Artifacts in knowledge management research: a systematic literature review and future research directions

Abstract Purpose – The purpose of this article is to assess the role of artifacts in the knowledge management field in the past 18 years (1997-2015) and to identify directions for future research.

Design/methodology/approach – The authors conducted a systematic literature review of 101 articles published in 7 journals retrieved from EBSCO and Google Scholar online research databases. The framework for analysis included 13 codes, i.e. author(s), title, year of publication, typology, theoretical lens, categorizations, methods for empirical work, relevancy, level of analysis, keywords, findings, research themes, and future research directions. Codes were analyzed using qualitative and quantitative methods.

Findings – Findings lacked cumulativeness and consistency in the current knowledge management debate. Empirical works outnumbered conceptual contributions by two to one, and the majority of articles focused at the organizational level of analysis. Knowledge management systems, knowledge sharing, and digital archives were the major research themes connected to artifacts, together with other closely aligned concepts such as learning and online learning, knowledge transfer and knowledge creation.

Research limitations – This study has temporal and contextual limitations related to covered time span (18 years) and journals subscription restrictions.

Originality/value – This article is a first attempt to systematically review the role of artifacts in knowledge management research and therefore it represents a primary reference in the knowledge management field. It provides directions to future theoretical and empirical studies as well as suggestions to managerial practices.

Keywords – Systematic Literature Review, Artifacts, Information Technology, Information Systems, Knowledge Management, Knowledge Sharing, Knowledge Transfer, Boundary Objects

Article type – Literature Review

Introduction

Artifacts are crucial to management practices. Many studies conducted in the areas of cognitive science (Clark, 1999), artificial intelligence (Steels, 1993), computer science (Carrol and Campbell, 1989), information system (Orlikowski and Iacono, 2011; Benbasat and Zmud, 2003), or practice-based activities (Dougherty, 2004) have investigated the role and use of artifacts in human activities and mediated interactions (Kajamaa, 2005).

Several definitions of artifacts have been proposed, including the use of labels such as objects (Cohen, 2012; Nicolini *et al.*, 2012), boundary objects (Carlile, 2002), cognitive artifacts (Norman, 1991), material artifacts (Jarzabkowski *et al.*, 2013; Svabo, 2009), technology (DeSanctis and Poole, 1994; Franco and Mariano, 2007), and routine artifacts (Kogan and Muller, 2006). These definitions have complemented some proposed classifications including notions of material infrastructures, boundary objects, epistemic objects, activity objects (Nicolini *et al.*, 2012); as well as objects, artifacts, tools, materials, and nonhuman elements (Svabo, 2009); and systems of tacit and explicit artifacts (Cacciatori, 2012).

These conceptual and empirical studies have linked artifacts to several knowledge management processes such as knowledge accumulation (Cacciatori, 2008), sharing (Di Maio, 2013), reproduction (Martin de Holan and Phillips, 2004), and creation (Nosek, 2004); and special issues in the knowledge management field (e.g. the 2012 special issue on "Kowledge as an Object" published by *Knowledge Management Research & Practice* Volume 10, Issue 3; see Edwards (2012) for details) have produced core contributions to better understand the role and influence of artifacts in the knowledge management debate.

This increased interest on artifacts is thus unmistakable, along with the proliferation of contributions that have appeared in several knowledge management-related journals (e.g. Svabo, 2009; Shariq, 1998). Such an exponential increase in publications has called for

reviews and syntheses of the literature that could help direct future research efforts toward more cohesive and interdependent developments. Previous studies have already attempted to synthesize the literature on artifacts in information system design (Offermann *et al.*, 2010), as well as in the education field (Akkerman and Bakker, 2011), although a comprehensive and systematic review in the knowledge management debate has not yet been produced. Additionally, previous studies have tried to synthesize current knowledge management classic work, trends and identity (Serenko and Dumay, 2015a, 2015b; Serenko, 2013), including the analysis of topics related to artifacts such as "information technology" or "knowledge as practice"; however, these studies have not specifically focused on the artifact metaphor and, therefore, they have not aimed to reach the deeper understanding and conclusions this study is hoping to achieve.

Given the increased interest in artifacts in the knowledge management field, and considering the benefits of a better understanding of artifacts in knowledge management-related processes and systems, this paper aims to provide an in-depth understanding and clear directions to scholars intended to study artifacts from a knowledge management perspective. In doing so, this paper proposes a list of four under-investigated areas and provides suggestions on methodological approaches to employ in future empirical studies.

To accomplish this aim, a systematic literature review approach is employed, following the recommendations of Tranfield *et al*. (2003) and Webster and Watson (2002).

The analysis is guided by two research questions:

1. How has the debate around artifacts developed in the knowledge management field from 1997 to 2015?

2. What future research directions will advance the debate on artifacts in the knowledge management field?

This assessment will increase current understanding of artifacts in the knowledge management debate, and it will be particularly beneficial to those scholars interested in building upon and expanding current theoretical as well as empirical studies on the role of artifacts in knowledge management research. From a practitioner perspective, this assessment will assist managers in the recognition and administration of artifacts in relation to knowledge management processes, systems, and mechanisms to improve knowledge dynamics (Mariano and Casey, 2013) as well as organizational performance.

Findings lacked cumulativeness and consistency in the current knowledge management debate. Empirical works outnumbered conceptual contributions by two to one, and the majority of articles focused at the organizational level of analysis. Knowledge management systems, knowledge sharing, and digital archives were the major research themes connected to artifacts, together with other closely aligned concepts such as learning and online learning, knowledge transfer and knowledge creation.

In this paper, a broad approach to the definition of artifacts is taken, being aware of the multifaceted and, often, contradicting terminology employed in the current literature. Therefore, the notion of artifacts chosen in this systematic literature review (as well as following analysis) includes other relevant terms such as material infrastructures, boundary objects, epistemic objects, and activity objects where material infrastructures relate to the structures that enable collaborative work; boundary objects serve the connection of social and cultural dimensions; epistemic objects embody emotional and intimate attachment dimensions which, in turn, enable social bonds; and activity objects enable object-oriented collective actions (for detailed descriptions, see Nicolini *et al.*, 2012). These terms formed the basis of the keywords search list and guided the retrieval of articles from the online electronic databases. In this paper, artifacts are defined as "tools, stories, symbols, websites, and the like" (Wenger, 2003, p. 83).

This paper is organized as follows. First, the authors discuss the research methodology and major steps taken to conduct the systematic literature review. It follows a presentation and discussion of major findings. Future research directions are proposed. Conclusions, implications and limitations close the paper.

Research methodology

The systematic literature review covered the 1997–2015 year period since some of the preliminary articles started appearing in 1997 (e.g. Harung, 1997) and 1998 (e.g. Shariq, 1998; Hayes *et al.*, 1998).

The authors limited the systematic literature review to peer-reviewed journal articles only, omitting other sources such as books, book chapters, conference articles, and working article series. This decision was made because of two reasons: (1) the widely accepted recognition of peer-reviewed journal articles as scientifically validated resources with high impact on the literature (Podsakoff *et al*. 2005); and (2) similar decisions made in previously published systematic literature reviews (e.g. Mariano and Walter, 2015; Massaro *et al.*, 2015; Senivongse *et al.,* 2015) as well as scientometric studies (Serenko and Dumay, 2015a, 2015b).

The recommendations of Tranfield *et al.* (2003) and Webster and Watson (2002) were followed to plan, conduct, and report findings.

Planning the systematic literature review. This was the early stage of the systematic literature review when the authors identified the need to review the knowledge management fields with regards to the role of artifacts since they were involved in a parallel investigation and, while surfacing the literature, they recognized the need and significance of such a systematic literature review in the knowledge management field. Therefore, existing literature and collected evidence of this specific need were surfaced, and two research questions and a review protocol were developed.

Conducting the systematic literature review. EBSCO and Google Scholar online research databases were used to search and retrieve journal articles from the official list of twenty-five academic journals appeared in Serenko and Bontis's (2013) article published in the *Journal of Knowledge Management*. The authors decided to use this list because, as of today, it represents the most widely accepted and comprehensive list of recognized knowledge management and intellectual capital journals. A list of key search terms was developed, specifically 'artifact*', 'object*', 'boundary object*', 'epistemic object*', 'activity object*', and 'material infrastructure*' that took into consideration the diversity of terminology currently used in the literature to capture the broad and multifaceted existing debate and to maximize the coverage of retrieved articles. The search was restricted to 'abstract' of full-text articles only.

The initial search yielded 324 articles. Articles that were non-relevant to the analysis were discarded. Examples included articles related to editorials, comments, book reviews, articles that did not specifically focus on artifacts, or articles that were published in journals not subscribed by the authors' affiliated institution (for example, *International Journal of Knowledge Society Research* or *The IUP Journal of Knowledge Management*). At the end of this screening, the final list comprised 101 articles in 7 journals.

As a second step, the authors downloaded and entered these articles in Mendeley© reference manager software. They read each article and marked relevant ones with a star sign, as per one of the software available functionalities. Note and tag functionalities were additionally used throughout the analysis. To record key findings, online spreadsheets shared between the two authors were used. The coding process was guided by a taxonomy developed considering previous similar studies as well as the classification of Nicolini *et al.* (2012) that distinguished among 'material infrastructures', 'boundary objects', 'epistemic objects', and 'activity objects'. If an article did not fit the taxonomy, a new label (agreed

upon by both authors) was added. In total, 4 new labels were added, specifically 'core' that complemented the 'minor' and 'major' options in the 'relevancy of article' label; and 'IL' (individual learning), 'OL' (organizational learning), and 'LO' (learning organization) to complement the 'theoretical lens' label. Both conceptual (n=34, 34%) and empirical articles (n=67, 66%) were included, grouping existing publisher categorizations under the two generic labels of 'conceptual articles', 'empirical articles'. For instance, Emerald existing categorization was grouped as follows: 'conceptual article', 'viewpoint', 'literature review', 'general review' and 'technical article' folded under the 'conceptual articles' label; 'research article' and 'case study' folded under the 'empirical articles' label. To increase the accuracy of research findings, two students enrolled in a PhD program in *Knowledge and Innovation Management* performed additional independent coding. These two students were familiar with the knowledge management literature, and were asked to separately code a randomly selected list of articles generated with a true random numbers software. A few disagreements emerged after the analysis that were promptly discussed and resolved by the authors. This process contributed to data triangulation (Creswell, 2003).

Reporting the findings from the systematic literature review. To represent the findings from the systematic literature review, author-centric and concept-centric tables (Salipante *et al.*, 1982; Webster and Watson, 2002) were created, as well as visual aids using R statistical analysis software package.

Findings

The following sections report the findings from this systematic literature review and address the first research question, i.e. (1) How has the debate around artifacts developed in the knowledge management field from 1997 to 2015?

In details, the first section discusses the developments over the past 18 years (1997-2015), and provides some descriptive statistics. The second section describes how the debate

has developed in the 7 selected journals, and discusses the theoretical lenses, methodological approaches, and level of analysis employed. The third section discusses categorization and use of terms, keywords analysis and key research themes. The final section provides a detailed description of 18 core articles that have shaped the current debate in the knowledge management field.

Follows the future research direction section that addresses the second research question, i.e. What future research directions will advance the debate on artifacts in the knowledge management field? This section derives from the analysis of the 'future research' code content in the systematic literature review framework.

Artifacts and developments over the 1997-2015 year period

Figure 1 and Figure 2 show how the current debate on artifacts has grown over the years. The exponential growth function (R^2=0.502) seems to better fit collected data, although its value does not significantly differ from the linear (R^2=0.427) or logistic (R^2=0.447) functions. 2007 and 2015 years registered the highest numbers of publications, with 10 and 12 published articles respectively. The *Journal of Knowledge Management* contributed the most to the debate, with 42 articles uniformly distributed over the years (excepted for 1997), followed by *VINE* and *Knowledge and Process Management* with 15 and 13 articles respectively (Table 1). The *Learning Organization* showed the longest range of publications, with the first article appeared in 1997 (Harung, 1997) and the latest articles appeared in 2015 (e.g. Fosstenløkken, 2015), followed by *Knowledge and Process Management* and the *Journal of Knowledge Management* that both had first articles published in 1998 (Figure 3).

Insert Table 1 and Figures 1, 2, 3, about here

Artifacts, theoretical lenses, methodologies, and level of analysis

The majority of articles (n=87) used knowledge management as a key concept or issue in their studies (e.g. Le Blanc and Bouillon, 2012; Zou and Panda, 2013; Weber, 2007). Six articles framed their contributions within the organizational learning debate (Tukel *et al.*, 2008; Fosstenløkken, 2015); 5 articles used an individual learning lens (e.g. Styhre, 2010; Harung, 1997; Kilby, 2001); 2 articles contributed to the intellectual capital debate, and therefore used it as a lens of analysis (Del Bello, 2006; Giuliani and Marasca, 2011); and 1 article focused on the learning organization lens (Sánchez-Alonso and Frosch-Wilke, 2005).

From a methodological perspective, 44 (44%) were conceptual articles (e.g. Sánchez-Alonso and Frosch-Wilke, 2005), and 67 (66%) were empirical articles (e.g. Kajamaa, 2011). The percentage of articles differed by type, $\varkappa^2(1, N = 101) = 10.78$, $p < .001$. Out of these empirical contributions, 54 articles employed a qualitative methodology (e.g. Maaninen-Olsson *et al.*, 2008); 5 articles employed a quantitative methodology (e.g. Tukel *et al.*, 2008), and 8 articles employed a mixed-method approach (e.g. Zuo and Panda, 2013). The *Journal of Knowledge Management* published empirical contributions the most, with 30 articles out of 42 total contributions, followed by *VINE* and *Knowledge Management Research & Practice* with 11 and 10 empirical articles respectively.

The majority of contributions (n=79) focused at the organizational level (e.g. Svabo, 2009; Padova and Scarso, 2012), while analysis at the individual (e.g. Rountree *et al.*, 2002), group (e.g. Singh *et al.*, 2009), and interorganizational levels (e.g. Hustad, 2007) seemed to be equally distributed with a total of 9, 6, and 7 articles respectively.

Table 2 and Table 3 provide detailed summaries.

Insert Table 2 and Table 3 about here

Artifacts, categorizations, keywords analysis, and research themes

Within the knowledge management literature, authors used different terms to discuss

artifacts. From the analysis of the 'categorization' code content, it resulted that 38 (37%)

articles referred to 'objects' (e.g. Padova and Scarso, 2012); 27 (27%) articles referred to

'artifacts' (e.g. Svabo, 2009); 9 (9%) articles referred to 'boundary objects' (e.g. Holford,

2014); and in 27 (27%) cases, articles did not use a specific term but referred to information

technology, information management, platforms, and repositories to name a few; in these

specific cases we used the code 'material infrastructure' to record corresponding articles (e.g.

Edwards *et al.*, 2005). This finding shows a fragmentation and a lack of cumulativeness and

consistency of research endeavors in the current knowledge management related debate.

The keywords analysis showed that 'knowledge management' was the most used

keyword with 35 occurrences, followed by 'knowledge sharing', 'learning', and 'knowledge'

with 12, 9 and 7 occurrences respectively. This outcome is closely associated to findings

from the analysis of employed theoretical lenses where the majority of articles used

knowledge management as a key concept or issue to frame the published contributions. In

addition to the keyword analysis, an analysis of research themes was also performed,

extrapolating key ideas from each retrieved article to have a better understanding of what

research themes are shaping the current debate on artifacts in the knowledge management

literature. The 'research themes' code content embedded this information, and from its

analysis it emerged that knowledge management systems, knowledge sharing, and digital

archives were the major research themes connected to artifacts (e.g. Shariq, 1998; Di Maio,

2013; Abram, 2004), together with other closely aligned concepts such as learning,

knowledge transfer and knowledge creation (e.g. Holford, 2014; Rountree *et al.*, 2002;

Aarrestad *et al.*, 2015). This seems to be in line with the other performed analysis of

categorization of terms used as well as keywords frequency, especially with respect to knowledge and information management related contents.

Table 4 and Figure 4 provide details of keywords frequency and word cloud.

Insert Table 4 and Figure 4 about here

Core articles shaping the current debate

The analysis was further extended to see if artifacts were used as a core notion in the retrieved articles. The overarching "relevancy" code captured this information, and articles were categorized as "core", "major", or "minor" contributions.

Core contributions included articles where the notion of artifacts was used to develop the core ideas in a significant way. Examples included the work of Kreiner (2002) on the role of artifacts in the management of tacit knowledge in the context of product development and knowledge mobilization processes; or the discussion of how artifacts mediate knowledge communities aided by sense-making processes as discussed by Shariq (1998). Additional examples included Svabo's (2009) work on how material artifacts stabilize as well as destabilize organizational actions; and Holford's (2014) ethnographic study on boundary construction in a community of practice, among others.

Major contributions included articles where the notion of artifacts was used to develop ideas, although it did not represent the core argument. Examples included articles on software development or applications, such as Jaime *et al.* (2005), and Venturini and Benito (2015). Additional examples included Evans and Alleyne (2009), and Gardner (2013), among others

Minor contributions included articles where the notion of artifacts was used marginally, without any further developments. Examples included the work of Subrt and Brozova (2007), Krone (2013), and Sharp (2006), among others

Eighteen articles (18%) formed the core group; 38 articles (38%) discussed artifacts as a major notion; and 45 (44%) discussed artifacts marginally, investigating a variety of topics including business engineering, bioinformatics, knowledge maps, and knowledge management portals, among others. Although the *Journal of Knowledge Management* contributed the most to the artifact debate as a whole (n=44, 44%), *Knowledge Management Research & Practice* contributed the most to the core debate (n=7, 39%), with its 2012 special issue on "Knowledge as an Object" (Volume 10, Issue 3) from which 4 articles were listed into the final count as per our definitions of core contributions (i.e. Martin *et al.*, 2012; Borgo and Pozza, 2012; Padova and Scarso, 2012; Bolisani and Oltramari, 2012).

From a longitudinal perspective, core and major articles (n=56) where analyzed with respect to their methodological approaches and level of analysis. It was found that empirical articles (n=42) outnumbered conceptual articles (n=14) throughout the entire period, with the sole exception of 1997-2000 year period. The majority of articles focused at the organizational level of analysis (n=44), with first articles discussing the individual (n=5), group (n=4), and interorganizational level (n=3) of analysis appearing in 1997, 2002 and 2007 respectively.

Insert Figure 5 about here

All 18 core articles were further investigated, looking at their methodological approaches, level of analysis, key findings, and suggestions for future research.

Ten articles (55%) were empirical contributions (e.g. Kreiner, 2002; Maaninen-Olsson *et al.*, 2008), while 8 (45%) articles developed their arguments in a theoretical way,

using an Activity Theory (Vygotsky, 1986, 1989; Leont'ev, 1978; Roth and Lee, 2007; Engestrom, 1991) lens in 3 cases (Shariq, 1998; Kajamaa, 2005; Sing *et al.*, 2009). Those articles that contributed empirically to the debate (n=10) employed case study (n=5, 50%), multiple case study (n=1, 10%), ethnography (n=2, 20%), or mixed methods approaches (n=2, 20%). The majority of core articles (n=18) focused at the organizational level of analysis (n=14, 78%), and only 4 articles (22%) focused at the individual (Rountree *et al.*, 2002), group (Holford, 2014; Singh *et al.*, 2009), and inter-organizational level of analysis (Hustad, 2007).

Key findings included a variety of topics, such as knowledge objects measurements (Bolsani and Oltramari, 2012), product development (Kreiner, 2002), knowledge management systems (Borgo and Pozza, 2012), system knowledge objects (Di Maio, 2013), dynamic entanglements (Holford, 2014), human-computer interactions (Jiang *et al.,* 2010), management of knowledge objects (Padova and Scarso, 2012) and boundary spanning activities (Hustad, 2007) among others.

Empirical contributions operationalized artifacts as co-constructing sketches and diagrams in the context of aircraft engine manufacturing (Holford, 2014); lists, prospects, guidelines, documentation, intranet or quality management systems that acted as boundary objects in the context of marine insurance industry (Hustad, 2007); co-created assessment tools in the context of a Finnish hospital (Kajamaa, 2011); a digital earing instrument developed by a leading Danish manufacturer (Kreiner, 2002); mediating tools such as referrals, laboratory reports, and instructions in a public medical service organization as well as routines and rules, prototypes or practical tests, and standards and documentations in a technology and engineering company in Sweden (Maaninen-Olsson *et al.*, 2008); a software development project pattern that manages knowledge objects in a software engineering organization (Martin *et al.,* 2012); a consolidated knowledge platform developed at Ernst &

Young (Padova and Scarso, 2012); digitalized artifacts such as still photographs or non-immersive photorealistic virtual reality to teach visual image analysis (Rountree *et al.*, 2002); ZingThing™ groupware and cognitive artifacts such as group discussions employed in an educational context (Sing *et al.*, 2009); and principles and methods for evaluation in a virtual organization (Zuo and Panda, 2013).

Some articles proposed measures of knowledge objects such as charts and indicators to compare different business cases or the same case over time (Bolsani and Oltramari, 2012), or evaluation methods to assess the trustworthiness of objects (Zuo and Panda, 2013). Other articles focused on developing frameworks for analysis, including artifacts or objects as formal constructs (Borgo and Pozza, 2012), codification methods (Di Mario, 2013), mediators of knowledge communities or networks (Shariq, 1998), communication processes (Le Bland and Bouillon, 2012), human-computer interactions (Jiang *et al.,* 2010; Martin *et al.,* 2012; Rountree *et al.*, 2002; Sánchez-Alonso and Frosch-Wilke, 2005), or knowledge integration processes (Maaninen-Olsson *et al.,* 2008). Finally, a discrete number of articles focused on the relationship between artifacts/objects and knowledge dynamics, studying how objects interacted with subjects in groups (Holford, 2014; Singh *et al.*, 2009), contributed to networks evolution (Hustad, 2007), stability or conflict (Svabo, 2009), boundary breaking outcomes due to lack of assessment tools (Kreiner, 2001), or how other intervening variables such as cognitive, organizational and managerial actions (Padova and Scarso, 2012) influenced the management of artifacts or objects (see also Mariano, 2010).

Each core articles provided future research suggestions that are summarized and discussed in details in the following sections to form a research agenda for future studies.

Overall, these findings confirmed some previous conclusions reached in other meta-analyses conducted to assess the current state of the knowledge management discipline (Serenko, 2013). In particular, these findings confirmed some over-differentiations,

inconsistencies, and lack of a common theoretical core in the academic body of knowledge

(Serenko, 2013) showing a lack of cumulative work as well as integration of existing

contributions, and the need of a more refined set of future research directions to thoroughly

address the notion of artifacts in the knowledge management field with regards to related

theoretical and empirical implications.

Table 5 summarizes the findings from the analysis of selected core articles.

Insert Table 5 about here

Summary

In summary, core articles – where the notion of artifacts was used to develop the core

ideas in a significant way – proposed measurements of artifacts or knowledge objects

(Bolsani and Oltramari, 2012; Zuo and Panda, 2013); discussed frameworks for analysis

where artifacts played crucial roles (e.g. Borgo and Pozza, 2012; Di Mario, 2013; Shariq,

1998); highlighted the human-computer interactions in knowledge management systems or

processes (Jiang *et al.,* 2010; Martin *et al.,* 2012; Rountree *et al.*, 2002; Sánchez-Alonso and

Frosch-Wilke, 2005; Maaninen-Olsson *et al.,* 2008); focused on the relationship between

artifacts/objects and knowledge dynamics at the group (Holford, 2014; Singh *et al.*, 2009) or

network levels (Hustad, 2007; Kreiner, 2001); or discussed the role of cognitive,

organizational and managerial variables (Padova and Scarso, 2012) that influenced the

management of artifacts/objects to enhance stability and reduce conflict (Svabo, 2009).

Empirical contributions operationalized artifacts as sketches and diagrams (Holford,

2014); lists, prospects, guidelines, documentation, intranet or quality management systems

(Hustad, 2007); co-created assessment tools (Kajamaa, 2011); digital earing instruments

(Kreiner, 2002); referrals, laboratory reports, and instructions as well as routines and rules,

prototypes or practical tests, and standards and documentations (Maaninen-Olsson *et al.*,

2008); software development project patterns (Martin *et al.,* 2012); consolidated knowledge platforms (Padova and Scarso, 2012); photographs or non-immersive photorealistic virtual reality (Rountree *et al.*, 2002); ZingThing™ groupware and cognitive artifacts (Sing *et al.*, 2009); and principles and methods for evaluation (Zuo and Panda, 2013).

Future research directions

This section addresses the second research question, i.e. What future research directions will advance the debate on artifacts in the knowledge management field? It is elaborated from the analysis of current gaps and future research suggestions as per the recommendations provided in the selected core articles. Four future research areas and corresponding research questions and methodological approaches are identified: refinement of existing definitions and terminology, refinement of theoretical treatments, specification of knowledge processes, and investigation of managerial influence and actions (see Table 6).

Research direction 1: develop a consistent set of definitions and terminology. A first call for future research recommends the development of a consistent set of terms to use in the current artifacts debate in knowledge management research (Shariq, 1998; Svabo, 2009). This could help differentiate data, information and knowledge within the context of human cognition to develop a unified framework for sense-making and artifacts (Shariq, 1998), as well as to clarify whether objects, artifacts, tools, materials, and nonhuman elements refer to the same empirical phenomena (Svabo, 2009).

Research direction 2: include refined theoretical treatments of artifacts. A second call for future research suggests the inclusion of clear ontological perspectives into the analysis of artifacts and knowledge management processes or systems (Jiang *et al.*, 2010). Recommendations include the elaboration of coherent theoretical constructs that covers how material artifacts participate in social actions (Svabo, 2009); investigation of artifacts in knowledge life cycles and standardization activities employing a reuse-oriented ontological

framework (Sánchez-Alonso and Frosch-Wilke, 2005); and elaborations of new integrated frameworks that capture ontologically motivated notions of knowledge objects (Borgo and Pozza, 2012).

Research direction 3: specify knowledge processes. A third call for future research suggests studying artifacts in relation to defined knowledge processes, such as knowledge implementation (Le Blanc and Bouillon, 2012), sharing (Zuo and Panda, 2013), mobilization (Kreiner, 2002; Le Blanc and Bouillon, 2012), use (Kreiner, 2002), and collaborative knowledge building (Sing *et al.*, 2009) to enhance supporting or corrective actions and improved performance (Zuo and Panda, 2013).

Research direction 4: investigate the influence of managerial actions. A fourth call for future research recommends the investigations of additional variables related to managerial actions and control and their influence on the adoption and use of artifacts. In particular, scholars recommend future works on how to employ artifacts to better manage knowledge without the need to use authority or control (Kreiner, 2002); the inclusion of managerial support in the analysis of sustainable mediated collaborations (Kajamaa, 2005); the investigation of trust and power (Maaninen-Olsson *et al.*, 2008) and power relations (Holford, 2014) in knowledge flows among individuals; and the integration of detailed analysis of managerial practices in future studies on knowledge objects management (Padova and Scarso, 2012).

Insert Table 6 about here

Conclusions

This paper reviewed the literature on artifacts in the knowledge management field and contributed to both theory and practice.

From a theoretical perspective, this paper aimed to synthesize the current debate on the role of artifacts in the knowledge management field, and provided research directions to scholars interested in the study of artifacts from a knowledge management perspective. To accomplish these aims, this paper systematically reviewed articles published in the past 18 years (1997-2015), and showed a lack of cumulativeness and consistency in the current debate, a majority of empirical works, and a tendency to focus at the organizational level of analysis. Knowledge management systems, knowledge sharing, and digital archives were the major research themes connected to artifacts, together with other closely aligned concepts such as learning and online learning, knowledge transfer and knowledge creation. This paper also contributed to theory by proposing a list of four under-investigated areas of research, such as: (1) refinement of existing definitions and terminology, (2) inclusion of refined theoretical treatments of artifacts, (3) specification of knowledge processes, and (4) investigation of managerial actions. These directions provided suggestions on theoretical as well as methodological approaches for the study of artifacts in a knowledge management context.

From a practice perspective, the findings from this study provided some insights on how knowledge dynamics could be better organized and performed in organizational contexts through the use of artifacts as crucial components of knowledge management processes and mechanisms. Therefore, when implementing a knowledge management system or designing knowledge management practices, managers would be aware of the role of artifacts and their related benefits, and include them into the design of new knowledge systems, processes, and related infrastructures.

Limitations of this study regard temporal and contextual boundaries related to time span (18 years) and journals subscription restrictions.

This article was a first attempt to systematically review the role of artifacts in knowledge management research. It represented a primary reference for those interested in the investigation of artifacts in the knowledge management field. We believe that we contributed to a better understanding of how the current debate around artifacts is developed, and provided useful directions for future explorations of the role of artifacts in the knowledge management field.

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