Eliciting Design Requirements for a Knowledge Management System in Cultural and Historical Heritage

Néstor A. Nova[1] [a] and Rafael A. Gonzalez[2] [b]
[1]Department of Information Science, Pontificia Universidad Javeriana, Bogotá, Colombia
[2]Department of Systems Engineering, Pontificia Universidad Javeriana, Bogotá, Colombia

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Abstract: Designing a Knowledge Management System (KMS) from a socio-technical approach, usually includes elicitation of distinct, yet related, requirements from a user, system and domain level. However, this perspective presents shortcomings in terms of emergent and co-evolving interactions between agencies, particularly in highly-dynamic use contexts. To address these issues, this paper reports on a design science study that develops three design requirements grounded on sociomaterial (SM) tenets, and based on the study of imbrications between social and material agencies. We do so in the context of an interorganizational knowledge sharing network in the cultural and historical heritage domain, showing how the sociomaterial coordination practices could be better understood and directed to design practices. The findings reveal that a KMS derived from sociomaterial lens could potentially address different coordination issues that arise when sharing knowledge between heritage projects. Our artefact will be helpful in applying what have been mostly theoretical discussions on sociomateriality in highly-dynamic design settings.

1 INTRODUCTION

Coordinating people to find an effective knowledge sharing space is one of the key issues in organization science (Malone and Crowston, 1994; Mintzberg, 1983). Designing coordination for sharing knowledge has been the primary goal of IS scholars and practitioners for at least three decades (Burton, Obel, & Haakonsson, 2020; Jarzabkowski, Lê, & Feldman, 2011; Malone & Crowston, 1994). However, the knowledge sharing is hindered by a lack of coordination design process that account for some of the novel technological phenomena such as ubiquitous and pervasive infrastructure and social phenomena like heterogeneity, which are becoming more common and natural in knowledge-sharing practices.

The design of coordination mechanisms, such as KMS, has evolved from a focus on a logic of pre-determination, prediction and pre-specification (Alavi & Leidner, 2001; Malhotra, 2004), to dynamic, emergent, contextualized and non-patterned coordination (Faraj & Xiao, 2006; Jarzabkowski et al., 2011; Okhuysen & Bechky, 2009). Recent studies have establish the benefits of using the sociomaterial approach to examine how the knowledge work is coordinated in practice (Beane & Orlikowski, 2014; Constantinides & Barrett, 2012; Hilaricus, 2011). This paper addresses the need for a more fine-grained knowledge for eliciting design requirements for KMS that contribute to improve coordination for sharing knowledge in interorganizational networks.

The motivation for this paper arose out of difficulties we experienced trying to design a KMS for an international and interorganizational network of universities aiming to share specialized knowledge about rehabilitation, conservation or protection of material and historical heritage. Prior approaches to design KMS have been proposed in the KM literature following the a socio-technical perspective (Cao, Thompson, & Triche, 2013; Grundstein & Rosenthal-Sabroux, 2007; Sajeva, 2010). When we attempted to use the socio-technical approach to identify design requirements for KMS, we had challenges obtaining results that could be ontologically aligned with our field observations. The main barrier of this sociotechnical approach is that its coordination design philosophy overlooks the social dynamics of

[a] https://orcid.org/0000-0003-2624-8314
[b] https://orcid.org/0000-0003-1237-4408

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coordination, the material agencies of the mechanisms and the contextual dimensions in which any of them unfolds for sharing knowledge at individual extent. For instance, heritage experts' everyday environments are flooded with digital and material artifacts for both sharing knowledge and performing technical activities, and this ICT diversity affords them many possibilities to become coordinated using different technologies with different people, in different ways, and at different times and places, which changes dynamically the knowledge work. These means that eliciting requirements for KMS from a static view can be incoherent when the coordination practices are totally dynamic.

After experiencing these difficulties, we elected to formulate new and more fine-grained knowledge about eliciting design requirements for a KMS in the heritage domain. We use the term design requirement to refer to the set of features and functions an artifact must embody and what constraints it must satisfy in order to address goals, capabilities, purposes and limits of the system (Hansen, Berente, & Lyytinen, 2009). Specifically, we consider design requirements as the specification of particular materiality enacted by a KMS to accomplish a goal. They capture increasingly diverging and dynamic needs of people during social interaction and evolution with the KMS.

In this paper, the design requirements are concerned with the improvement of the coordination process for sharing knowledge. Furthermore, we used a design science research approach to explore an interorganizational knowledge sharing network in the heritage domain and the theoretical bases of sociomateriality in order to elucidate the design requirements for KMS. Design science research (DSR) addresses important unsolved problems by combining theory, field research, and design and evaluation practices in unique or innovative ways to develop innovative artifacts and derive new knowledge. Design science research is a proper approach when investigating in the information systems arena (Hevner & Chatterjee, 2010) however, this paper demonstrates how DSR it is also well-suited for identifying sociomaterial design requirements for KMS in the heritage domain.

The benefits of fine-grained knowledge about the sociomaterial elicitation of design requirements for KMS are (1) researchers can explore an empirical example about eliciting design requirements for IS artifacts from sociomateriality, and (2) practitioners can receive specific guidance to improve the coordination process for sharing knowledge when designing a KMS in knowledge sharing networks.

In the following sections, we begin by examining prior approaches in the research literature for sociomateriality followed by a description of the methodological approaches to study design. We then describe the DSR methodology and the design process. Next, we outline the sociomaterial design requirements and the corresponding evaluation. The following section describes the findings of the case study that was used to elicitate the design of requirements and evaluate the reliability, validity, and utility. We conclude with a discussion of implications for future research and practice.

2 BACKGROUND

Among scholars and organizational practitioners alike, Knowledge Management Systems (KMS), have attracted considerable attention during the last decade and it is projected to be one of the top research priorities in future IS research about Knowledge Sharing (KS) (Alavi & Leidner, 2001; Chaudhuri, Chavan, Vadalkar, Vrontis, & Pereira, 2020). KS is one of the major Knowledge Management (KM) processes along with discovery, capture and application (Alavi & Leidner, 2001; Becerra-Fernandez & Sabherwal, 2010; Davenport & Prusak, 1998). Scientific literature highlights that KMS, defined by Alavi and Leidner (2001) as Information-Technology (IT)-based systems supporting the different phases of the KM processes, have an important role in promoting knowledge sharing (KS) (Choi, Lee, & Yoo, 2010). Understanding the KS process in practice can affect the KMS design and implementation (Cerchione, Centobelli, Zerbino, & Anand, 2020) mainly because there are philosophical considerations about alignment between both social structures and technologies involved in the KS process that are often overlooked (Néstor A. Nova, 2019).

The development of information systems should be informed by a well-designed approach. Different KMS design approaches can be traced from IS literature. For example, Alavi and Leidner (2001) consider KMS as an IT-based information system applied to managing organizational knowledge to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application. Technical aspects of the KMS leads to usage, and usefulness perception (Alavi & Leidner, 2001). In addition, Maier (2007) also consider KMS from an IT-based perspective (instruments, services, platforms) aiming to support user and business needs (initiatives, process, participants) within a domain context (Maier, 2007). Complementary, a KMS can be considered as a variety of IT-based mechanisms or a dynamic combination of them, to support the KM processes (Becerra-Fernandez & Sabherwal, 2014).

One of the main functions of a KMS is to facilitate the communication processes and information flows across individuals, groups, departments, and/or organizations (Alavi & Leidner, 2001; Becerra-Fernandez & Sabherwal, 2014). In general, the approaches to elicitate KMS requirements are grounded in the information-processing view of coordination which implies identifying separately and the matching knowledge needs and coordination mechanisms (Malone & Crowston, 1994). The focus of the elicitation process in KMS design has been traditionally placed upon the system-level, stakeholder-level or domain-level (Deve & Hapanyengwi, 2014; Williams, 2015). Consequently, the whole organizational system has to be treated and analysed in pieces. Some attempts for considering an integrated view of technological mechanisms and human/social structures when designing a KMS have been proposed following the socio-technical (ST) perspective (Gallupe, 2001; Grundstein & Rosenthal-Sabroux, 2007; Sajeva, 2010). The ST approach is considered the most prominent philosophical perspective to design KMS (Sajeva, 2010) and it looks for a balance, synergy and interplay between technological and social agencies aiming to manage knowledge more effectively (Sajeva, 2010). From a ST view, designing a knowledge sharing system is not just a matter of knowledge access and retrieval. A successful KMS must have the quality attributes related with scale, extension, collaboration, complexity, flexibility, heuristic properties, access, centralization, retrieval, visualization, understanding, awareness (knowledge and knowers). Table 1 lists the crucial requirements for the success of a KMS.

Even though the ST approach has many attractions when elicitating KMS requirements, the high failure rates of IS projects questions existing assumptions and approaches as they have not served us too well (Cecez-Kecmanovic, Kautz, & Abrahall, 2014; Kautz & Cecez-Kecmanovic, 2013). The ST approach to elicitate KMS requirements is also flawed in a number of significant ways. For example, it (1) often focus design on technologies without consideration of the social processes that surround them (Hasan & Crawford, 2003); (2) assumes a determinist perspective (Halawi, McCarthy, & Aronson, 2017; Sajeva, 2010) focusing just on human agency (people), thus ignoring material structures, or focusing on the material agency (technology) underplaying the action of humans; (3) refers to knowledge work at institutional level as opposed to individual inquiries (Leonardi, 2012) ignoring some novel technological phenomena such as ubiquitous and pervasive infrastructure (Jarrahi, Nelson, & Thomson, 2017) and social phenomena like heterogeneity (Cummings, Kiesler, Bosagh Zadeh, & Balakrishnan, 2013); and (4) ignores the dynamic, emergent and situated behavior of coordination for sharing knowledge (Okhuysen & Bechky, 2009). These issues call for a sociomaterial perspective that dissolves the analytical boundaries between users, systems and domains, in order to capture dynamic social interaction and co-evolution with the KMS (Néstor A. Nova, 2019).

In this research, we use sociomateriality as a justificatory knowledge (kernel theory) that inform the elicitation of KMS requirements. Sociomateriality literature incorporates various preceding theories, e.g. socio-technical systems, actor network, and practice theory (Leonardi, 2013). Sociomateriality aims to understand and explain the relation between the social and the material in organizational and technological contexts (Cecez-Kecmanovic et al., 2014). The two major streams of sociomateriality can be traced in literature, which differ by their ontological foundations (Kautz & Cecez-Kecmanovic, 2013). The agential realism view treats the social and material as inseparable, self-contained and entangled in organizational practices (Scott & Orlikowski, 2008), whereas, the critical realism view consider that the social and material can be identified separately and explained as overlapping patterns of routines and technologies that get imbricated overtime (Leonardi, 2013). In this research, we ground on the imbrication view as it leaves space for improvement (Bratteteig & Verne, 2012) and offers more opportunities for design intervention, as it assumes that sociomaterial assemblages can be disentangled, separately improved and re-arranged. Acknowledging the empirical separateness and potential imbrication of these agencies is a necessary move for designing technologies and organizations that work better (Leonardi & Rodriguez-Lluesma, 2012). From this perspective, technology and social agencies constitute a sociomaterial ecosystem in which a group of technologies and people are ensembled and orchestrated temporary and dynamically according to emergent and contextual needs (Néstor A. Nova, 2019). The sociomaterial ecosystem exists initially at individual level, but when collaborating with others, new and larger ecosystems can be formed to develop group tasks.

In this research we use the imbrication metaphor to understand how affordances (possibilities for action) (Leonardi, 2011) can lead the design and redesign of coordination mechanisms for sharing knowledge in the heritage domain. Employing the metaphor of imbrication, however, has several implications. First, recognizing that that someone (heritage expert or IT designer) is responsible for putting the social and the material together, but that they were ever separate in the first place. Second,

Table 1: KMS design requirements from the socio-technical perspective.

Requirement	Source
Scalable: should manage to support a large number of users	(Deve & Hapanyengwi, 2014; Nevo & Chan, 2007)
Extensible: expands per organizational needs	(Deve & Hapanyengwi, 2014)
Secure: should allow different access level to project information enabling to share relevant knowledge according to project needs	(Deve & Hapanyengwi, 2014; Nevo & Chan, 2007; Nestor A. Nova & Gonzalez, 2016a)
Collaborative: should support the interactions of the various organizational units across the organization	(Deve & Hapanyengwi, 2014; Nevo & Chan, 2007; Nestor A. Nova & Gonzalez, 2016a; Perez-Araos, Barber, Eduardo, & Eldridge, 2007; Secundo, Del Vecchio, Simeone, & Schiuma, 2020)
Complex querying capabilities	(Deve & Hapanyengwi, 2014; Frank, 2001)
Flexible: should be able to handle all possible forms of knowledge used and required by the organization	(Becerra-Fernandez & Sabherwal, 2014; Deve & Hapanyengwi, 2014; Nevo & Chan, 2007; Nestor A. Nova & Gonzalez, 2016a)
Heuristic: the KMS should learn about its users and the knowledge it possesses	(Deve & Hapanyengwi, 2014)
Accessible: enable access to project insights during and after the project life-cycle affording reuse of knowledge	(Frank, 2001; Lisanti, Luhukay, Veronica, & Mariani, 2014; Nevo & Chan, 2007; Nestor A. Nova & Gonzalez, 2016a; Perez-Araos et al., 2007; Secundo et al., 2020)
Centralized: should allow to connect different knowledge repositories in a central storage medium	(Becerra-Fernandez & Sabherwal, 2014; Nevo & Chan, 2007; Nestor A. Nova & Gonzalez, 2016a)
Retrievable: should support experts to complete the information needed to perform project tasks and make decisions effectively	(Becerra-Fernandez & Sabherwal, 2014; Nevo & Chan, 2007; Nestor A. Nova & Gonzalez, 2016a; Perez-Araos et al., 2007)
Visualizable: should offer different knowledge visualization options enabling customized connection with the already available knowledge	(Becerra-Fernandez & Sabherwal, 2014; Frank, 2001; Nevo & Chan, 2007; Nestor A. Nova & Gonzalez, 2016a; Secundo et al., 2020)
Understandable: should offer definitions of concepts that are needed for the description and analysis of a corporation	(Frank, 2001)
Awareness: should support the dissemination of knowledge	(Frank, 2001; Nestor A. Nova & Gonzalez, 2016a)

time and space are an important part of the conversation (symbolic communication within and between social and material agencies) because affordance perception depends on contextual situations that determine the type and length of the imbrication. And, third, imbrications can be dismounted (Leonardi & Rodriguez-Lluesma, 2012) and there is no ideal or finite number of imbrications. In particular, Leonardi argues that the perception of constraints leads people to change their technologies, while the perception of affordance leads people to change their organizational routines. Both perceptions are constructed in the space of imbrication called trading zone (Leonardi, 2011).

3 METHODOLOGY

We ground this research in the Design Science Research (DSR) approach (Gregor and Jones 2007; Hevner et al. 2004) because our primary goal is to develop a new artifact. The choice of DSR as research strategy is based on the nature of the research problem, on the status of theory development in the research field, the audience to whom it is to be communicated (Gregor & Hevner, 2013) but also in the coherence with the critical realism perspective (Leonardi, 2013) that we adopted to study sociomateriality in the design arena (Carlsson, 2010). This improvement research (Gregor & Hevner, 2014) aims to create a better solution for eliciting KMS design requirements in sharing knowledge networks. Since DSR in information systems is issue-driven (Hevner, March, Park, & Ram, 2004), the Relevance Cycle guided the start of this research. A preliminary exploration of the case study was conducted in order identify real problems coordination issues for sharing knowledge. The Rigor Cycle then began by studying literature about coordination in practice and identifying the limits of the knowledge-base. This led back to the Relevance Cycle in the case study in which observation of coordination for sharing knowledge provided empirical content to the theoretical concepts and contributed to identifying the role of social and material agencies in coordination practices. Afterwards, we performed a Rigor Cycle by

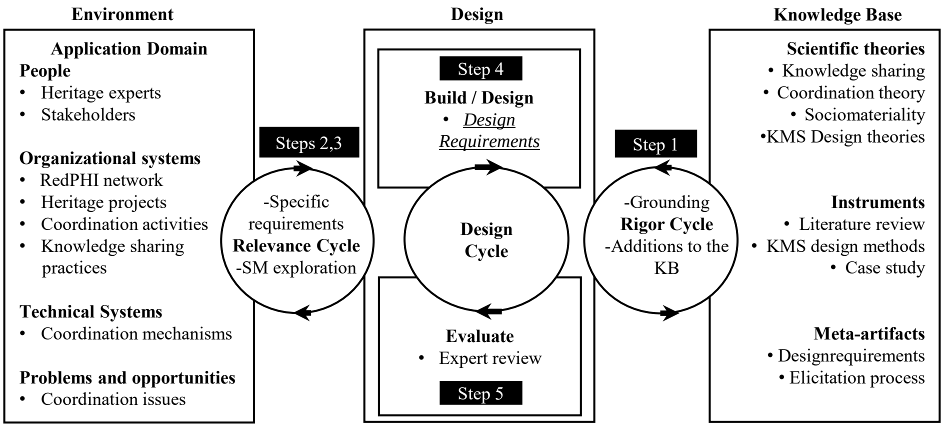

Figure 1: DSR setting (adapted in parts from Hevner 2007) and the elicitation steps.

drawing on the existing body of knowledge regarding information systems design and sociomateriality. In the Design Cycle, we derived a set of design requirements (Walls, Widmeyer, & El Sawy, 1992) that lead the KMS design. Evaluation was conducted through an expert review session by following the principles suggested by (Maranzano et al., 2005). Furthermore, the final set of design requirements was formulated and corroborated through empirical evidence and literature insights. This paper describes the final iteration of the research process which is presented in Figure 1.

To ensure the artefact is grounded in theory and empirical evidence, it is developed using exploratory research methods for developing theories or managerial guidelines from case study evidence (Eisenhardt, 1989). In this paper, the knowledge developed from the case study consists of actionable propositions related to the elicitation of design requirements rather than a design theory (Gregor & Jones, 2007). The case study focuses on the contemporary phenomenon of coordination for sharing knowledge, and the researcher had no control over the behavioural events of the study. According to Yin (2009), these conditions argue for the use of case study research.

This research is grounded on an exploratory single-case study (Yin, 2009). The case study was a knowledge sharing network about historic and cultural heritage called RedPHI. RedPHI is an international and interorganizational network of 46 universities of seven countries which are highly specialized in heritage projects, involving diagnosis, management, conservations, restoration, and maintenance of material heritage objects, and aiming for protection and conservation through research, education and consultancy projects in the architectural, urban and landscape scope. RedPHI has some characteristics which make it a special setting for studying sociomaterial knowledge sharing coordination. First, heritage projects involve heterogeneous actors that develop specialized heritage activities. Heterogeneity means different: disciplines, groups, institutions, networks, location, research philosophies and methods, data and information types, tasks and activities, and others. Second, heritage projects involve a set of coordination issues for knowledge sharing (Nestor A. Nova & Gonzalez, 2016a). Third, RedPHI has evolved from using an ontological view of heritage objects as monument, which is based on environmentalist and geometric statements, towards a territorial approach focused on considering physical space, human and social behaviours, and contextual dimensions as an entanglement where the concept of territory embodies a sociomaterial notion (Montañez & Viviescas, 2002; Santos, 1997).

At the time of this research, the RedPHI had designed a web-based KMS service to visualize structured text of heritage objects aiming to facilitate knowledge sharing between experts, however, the performance was not satisfactory due to misalignment between materiality of the system and human agency. The selection of the cases study was based on these issues jointly with full access to data resources by the heritage experts and the particular sociomaterial characteristics of the heritage work. The possibility to "observe transparently" the process of interest and flexibility during data collection (Eisenhardt, 1989) were also indicated as criteria to select RedPHI.

The data collection in this case study included document analysis, interviews and direct observation in the fieldwork. We collected several documents including publications, technical reports, technical memos, videos, pictures, audio and video records, presentations, among other information. Constant access to the project content and updates were guaranteed in order to monitor continuously the heritage projects through conversations and data for subsequent analysis. In addition, several interviews with heritage experts at RedPHI and native informants (people living within or around the heritage object) were held during the whole research. Information about knowledge sharing and information exchange between RedPHI researchers and other people was also informed during interviews and conversations. All formal interviews were recorded and transcribed and copious observational field notes were taken. Researchers visited the fieldwork taking advantage of willingness of heritage experts to share continuously their experiences, knowledge and documentation with researchers. In addition, researchers attended staff and group meetings, coffee conversations and phone calls with heritage experts. All data collected was related to creation and operation of RedPHI projects developed inside the case study and individual experiences of heritage experts. In addition, data was listed and saved in a database in order to ensure traceability of findings. Data analysis was carried out through structural codification process (Miles & Huberman, 1994). This process was tested in quality and functionality until reaching 90% of recode consistencies. Coding process were stopped when categories reached saturation. Case study analysis included pattern-matching logic (Yin, 2009).

Objectivity and quality of findings were assured via triangulation of multiple data sources (Eisenhardt, 1989). Use of such multiple sources helped us to generate data rich in detail and rigor, providing better scope for triangulation (Miles & Huberman, 1994) but also to mitigate bias. This increased the validity of the findings while contributing different perspectives on the constructs. Objectivity and content validity were also ensured through constant comparisons and pattern matching between the theories and data, through searching for rival explanations, via theoretical sensitivity of the researchers and by comparison between respondents (Eisenhardt, 1989; Strauss & Juliet Corbin, 1998; Yin, 2009). A formal case study protocol directed the case study exploration but also reinforced reliability, maintaining a database of evidence and findings, and comparing results from multiple respondents (Yin, 2009).

4 THE SM DESIGN REQUIREMENTS FOR KMS

By following the publication schema for a DSR study (Gregor & Hevner, 2013), in this section, we provide an overview of the design process and the set of design requirements for KMS (artifact design).

4.1 The Elicitation Process

The literature on design science in information systems has already pointed out the need for methodical support for the requirements elicitation process (Braun, Benedict, Wendler, & Esswein, 2015). In order to increase credibility on this study when eliciting design requirements, in this section we provide the detailed process carried out to elicitate them from a sociomaterial view. The five-step process to identify the design requirements is presented in Figure 1 and explained below.

First, a deeper analysis following the sociomaterial tenets was carried out in two major steps. First, several sociomaterial ecosystems participating in heritage projects were identified and characterized by analysing the data collected. This activity was important in order to know boundaries of the heritage work and determine the scope of the exploration in terms of coordination activities. Given the size of the network, we decided to filter heritage actors, focusing only on experts. Second, discussions about the ontological background of heritage work determined how we should perform further activities to explore conversations in RedPHI from sociomateriality. The focus of explorations was on sociomaterial practices for sharing knowledge between projects, but also on how the particularities of the design permeates the coordination of knowledge.

Second, several dependencies between knowledge coordination activities were identified and analysed as well as the coordination mechanisms used by experts to manage them (Nestor A. Nova & Gonzalez, 2016a). At this point, we used a people-dependencies-mechanisms framework (Okhuysen & Bechky, 2009) because it enacts a critical realist view that is coherent with our sociomaterial perspective of imbrication. The empirical separateness and potential imbrication of experts, coordination mechanisms and dependencies are necessary to understand the sociomaterial coordination in practice. Additionally, it is useful to identify how the knowledge sharing work can be improved by changing one (or more) of the constituents of the sociomaterial imbrication characterizing the situation. By analysing the collected evidence at this time, we identified several affordances and constraints perceived during the heritage work and the arguments for using a specific mechanism in a particular contextual dimension. Theses insights enact conversations in which relationships between expert´s goals and mechanisms are negotiated. The exploration of this continuum of conversations led us to identify different imbrications moments in practice across different contextualized actions (Nestor A. Nova & Gonzalez, 2016b).

Third, we examined the temporal embeddedness of coordination processes, and how orientations to the past and future by heritage experts influence the way how coordination mechanisms become imbricated in emerging coordination practices. Time is a characteristic of the Leonardi´s view who argue that without a temporal consideration, no analyst could explain why practices arise, endure, or change (Leonardi, 2013). Through interviews and surveys with heritage experts, we examined how people come to understand, interpret and deal with the materiality of technology-based mechanisms and how this existing materiality becomes imbricated with the knowledge sharing contexts into which it is introduced. We asked experts to answer questions regarding how people negotiate with materiality of technology during the heritage work; in which way materiality has supported or limited the knowledge sharing process over time; how experts change technology as they perceive constraints and how the change routines due to affordances perception; what role experts play in the creation of the sociomaterial over time; what are the particularities of the trading zones in which imbrications happen, among other questions.

Fourth, linking the problem space from the case study with the solution space from the literature in a structured and iterative manner (Hevner et al., 2004), allowed to abstract and formulate the design requirements. We aggregated theoretical positions and domain characteristic into design requirements and explained the goal of the KMS and why the sociomaterial design perspective can contribute to improving coordination in knowledge sharing activities.

Fifth, an expert review was conducted as evaluation process for the design requirements.

4.2 The Design Requirements (DQ)

The exploratory case study revealed that the coordination ecosystems for knowledge sharing activities are independent and temporary disconnected. All the coordination materials compose personal ecologies (Jarrahi et al., 2017) that each heritage expert configure and reconfigure differently. The coordination ecosystems include all the technology-based materials that people use to communicate, exchange information and share knowledge with others. The literature review revealed that coordination mandates which does not account for mutual influences between partner's ecosystems lead to failures (Cummings & Kiesler, 2008). Coordination practices for sharing knowledge at RedPHI draw upon a huge and dissimilar set of interdependencies of different experts with various coordination technologies.

By combining this diversity, it is possible to reach a high level of coordination for sharing knowledge, however, the lack of interconnection among various technologies (Kallinikos, Aaltonen, & Marton, 2013) leverage independency and disconnection. In this sense, the KMS must address individual coordination preferences but also it should allow connection of different ecosystems - no in the sense of interoperability- but as self-sufficient and independent modules within a wider coupled network of coordination relationships between artifacts (Néstor A. Nova, 2019). Switching, combining, adding and removing technologies within and among ecosystems is a context-awareness process grounded on variables such as location, role, time, situation, interest and utilization. Consequently, different ecosystems should be able to be orchestrated in the KMS in order to meet new contextual and situational opportunities and challenges of the knowledge coordination work. Correspondingly:

DQ 1: The KMS should embody mechanisms to naturally interconnect individual ecosystems enabling knowledge sharing between heterogeneous experts.

A heritage project involves different activities essentially being carried at the individual level, but aiming to synchronize at certain points to ensure task performance. Sharing findings directly with colleagues at some point in the project, is one of the most important activities in the heritage work. A heritage work often is developed individually by each expert but then, they need to work in a team in order to get feedback and be ontological and operational alliterated. This behaviour demands a seamless transition between individual to collaborative work and vice versa. The heritage projects are based on loosely coupled workflow processes (Van der Aalst, 2000) which operate essentially independently, but have to synchronize at certain points to ensure task performance. Therefore, several combinations and flows of individual work and group interaction must be supported in the KMS. In the heritage domain, these combinations are relevant for both important project findings and the processes, methods, resources, knowledge and capabilities that led to them. In addition, due to the multidisciplinary character of the heritage domain, the transition between individual and collective work also happens within disciplinary teams but also it is important for the whole project team. Thus, combination of workflows preferably should be on different abstraction levels allowing both individual work and communication with other experts (Néstor A. Nova, 2019). Accordingly*:*

DQ 2: The KMS should support the transition and combination between individual and collaborative workflows, enabling coordination in knowledge sharing processes.

The insights of the RedPHI case study aligns well with the metaphor of imbrication (Leonardi, 2011) as heritage experts change routines and technologies as they perceive affordances or constraints of materials. Flexibility and improvisation are technology characteristics that determine the episodic interactions with people. In addition, this materiality is embedded in the context where people can have it modified to fit their needs in relatively short order. As the affordance perception is non-planed, the KMS should decline attempts at prediction but it must support those changes. Therefore, the KMS should support emergent coordination, affording different, new and improvised ways of working and organizing but also recognizing that certain uses are enabled or hindered by the qualities afforded by the current technological artifacts. Technology affordances of communication tools has transformed the knowledge sharing practices and the effectiveness in making decisions in fieldwork. However, technological rules in some projects limit experts to take advantage from this potential so that routines have to be switched back in order to accomplish a contract regulation (Nestor A. Nova & Gonzalez, 2016b). Therefore, the KMS should support stable or ongoing processes of sharing knowledge allowing reconfiguration of coordination practices. Consequently:

DQ 3: The KMS should support changes in routines and technologies allowing to configure and reconfigure functions and content according to particular project requirements.

5 EVALUATING DESIGN REQUIREMENTS

As design science is an iterative and incremental procedure, requirements act as an intermediate result of the design process, and so revision is also necessary. The evaluation activities demonstrate goal achievement, as the designed artifact is "complete and effective when it satisfies the requirements and constraints of the problem it was meant to solve" (Hevner et al., 2004). In this study, an evaluation process for the design requirements was performed in order to validate initial statements and refined them through literature research, discussions with heritage experts and practitioners and further evaluation.

Evaluation was conducted through an expert review session by following the principles and process suggested in (Maranzano et al., 2005): screening, preparation, review meeting and follow-up. Screening describes the primary version of the design requirements including the elicitation process. Preparation involves the reviewer's selection. In this case, nine experts from RedPHI participated in the review. Reviewers were different from those who participated in the elicitation process. The evaluation team was selected according to their expertise in developing heritage projects as well as experience in teaching, research and consulting in the heritage domain. Afterwards, the review meeting was conducted. The reviewers asked questions and recorded issues that could have made the design requirements an incomplete or inadequate solution to the problem. During the follow-up, reviewers delivered comments regarding the design requirements which were embedded in the final version of them. Next, we present a summary of consideration regarding the artifact evaluation.

Reviewers agreed in considering that the design requirements fit the reality of knowledge coordination in heritage projects. An expert highlighted flexibility in configuring projects as the breakthrough for improving coordination: *…I think that flexibility should be the main feature of a KMS, because we often perform [sequentially or simultaneously] different research projects at a personal and interorganizational level but also consulting, which sometimes involves different and novel methods and formats that do not fit research project standards.*

The importance of providing flexibility was further highlighted at collaboration level. For instance, it was pointed out that supporting transition between individual and group workflows would enhance coordination and productivity more than just exchanging individual resources in a dyadic way. For instance, an expert stated: *…In our network the work is mostly multidisciplinary, each team member and even experts of the same discipline such as […] manage their own knowledge in a different way but when we have to integrate individual results in just one report, the whole knowledge needs to be available to everyone in the group in order to reach the project goals.*

Experts also remarked the importance of material agency being adapted to humans needs rather than learning a new tool for every project they develop. Most of the reviewers agreed in considering consistency between the project requirements and the specific materiality afforded by the KMS, due to each project is unique and they do not often use predefined templates. In this sense, an expert posited an example on this: …*We often are limited by 3D scanners availability […] to evaluate the heritage objects so that we have to switch immediately our technical approach from analysing data points in a software with virtual models to use a total station or even in the worst case, to take pictures and model the object later with less precision sometimes.*

Another reviewer mentioned that the project requirements are different among project types and so flexibility in function and content configuration is a useful characteristic of the system: …*for me as a consultant and professor […] the flexible configuration of the KMS functions is high-value because when involving students in a research project, I have to deal with academic information at different quality levels and this requires a dedicated knowledge organization strategy.* In this regard, another expert also mentioned: …*if there are, for example, four task forces producing information for the same project, we then struggle with filtering the content needed to produce a specific outcome. For me, as project manager, it can be even more problematic when team members have not participated in prior project versions, because we must explore and understand a huge amount of physical and material documents which takes a lot of time.*

6 DISCUSSION

In (Bjørn & Østerlund, 2014) and (Leonardi & Rodriguez-Lluesma, 2012, p.) the potential of sociomateriality has been identified to advance in IS design as both product and process. One of the challenges for sociomaterial design starts by determining a framework that guides the exploration of real settings (Constantinides & Barrett, 2012) but also the design of innovative artifacts. In this sense, we consider a sociomaterial lens particularly helpful in eliciting requirements for KMS in coordinative and collaborative settings for sharing knowledge. Consequently, the design requirements proposed in this study advance the design of coordination (Faraj & Xiao, 2006; Jarzabkowski et al., 2011; Okhuysen & Bechky, 2009) involving a range of useful design insights that naturally could overcome coordination issues that are not fully gathered and explained through the socio-technical and engineering focus of eliciting software requirements.

In the socio-technical scenario, the role of information systems is grounded on the intersection of the material and the social (Hovorka & Germonprez, 2011), but the current elicitation process privilege the material agency as causing or occasioning some organizational effects (Scott & Orlikowski, 2008). By exploring people and technologies as shifting and imbricated ecosystems of social and material agencies, designers can finally dispense with independent explorations of them (Leonardi & Rodriguez-Lluesma, 2012), examining how the coordination mechanisms are intrinsic to every knowledge sharing activity. Imbrications happens mainly at individual level and so it should be focal point of the sociomaterial design, because the heritage experts always decide how they will let the technology influence their knowledge work.

By making a KMS scalable, extensible and heuristic (Deve & Hapanyengwi, 2014; Nevo & Chan, 2007), designers focus attention specifically on the materiality of technology during implementation times but omitting the ongoing set of imbrications between the social and material agencies in which, the perception of affordances or constrains should be addressed by malleable material properties of the KMS. By designing a KMS from a socio-technical perspective, designers take the side of identifying imbrication patterns as organizational practices, dismissing the uniqueness of each individual imbrication (Leonardi, 2011). Improvements in coordination for sharing knowledge can be reach by understanding how materiality of mechanisms is activated according to the context of use and how people could configure and reconfigure those functions according to their knowledge needs (Néstor A. Nova, 2019). In this sense, some calls for making the KMS flexible, collaborative and visualizable are partially in the side of the sociomaterial inquiry (Becerra-Fernandez & Sabherwal, 2014; Nestor A. Nova & Gonzalez, 2016a). Consequently, the design process is dual, because not only implies the initial configuration of the KMS based on requirements such as those presented in the Table 1, but also the ongoing reconfiguration of the system made by users, according to their affordance perceptions and leading to changes in routines or technologies. Therefore, the elicitation process requires to be attentive to emergent interactions among people and technologies and changes derived from them, as well as their complex interactions (Jarke & Lyytinen, 2015) which lead to consider the requirements engineering tasks from a critical realist perspective on sociomateriality (Leonardi, 2013).

In a short summary, the KMS should address individual and group knowledge needs about heritage objects and the research processes about them; must be capable of facilitating the knowledge work by affording malleable material properties that support both design prior to use and design in use activities; should serve to heterogeneous heritage experts by allowing to orchestrate different and individual sociomaterial ecosystems in a dynamic and non-patterned way; and must it conform to affordances and constraints perceived by people in real practices.

7 CONCLUSIONS

In this paper, we presented a set of design requirements for KMS grounded on sociomaterial tenets and applicable to knowledge sharing networks in the heritage domain. The purpose of the paper was to demonstrate that by changing the ontological approach of separating users, systems and domains when eliciting requirements, into a sociomaterial lens, it is possible to observe both the ways in which the knowledge sharing process is bound up with the materiality of coordination mechanisms, and how people act and interact as they perceive contextual affordances and constraints from them during the coordination practices.

By exploring the RedPHI network and the limited literature about the sociomaterial design of information systems, we formulated three design requirements, focusing on observing, exploring and tracking imbrications between social and material agencies, conversations between and among them, and people´s perceptions of affordances and constraints from technology. These considerations could lead to a sociomaterial configuration of the KMS in practice. We also highlighted differences between eliciting requirements from a sociomaterial perspective and a socio-technical one.

Overall, our results are in line with recent calls for consistency between the philosophical principles of sociomateriality and the empirical exploration of environments aiming to design new artifacts. At this point, however, it is also essential to consider the limitations of our artifact. This concern, in particular, the generalizability of the results. Our results are tailored to elicitate design requirements for KMS aiming to improve coordination for sharing knowledge, but this only covers the heritage project domain. Moreover, we only consider interorganizational networks, whereas the results with a focus on intraorganizational settings could vary. A more extensive range of case studies would provide fruitful insights over time. Furthermore, it would also be essential to determine a set of design guidelines that fit the design requirements and guide KMS designers in real settings when designing technology-based artifacts from the sociomaterial perspective. This is necessary in order to reach ontological consistency between elicitation and design processes. Additionally, it would also be interesting to design a KMS prototype fulfilling the design requirements.

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