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

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Abstract

Purpose – *The purpose of this paper 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 seven 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 – *The findings lacked cumulativeness and consistency in the current knowledge management debate. Empirical works outnumbered conceptual contributions by two to one, and the majority of papers 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/implications – *This study has temporal and contextual limitations related to covered time span (18 years) and journals' subscription restrictions.*

Originality/value – *This paper 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 and suggestions to managerial practices.*

Keywords *Information technology, Information systems, Knowledge transfer, Knowledge management, Knowledge sharing, Literature*

Paper 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 (Carroll and Campbell, 1989), information system (Orlikowski and Iacono, 2001; 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, 2011).

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 and activity objects (Nicolini *et al.*, 2012); objects, artifacts, tools, materials and nonhuman elements (Svabo, 2009); and systems of tacit and explicit artifacts (Cacciatori, 2012).

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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 (the 2012 special issue on "Knowledge 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 (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 intending 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 used, following the recommendations of Tranfield *et al.* (2003) and Webster and Watson (2002). The analysis is guided by two research questions:

RQ1. How has the debate around artifacts developed in the knowledge management field from 1997 to 2015?

RQ2. 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 and 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; Mariano and Casey, 2016), 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 used 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 period since some of the preliminary articles started appearing in 1997 (Harung, 1997) and 1998 (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 (Mariano and Walter, 2015; Massaro *et al.*, 2015; Senivongse *et al.*, 2015) and 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, as 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

"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."

"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."

specific need 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 25 academic journals that 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 (*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 and 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, four 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 per cent) and empirical articles ($n = 67$, 66 per cent) were included, grouping existing publisher categorizations under the two generic labels of "conceptual articles" and "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 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- 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 *RQ1*.

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 seven selected journals and discusses the theoretical lenses, methodological approaches and level of analysis used. 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 *RQ2*. 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 period

Figures 1 and 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. The years 2007 and 2015 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 I). 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 (Fosstenløkken, 2015), followed by *Knowledge and Process Management* and the *Journal of Knowledge Management* that both had first articles published in 1998 (Figure 3).

Figure 1 Frequency of publications (1997-2015)

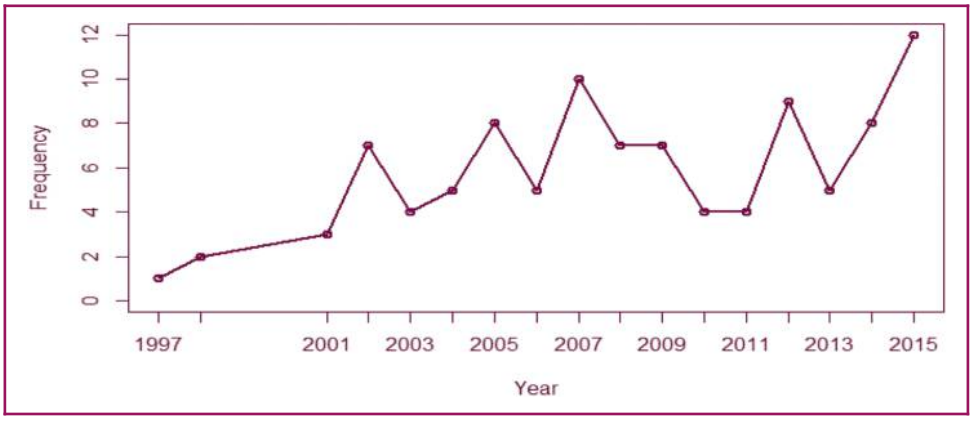


Figure 2 Trends of published articles and best fit

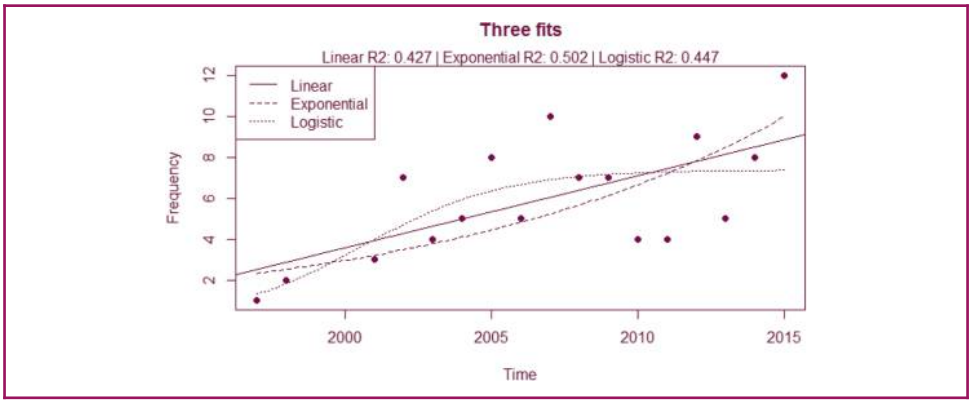
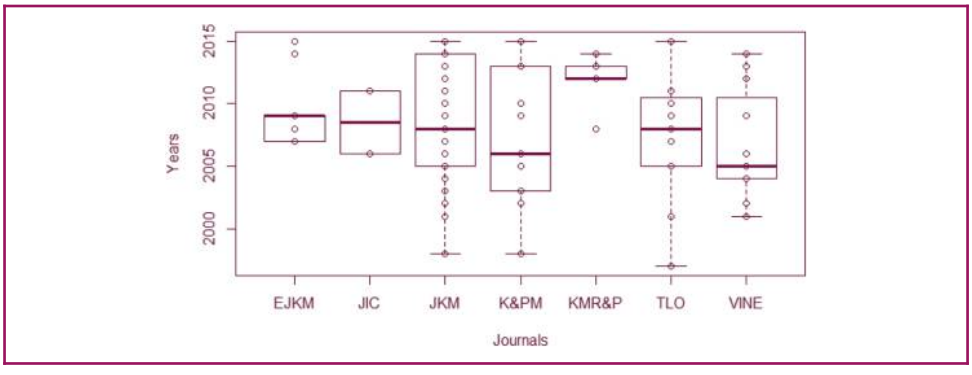


Table I Final list of retrieved articles

Rating	*Journal titles*	N
A+	*Journal of Knowledge Management*	42
A+	*Journal of Intellectual Capital*	2
A	*The Learning Organization*	11
A	*Knowledge Management Research & Practice*	9
A	*Knowledge and Process Management*	13
B	*Electronic Journal of Knowledge Management*	9
B	*VINE – The Journal of Information and Knowledge Management Systems*	15
Total		*101*

Figure 3 Contribution of journals to current debate (1997-2015)



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 (Le Blanc and Bouillon, 2012; Zuo and Panda, 2013; Weber, 2007). Six articles framed their contributions within the organizational learning debate (Tukel *et al.*, 2008; Fosstenløkken, 2015); five articles used an individual learning lens (Styhre, 2010; Harung, 1997; Kilby, 2001); two articles contributed to the intellectual capital debate, and therefore, used it as a lens of analysis (Bello, 2006; Giuliani and Marasca, 2011); and one article focused on the learning organization lens (Sánchez-Alonso and Frosch-Wilke, 2005).

From a methodological perspective, 44 (44 per cent) were conceptual articles (Sánchez-Alonso and Frosch-Wilke, 2005) and 67 (66 per cent) were empirical articles (Kajamaa, 2011). The percentage of articles differed by type, $\varkappa^2$ (1, N = 101) = 10.78,

$p < 0.001$. Out of these empirical contributions, 54 articles used a qualitative methodology (Maaninen-Olsson *et al.*, 2008); five articles used a quantitative methodology (Tukel *et al.*, 2008) and eight articles employed a mixed-method approach (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 (Svabo, 2009; Padova and Scarso, 2012), while analysis at the individual (Rountree *et al.*, 2002), group (Singh *et al.*, 2009) and interorganizational levels (Hustad, 2007) seemed to be equally distributed with a total of nine, six and seven articles, respectively.

Tables II and Table III provide detailed summaries.

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 per cent) articles referred to "objects" (Padova and Scarso, 2012); 27 (27 per cent) articles referred to "artifacts" (Svabo, 2009); 9 (9 per cent) articles referred to "boundary objects" (Holford, 2014); and in 27 (27 per cent) 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 (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 used 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

Table II Journal titles and methodological approaches

	Journal titles							
Methodology	EJKM	JIC	JKM	K&PM	KMR&P	TLO	VINE	*Total*
Mixed	0	0	4	1	1	0	2	*8*
Qualitative	4	2	22	9	3	5	9	*54*
Quantitative	0	0	4	0	0	1	0	*5*
Total	*4*	*2*	*30*	*10*	*4*	*6*	*11*	*67*

Table III Level of analysis and types of contributions

	Types of contributions		
Level of analysis	*Conceptual*	*Empirical*	*Total*
Individual	4	5	9
Group	2	4	*6*
Organizational	24	55	*79*
Interorganizational	4	3	*7*
Total	*34*	*67*	*101*

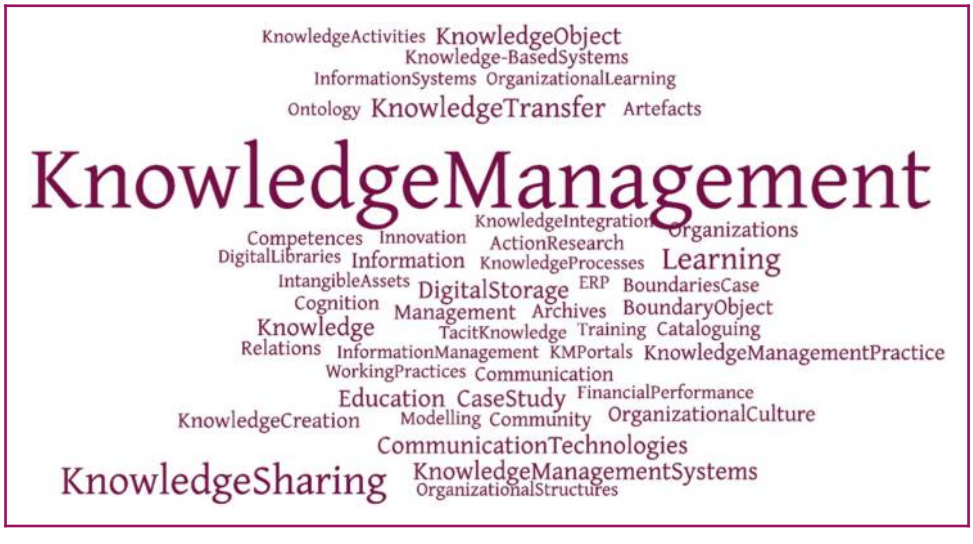
connected to artifacts (Shariq, 1998; Di Maio, 2013; Abrams, 2004), together with other closely aligned concepts such as learning, knowledge transfer and knowledge creation (Holford, 2014; Rountree *et al.*, 2002; Aarrestad *et al.*, 2015). This seems to be in line with the other performed analysis of categorization of terms used and keywords frequency, especially with respect to knowledge and information management-related contents.

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

Table IV Keywords frequency

Rank	*Keywords (n = 424)*	*Count*	*(%)*
1	Knowledge Management	35	8.25
2	Knowledge Sharing	12	2.83
3	Learning	9	2.12
4	Knowledge	7	1.65
5	Knowledge Transfer	6	1.41
6	Knowledge Management Systems	5	1.17
7	Case Study, Communication Technologies, Education, Digital Storage, Knowledge Object	4	0.94
8	Boundary Object, Information, Management, Organizations, Organizational Culture, Knowledge Creation	3	0.70
9	Action Research, Archives, Artefacts, Knowledge-Based Systems, Boundaries, Case, Cataloguing, Cognition, Communication, Community Relations, Competences, Digital Libraries, ERP, Financial Performance, Information Management, Information Systems, Innovation, Intangible Assets, KM Portals, Knowledge Activities, Knowledge Integration, Knowledge Management Practice, Knowledge Processes, Modelling, Ontology, Organizational Learning, Organizational Structures, Tacit Knowledge, Training, Working Practices	2	0.47
10	(Extract) Academic Libraries, Accessibility, Accounting, Accounting System, Actor, Adapted Aids, Admissions, Aerospace Industry, Aircraft Industry, Algorithm, Apprenticeships, Architectures, Best Practice, Bibliographic Systems, Bioinformatics, Capitalization, Care, Collaboration, Conflict, Constructivism, Creativity	1	0.23

Figure 4 Word cloud



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 and 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 per cent) formed the core group; 38 articles (38 per cent) discussed artifacts as a major notion; and 45 (44 per cent) 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 per cent), *Knowledge Management Research & Practice* contributed the most to the core debate (n = 7, 39 per cent), with its 2012 special issue on "Knowledge as an Object" (Volume 10, Issue 3) from which four articles were listed into the final count as per our definitions of core contributions (Martin *et al.*, 2012; Borgo and Pozza, 2012; Padova and Scarso, 2012; Bolisani and Oltramari, 2012).

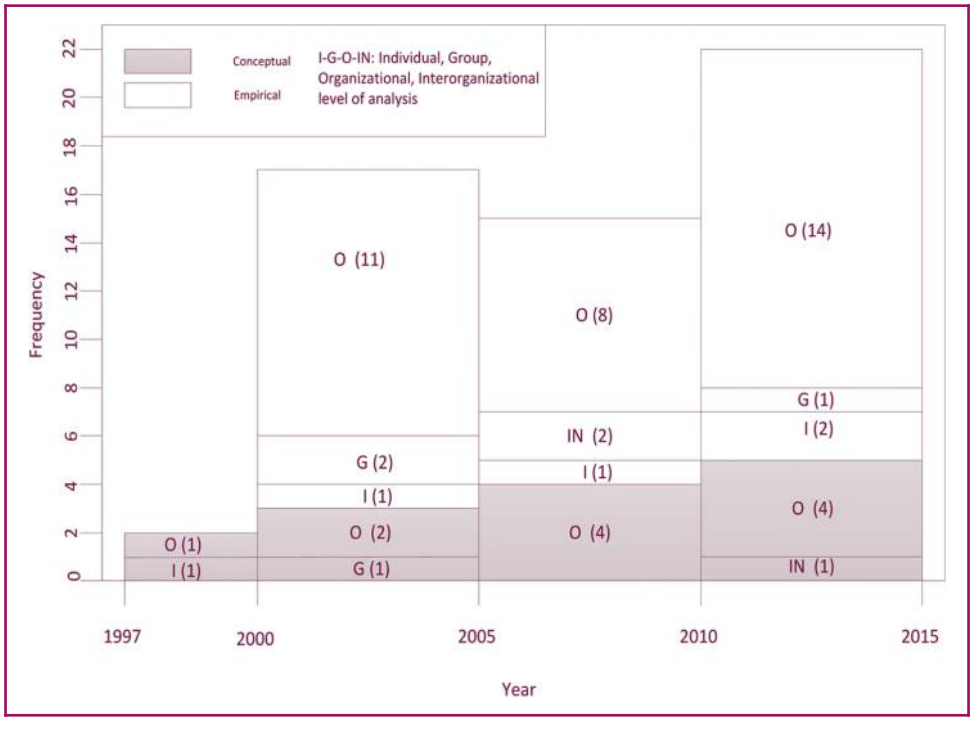
From a longitudinal perspective, core and major articles (n = 56) where analyzed with respect to their methodological approaches and level of analysis. It was found that empirical articles (n = 42) outnumbered conceptual articles (n = 14) throughout the entire period, with the sole exception of the 1997-2000 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 (Figure 5).

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 per cent) were empirical contributions (Kreiner, 2002; Maaninen-Olsson *et al.*, 2008), while 8 (45 per cent) articles developed their arguments in a theoretical way, using an Activity Theory (Vygotsky, 1986, 1989; Leont'ev, 1978; Roth and Lee, 2007; Engeström, 1991) lens in three cases (Shariq, 1998; Kajamaa, 2011; Singh *et al.*, 2009). The articles that contributed empirically to the debate (n = 10) used case study (n = 5, 50 per cent), multiple case study (n = 1, 10 per cent), ethnography (n = 2, 20 per cent) or mixed-methods approaches (n = 2, 20 per cent). The majority of core articles (n = 18) focused at the organizational level of analysis (n = 14, 78 per cent) and only 4 articles (22 per cent) 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 (Bolisani and Oltramari, 2012), product development (Kreiner, 2002), knowledge

Figure 5 Longitudinal analysis by methodology and level of analysis (1997-2015)



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 used in an educational context (Singh *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 (Bolisani 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 Maio, 2013), mediators of knowledge communities or networks (Shariq, 1998), communication processes (Le Blanc 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, 2002) 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 detail 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 regard to related theoretical and empirical implications.

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

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 (Bolisani and Oltramari, 2012; Zuo and Panda, 2013); discussed frameworks for analysis where artifacts played crucial roles (Borgo and Pozza, 2012; Di Maio, 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, 2002); 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 (Singh *et al.*, 2009); and principles and methods for evaluation (Zuo and Panda, 2013).

Future research directions

This section addresses *RQ2* 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 VI).

Table V Core contributions

Authors	*Journal*	*Methodology*	*Level of analysis*	*Key findings*	*Future research suggestions*
Bolisani and Oltramari (2012)	*KMR&P*	Conceptual	Organizational	Approach proposed to measure knowledge objects and knowledge generated, possessed and exchanged by organizations. Charts and indicators (similar to those used in accounting practices) developed to interpret and compare different business cases over time	Test the proposed approach in other organizational settings Include a multiple transactions perspective to measure value-generating knowledge management processes
Borgo and Pozza (2012)	*KMR&P*	Conceptual	Organizational	Knowledge object proposed as a formal construct for knowledge modeling and knowledge management systems. Knowledge object theorized as a new type of entity that emerges from the explicit interaction of material entities, information entities and roles within an organization	Further investigate knowledge objects in knowledge management contexts Elaborate new integrated frameworks that capture ontologically motivated notions of knowledge objects
Di Maio (2013)	*KMR&P*	Conceptual	Organizational	The role of knowledge objects proposed as a possible codification method to facilitate and reduce the costs associated with system knowledge sharing. Two novel knowledge object architectures proposed as possible artifacts to facilitate system knowledge object and systems engineering knowledge object	Test reliability/usefulness of proposed object architectures in multiple case studies Integrate future investigations with more in-depth observations to support further developments and refinements
Holford (2014)	*KMR&P*	Ethnographic Case Study	Group	Blurring or dynamic entanglement occurs between objects and subjects in a community of practice. Such dynamics involve co/reconstructions constant movements at the boundary of intra-acting subjects. Boundary co/reconstructions are embedded in effective workplace dialogue as part of the process of knowing	Investigate further groups in other high-tech institutions Direct future research questions on gender and power relations, such as: What type of dynamic occurs with mixed or all-female work groups? What happens when power or rank comes into play?
Hustad (2007)	*EJKM*	Case Study	Interorganizational	Studies distributed networks of practices in the marine insurance industry and shows how network members' evolution was enacted by boundary spanning activities to overcome the barriers caused by structural diversity. Knowledge brokers' roles and boundary objects were crucial. Some boundary objects acted as obstacles while others emerged unexpectedly and illogically and became the most efficient boundary objects. Different communication media such as video and teleconferences, email and intranet supported the boundary spanning processes. Diversity and cross-network interactions transformed the networks and the role of knowledge brokers, boundary spanners and boundary objects were critical in the evolution	Investigate the implications of this study in other multinational companies Include structurally diverse networks as valuable resources for utilizing the knowledge potential of organizations Investigate the development of boundary management skills as in structurally diverse networks
Jiang *et al.* (2010)	*K&PM*	Conceptual	Organizational	Expands task–artifact framework developed to support better utilization of behavioral, cognitive and social science in human–computer interaction design at the organizational level with organizational learning theories	Empirically test and develop proper approaches or forms that fit domain-specific needs and utilize theories or models at the organizational level of analysis
Kajamaa (2011)	*TLO*	Longitudinal Ethnographic Study	Organizational	Organizational boundaries viewed from an activity-theory lens as tension-laden triggers for learning and change between nurses and evaluation professionals in a Finnish hospital. Their collaboration effort led to boundary breaking, after initial expansive learning actions. This was due to lack of a shared assessment tool (i.e. a boundary object) and management support	Investigate sustainable collaborations between distinct activity systems through the inclusion of boundary breaking, multiple learning actions, managerial support and co-created boundary objects

(*continued*)

Table V

Authors	*Journal*	*Methodology*	*Level of analysis*	*Key findings*	*Future research suggestions*
Kreiner (2002)	*JKM*	Case Study	Organizational	In the context of product development and knowledge mobilization, artifacts facilitate order and coordination to emerge spontaneously without the need to employ control mechanisms in the management of knowledge	Better conceptualize knowledge management role and function that reflects the double-sided concern of protect/use and mobilize/expand knowledge resources Investigate better ways to manage tacit knowledge that goes beyond authority and control
Le Blanc and Bouillon (2012)	*VINE*	Conceptual	Organizational	An analytical framework for knowledge management in relation to artifacts (objects) of communication is proposed. Three perspectives are proposed to analyze the communication devises with respect to their design, dissemination and transformation	Investigate artifacts of communication in conjunction with the rationalization of social relations associated with production, implementation and mobilization of knowledge
Maaninen-Olsson *et al.* (2008)	*KMR&P*	Multiple Case Study	Organizational	An investigation of knowledge integration in healthcare and engineering settings found different uses of boundary spanning activities and boundary objects, where referrals, laboratory reports and instructions for specimen taking were used as mediating tools in the first case, while routines, rules, prototypes or practical tests and documents were preferred in the second case. Similarities were found in the organizational structures and mechanisms in terms of purposes, rules and infrastructures that facilitated/inhibited the integration of knowledge	Investigate multiple units of analysis and apply a mixed methodology Investigate trust and power in a temporary vs permanent work setting Employ social network analysis to map/measure relationships and flows among individuals
Martin *et al.* (2012)	*KMR&P*	Mixed Methods	Organizational	A Software Development Project Patterns framework proposed as an approach to create and manage knowledge objects in software projects. Correct modeling found to be influenced by quality of references, experience in modeling and explicit knowledge of the model. Use of process patterns enables quality in software development projects, while relevant effort to teach principles, concepts, data model and tool is required in the implementation phase	Refine the proposed framework with further analysis of different types of software development organizations, software projects and number and type or patterns Qualitative evaluation of emerged patterns
Padova and Scarso (2012)	*KMR&P*	Case Study	Organizational	Management of knowledge objects discussed in the context of E&Y (and its global knowledge platform) case study. Cognitive, organizational and managerial issues were found to influence the management of knowledge objects; therefore, it was proposed that a pure codification, technology-based approach to knowledge management needed integration with social and organizational antecedents to turn into a successful initiative	Integrate detailed analyses of managerial practices in further studies on knowledge objects management
Rountree *et al.* (2002)	*VINE*	Case Study	Individual	Discusses digitalized artifacts for teaching visual analysis in classical art courses. Quality of the media, integrity of reproduction and engagement with artist's work addressed as critical issues determining the potential of the media	Study digital images as effective learning tools
Sánchez-Alonso and Frosch-Wilke (2005)	*TLO*	Conceptual	Organizational	Learning-oriented artefacts to be integrated into the organizational context and knowledge life cycle (KLC) and elaboration of a reuse-oriented e-learning framework	Investigate knowledge life cycle and standardization activities employing the ontological schemes proposed

(*continued*)

Table V

Authors	*Journal*	*Methodology*	*Level of analysis*	*Key findings*	*Future research suggestions*
Shariq (1998)	*JKM*	Conceptual	Organizational	Artifacts mediate knowledge communities or networks. Shifting the design of artifacts from an information centric to a sense-making paradigm since artifacts help make sense of the environment	Integrate knowledge management with sense-making research Develop a consistent set of definitions and terminology to differentiate data, information and knowledge within the context of interactive human cognition Develop a unified framework for sense-making and artifacts in knowledge management
Singh *et al*. (2009)	*VINE*	Case Study	Group	Describes a group knowledge building exercise within an educational context using an activity theory lens. Conceptualize the collaborative knowledge building process as an activity system in which the group works towards a shared object using reflective thinking processes for resolving contradictions and developing shared understanding; identify the contradictions (reflective and developmental) in the activity system	Investigate collaborative knowledge building process in different contexts (e.g. groups from organizational contexts, knowledge intensive group problem solving contexts) Explore additional variables and mediating processes involved in collaborative knowledge building processes
Svabo (2009)	*TLO*	Conceptual	Organizational	Several processes govern the interaction between social and material realities, i.e. object-oriented activity, symbolization, embodiment, performance, alignment and mediation. Material artifacts stabilize/destabilize organizational actions, ensure coordination, communication and control, as well as create disturbance and conflict	Investigate the relations among objects, artifacts, tools, materials, nonhuman elements and clarify whether they cover the same empirical phenomena Elaborate of a coherent theoretical construct that covers how material artifacts participate in social actions
Zuo and Panda (2013)	*VINE*	Mixed	Organizational	Evaluates the trustworthiness of an object (e.g. a software program, a document, a file) in a virtual organization. Defines object trust management and proposes object trust evaluation assisted by novel mechanisms to help users evaluate the quality and security features of available objects	Use empirical components such as more comprehensive case scenarios, model prototyping and user experience analysis to further validate the proposed approaches and to quantify their benefits to information sharing and knowledge management in virtual organizations

Table VI Future research directions, questions and suggested methodologies

Research directions	*Research questions*	*Suggested methodologies and methods*
Research direction 1: develop a consistent set of definitions and terminology	How do data, information and knowledge differentiate to contribute to the artifacts debate in knowledge management research? Do objects, artifacts, tools, materials and nonhuman elements refer to the same empirical phenomena in the context of knowledge management research?	Review of existing theoretical perspectives and synthesis of current literature from an interdisciplinary approach
Research direction 2: include refined theoretical treatments of artifacts	What theoretical lens is more suitable to study artifacts in knowledge management research? What theoretical lens can best describe how artifacts participate in social actions in knowledge management systems?	Selection or integration of existing theories and clear definition of ontological and epistemological perspectives in used research designs
Research direction 3: specify knowledge processes	How do artifacts contribute to knowledge implementation? How do artifacts contribute to knowledge sharing? How do artifacts contribute to knowledge mobilization? How do artifacts contribute to knowledge use? How do artifacts contribute to collaborative knowledge building?	Qualitative, inductive approaches: interviews, observations, focus groups, analysis of documents Quantitative approaches: survey research on potential identified variables and relationships Inclusion of multiple research settings or multiple organizations; case studies or mixed-method approaches favored
Research direction 4: investigate the influence of managerial actions	How do managerial actions influence artifacts adoption and use? What role do control mechanisms have on the use of artifacts in organizational settings? How can organizational knowledge be better managed through the use of artifacts? How can authority or control be limited through the use of artifacts? How can managerial support enhance sustainable mediated collaborations? How do trust, power and power relations influence the knowledge flows mediated by artifacts? What managerial practices best serve knowledge objects management?	Qualitative, inductive approaches: interviews, observations, focus groups, analysis of documents Quantitative approaches: survey research on potential identified variables and relationships

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) and 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 cover how material artifacts participate in social actions (Svabo, 2009); investigation of artifacts in knowledge life cycles and standardization activities using 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 (Singh *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 use 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, 2011); 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).

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 and 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 the 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. This article 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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