personal judgement in determining the use of each guideline in a research project.

Figure 2: Guidelines for Design Science Research

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Description</th>
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<tbody>
<tr>
<td>Guideline 1: Design as an Artifact</td>
<td>Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.</td>
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<tr>
<td>Guideline 2: Problem Relevance</td>
<td>The objective of design-science research is to develop technology-based solutions to important and relevant business problems.</td>
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<tr>
<td>Guideline 3: Design Evaluation</td>
<td>The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.</td>
</tr>
<tr>
<td>Guideline 4: Research Contributions</td>
<td>Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.</td>
</tr>
<tr>
<td>Guideline 5: Research Rigor</td>
<td>Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.</td>
</tr>
<tr>
<td>Guideline 6: Design as a Search Process</td>
<td>The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.</td>
</tr>
<tr>
<td>Guideline 7: Communication of Research</td>
<td>Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.</td>
</tr>
</tbody>
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Source: HEVNER, et al. 2004, p. 83
The Framework and the guidelines (Figure 1 and 2) provide the specificities to be included in the steps and subsequent definition of the design metrics to solve the mentioned problems. Thus, the guidelines should inform the development of an efficient and effective information system according to the human needs found in order to optimize knowledge organization.

Conclusions

The postmodern museum is clearly a participatory and attractive museum (Black 2005; 2012; Simon 2010). Thus, the museum needs to undergo transformations and have some flexibility. Many museums seek to be collaborative and interactive and, at the same time, they must be places that provide social interaction, the construction of relevant meaning, and places of experimentation and curiosity. All these elements cover a flexible form of communication. In order to construct a strong and robust new museum communication, museums should implement a thorough communication strategy. The transformations in museums have been underway for some time, although museums are always different and approach new features in their own way. Most museums could benefit from articulating their goals and purposes in redefining communication and using the principles of Design Science Research.

Hornecker and Sifter (2006, p. 7) highlight that:

One of the proponents of ‘Experience Design’, Nathan Shedroff (2000) argued that the most engaging interactive experiences allow for productivity, creativity and/or communication, as these (a) are basic human motivations, and (b) inherently entail interaction by requiring open-ended activity of users. This leads us to suggest creative, communicative and personal interactions as a valuable avenue for installations in public spaces (museum installations seem a useful test bed for exploring these types of interactive experiences).

In general, the organizational structure of information appropriation in different contexts and media in digital environments of museological entities demands a re-contextualization of the museum object when it is transformed from the physical to the digital context. In this process, the interface is the locus where the interaction of the individual with the museum objects and the knowledge organization content of this digital environment take place. This interface should, therefore, be based on the principles of Design Science Research framework and guidelines to provide quality solutions and innovations, pointing out new perspectives for communication and mediation of museum objects.

References


