Knowledge management and information and communication technologies: some lessons learned for education

Gestión del conocimiento y las tecnologías de la información y la comunicación: lecciones aprendidas para la educación

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Abstract
Knowledge Management (KM) is an almost nonexistent topic in the pedagogical framework, which is paradoxical, given education's affinity with the construction, conservation, assimilation, and dissemination of knowledge, especially regarding the use of Information and Communication Technologies (ICT). A literature review of 103 studies about KM was undertaken in order to identify relationships with ICT and possible applications in higher education teaching practices. Results show that the current way of understanding KM facilitate its application to the design of teaching strategies.
Key words: knowledge management; ICT; teaching strategies; educational practices.

Resumen
La Gestión del Conocimiento (GC) es un tema casi inexistente en el ámbito pedagógico, lo cual es paradójico, dada su afinidad con la construcción, conservación y difusión del conocimiento, especialmente relacionadas con el uso de las Tecnologías de la Información y la Comunicación (TIC). Al respecto, se realizó una revisión de 103 estudios sobre GC para identificar sus posibles aplicaciones en las prácticas de enseñanza en educación superior. Los resultados muestran que la forma actual de entender la GC facilita su aplicación al diseño de estrategias de enseñanza.
Palabras clave: gestión del conocimiento; TIC; estrategias de enseñanza; prácticas educativas.

1. Introduction

The need to improve the quality of education, especially in the contexts of developing countries, has long been discussed but that is becoming increasingly urgent due to the global dissemination of results from international standardized tests such as PISA, TIMSS, or PIRLS (Anagnostopoulos, Lingard and Sellar, 2016; Bouhlila, 2011; Knipprath, 2010; López, 2010; Martínez-Rizo, 2018). Such results have been very sensitive topics for educational authorities and policymakers as contemporary social and economic contexts underscore uncertain and rapidly changing environments (Asmolov, 2018). Within this framework, and based on the progressive increase of educational uses of Information and Communication Technologies (ICT), educational offerings are becoming

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much more diverse but also frequently include various types of alternatives whose quality has not been adequately tested or assured (Kafaji, 2018; Robinson, 2008; Sani, Tasisa and Panigrahi, 2013; Shields, 2011). Moreover, educational offerings with transnational characteristics imply tensions between national normative frameworks, local educational institutions' capacities to change and update themselves, and the demands and expectations from target student populations regarding their educational needs. Additionally, concerns about quality also depend on the capacities of educational offerings to respond to expectations regarding the development of 21st-century skills (Chu, Reynolds, Tavares, Notari and Lee, 2017).

In addition to being uncertain and changeable, however, the current social context has a further feature that poses special challenges to educational systems around the world: the accelerated production of enormous amounts of information. This a phenomenon unlike any that has preceded it, driven by various factors but not least the imminent implementation of what was until recently just a theoretical proposal: the Internet of Things (Moreira, Magalhães, Ramos and Vairinhos, 2018). This situation creates in educational institutions a need to convert their accumulated data and information into knowledge, which requires not only appropriate technical skills but also institutional preparation and the display of principles and practices that favor the appropriate management of the resultant knowledge. In other words, an adequate Knowledge Management System is required.

Knowledge management (KM) is defined as the systematic and integrative process of coordination, throughout an organization, of the activities of acquisition, creation, storage, exchange, development and deployment of knowledge, valuable information, and the experiences of individuals and groups in pursuit of organizational objectives (Shongwe, 2015). It involves not only the existence of knowledge but also processes of its accessibility, shared use, storage, retrieval, and application. Complementarily, Koohang, Paliszkiewicz, and Goluchowski (2017) define KM as an interdisciplinary approach that is used to ensure leadership and organizational competence by developing strategies for the efficient, effective, and rapid use of information. In this sense, KM encourages members of an organization to share knowledge and improve the quality of organizational operations, thereby generating greater efficiency, performance, and competitiveness (Carneiro, 2000).

Accordingly, there is an extensive and profuse tradition of research on Knowledge Management, as shown in Figure 1.

A closer look at Figure 1 reveals that from the 1960s and for more than 30 years subsequently, KM was permanently present as a topic of research, though one with a relatively limited amount of annual production. This trend, however, was broken in the middle of the 1990s at the same time as the massification of the Internet. From this point and over the next 20 years, there was a notable increase in the production of research on KM, reaching an average of 4000 documents per year, which represents a considerable magnitude from the point of view of research publication in the social sciences.

With the expected advent of informational phenomena such as Internet of Things (IoT), BigData, or the increased availability of Artificial Intelligence-based services, then matters such as the recovery, interpretation, and application of information will become processes of enormous complexity and, consequently, huge challenges for knowledge construction in the field of education (Pei, Wang, Wang and Li, 2013).

Figure 1
Research on Knowledge Management (as published in Scopus-indexed journals).
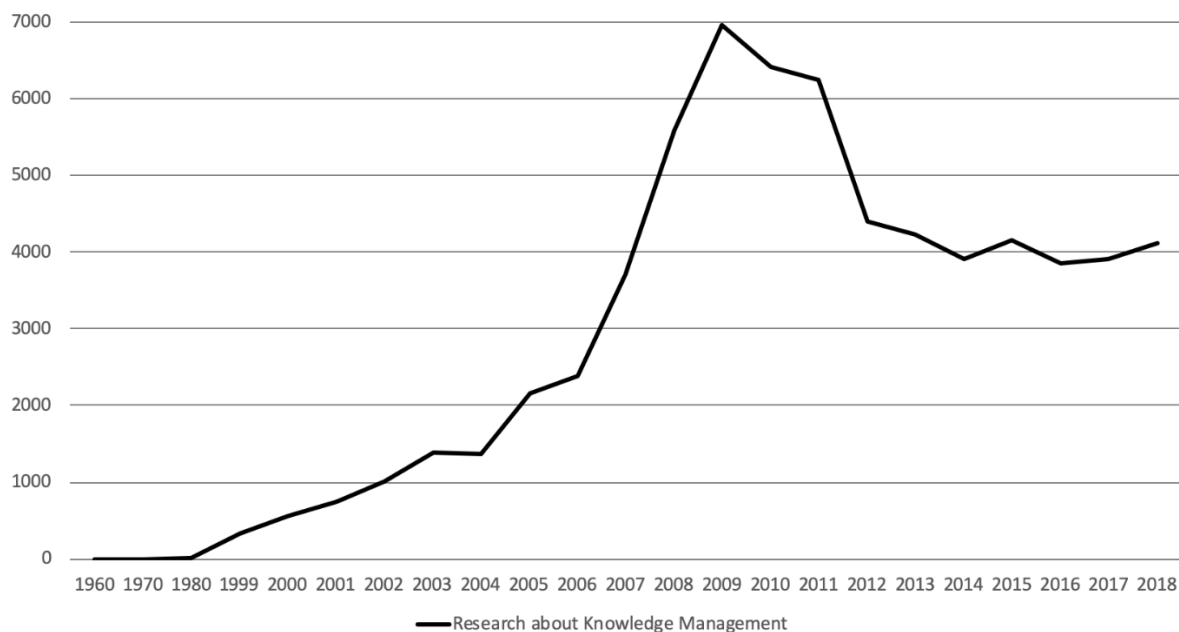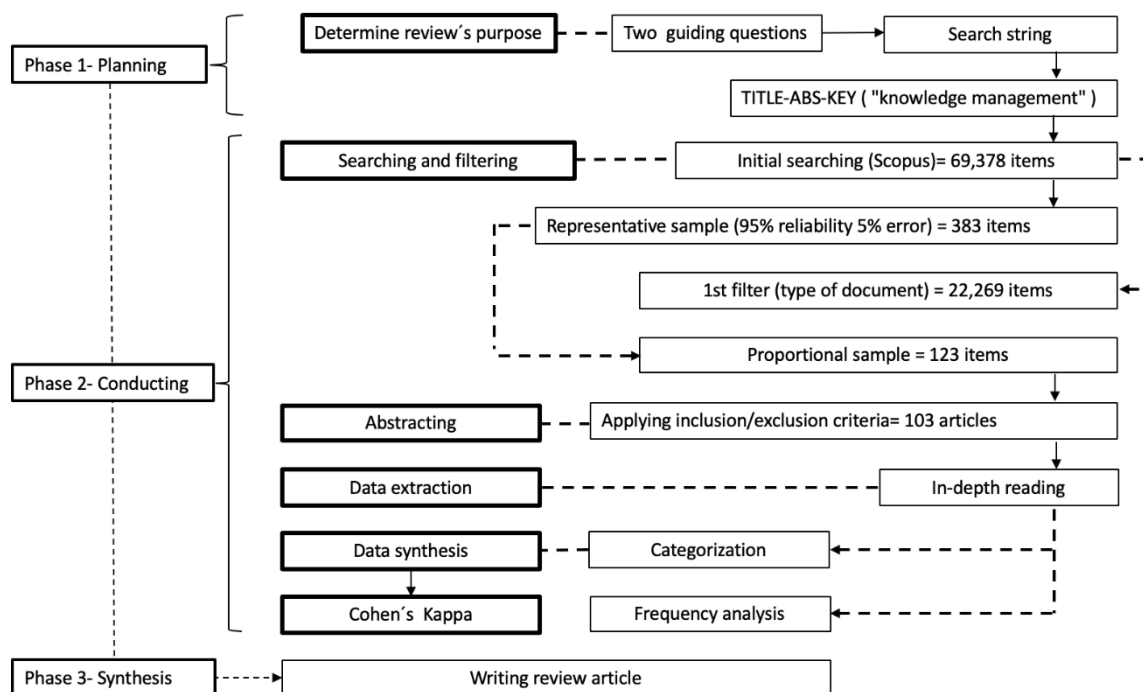

Source: own elaboration based on Scopus data

Accordingly, KM needs to be recognized as not only a highly relevant issue but also one that needs to be adaptable. To date, KM has been developed from and for corporate contexts and has scarcely been discussed in relation to educational environments – which is somewhat strange, given that one of education's fundamental purposes is the construction and assimilation of knowledge, not least among student populations.

To better understand how KM might fit into educational contexts, the present study performed a systematic literature review on this topic, with a specific focus on peer-reviewed publications made accessible through digital academic databases with the objective of identifying elements of KM that could be transferred effectively to diverse educational practices.

2. Method

Literature reviews are a type of documentary research whose purpose is to uncover informational patterns in the published literature on a specific topic (Fink, 2019). The present review was conducted by applying a rigorous protocol adapted from the phases described by Booth, Sutton, and Papaioannou (2016), which are summarized in Figure 2.

Figure 2
Review method

Source: own elaboration based on Booth, Sutton, and Papaioannou (2016)

2.1. Planning

In this first phase, the literature review's objectives were established: to identify aspects of KM, not limited to a particular model, that could be applied in diverse ICT-based educational practices. For this purpose, two guiding questions were formulated: *How has KM been understood and evolved conceptually over time?* and *What aspects of KM can be applied to ICT-mediated education?*

To address these questions, the following string of search descriptors was defined: TITLE-ABS-KEY ("knowledge management") for use with Scopus, considered a broad and interdisciplinary academic database of peer-reviewed publications, to assure high quality and impact in the research literature reviewed, as well as sufficient quantity and temporal coverage.

2.2. Conducting

The second phase began with an initial search, applying the defined string of descriptors (see 2.1) to a search in the Scopus database. This search yielded a corpus of 69,378 documents, for which an initial representative sample was calculated (n=383) with parameters of 95% reliability and 5% error.

From this initial set of documents, a first filtering by document type was carried out to include only published and "in press" journal articles, which resulted in a second set of documents (n=22.269). Based on this second set, a proportional sample was calculated (n=123) without any temporal delimitation, as one of the study's guiding questions demanded a wide chronological coverage (see 2.1).

Thereafter, an abstracting process was applied to the second set of documents, with a focus on ensuring thematic relevance and the presence of research results in the articles that would later be read in-depth (n=103).

Then, through an in-depth reading process of each analyzed article, researchers extracted the information needed to answer the study's guiding questions (see 2.1). The extracted information was recorded in a documentation matrix on which both a qualitative, categorization-based analysis and a complementary quantitative, frequency-based analysis were then performed.

As a strategy of triangulation and verification of personal bias for those analyses, the data were reviewed by two observers and compared by applying a Cohen's kappa coefficient (κ=0.638), which is recognized as an adequate level of inter-rater reliability (Tang, Hu, Zhang, Wu and He., 2015).

2.3. Synthesis

At the end of the literature review process, the data were interpreted and synthesized through a writing process that led to the structuring of an IMRaD-type review article.

3. Results

Initial results of a bibliographical nature show that the research on KM has been published in an unconcentrated, very homogeneous way across 158 journals. The quality of these sources was established by considering the publishing journal's SJR (SCImago Journal Rank) and SCImago quartile ranking, as indicated in Table 1, which identifies the 10 journals with the most publications on KM considered in the present study.

Table 1
Journals with the most publications on
KM considered by the present study

Journal	% contribution	SJR 2018	SJR quartile
Journal of Knowledge Management	3.38%	1.284	Q1
Expert Systems with Applications	1.23%	1.190	Q1
Lecture Notes in Computer Science	1.23%	0.283	Q2
Journal of Information and Knowledge Management	1.08%	0.192	Q2
Knowledge Management Research and Practice	1.00%	0.396	Q1
Vine	0.92%	N/A	Q1
International Journal of Technology Management	0.78%	0.502	Q1
Knowledge and Process Management	0.75%	0.398	Q2
International Journal of Knowledge Management	0.72%	0.307	Q2
International Journal of Information Management	0.68%	1.711	Q1

Source: own elaboration based on Scopus data

3.1. The 1950s: Origins

More than fifty years ago, some researchers were already starting to write about knowledge and its management. In governmental, business, and other private organizations, groups of professionals began to emerge, in charge of generating ideas and knowledge that was then managed to help present products or services to given industrial communities. The reference for the time was Vannevar Bush's 1945 article "As we may think", which anticipated a number of technological and social trends that were to become more evident in subsequent years. Particularly, Bush focused on the problem of information overload and observed that in the future, despite the new technological innovations, such information problems would become more extreme (Levy, 2009).

The first model for KM appeared in 1967, framed within management by objectives in the context of the U.S. penitentiary system. At the time, this system was considered very modern but nevertheless had only

low general acceptance in management communities, probably due to a lack of sophistication in its organizational management and because it had to deal with very complex social distinctions, which often ran contradictory to penitentiary objectives (Terwilliger & Adams, 1969).

3.2. The 1960s and 1970s: Personal computing and the primitive background of Knowledge Management

Technological developments in early information science (e.g. involving the aerospace industry, marine exploration, ARPA/the Internet) saw the concept of KM (although not explicitly identified by that term) focused particularly on the management of information for engineering teams (Jasper, 1966; Konikoff, 1960) and for early developments in computing.

In this regard, Becker and Hayden (1971) argued that a well-designed management information system derived from data processing was vital for successful management control. In the same year, Zaltman and Vertinsky (1971) presented a social marketing model, whose contribution consisted of ways to structure and organize diverse sources of knowledge and data. A year later, with already growing amounts of data and information, Ferrero diRoccaferrera (1972) questioned whether computers would eliminate administrative decision-making and argued that responsible managers, as well as the implementation and use of management systems, were still needed to solve companies' problems.

During the mid-1970s, Stepp, Henry, Scott, and Gwinn (1974), proposed a management model with a financial perspective in the context of hospital administration based on rudimentary computational developments in that sector intended to anticipate the effects of public policies and other external factors. Another remarkable advance from this period was Galbraith's (1977) formulation of a conceptual framework to handle organizational problems and issues.

3.3. The 1980s: The beginnings of Knowledge Management Systems

The 1980s were dominated by a constant spirit of innovation (Tohidi & Jabbari, 2012). One of the decade's most representative milestones was the massification of personal computers, which opened up enormous possibilities – and challenges – for the production and personal/organizational use of information. The rise of desktop computers and their increasingly widespread use in companies of all kinds encouraged some futurists at the time to predict that, because of these new technologies, by the year 2000 almost three-quarters of the workforce would be devoted to information management rather than the production of goods. Likewise, they predicted that half the workforce, including at universities, would be classifiable as *knowledge workers* (Witt, 1982).

In alignment with such predictions, Borko (1983) understood information as an essential ingredient in office work, management decision-making, and the productivity of knowledge workers. He also argued that information science could – and should – be applied to study the economic benefits of organizations' information systems with the purpose of investigating the social and behavioral implications of the new technologies. The fruits of such research would support the planning of government policies and preparation for further systemic changes resulting from the storage, transfer, visualization, and use of information.

During the 1980s, knowledge management developed interdependently with the information sciences as the kind of information needed to carry out effective organizational management processes was itself supported by the creation of internal information systems. Such management and computational developments ended up converging in the so-called "Knowledge Management Systems". Some of the earliest of these referred to the use of computerized systems in medicine, intended for the direct use of physicians, which supported multiple languages of representation and provided "selective storage and retrieval of synthesized clinical knowledge for

reference purposes; and [...] supports the computer application of its knowledge to patient information to help physicians make decisions" (Reggia, Pula, Price and Perricone., 1980, p. 190). Another example was the decision support system developed by the Naval Postgraduate School of Monterey, California to facilitate technology transfer processes, which at the time were considered one of the main challenges in applying new technologies to the solution of administrative and management decision-making problems (Roland, 1982).

3.4 The 1990s: the rise of the Internet, the data realm, and the boom in Knowledge Management

During the 1990s, ICT were no longer limited to a role as support resources for certain organizational processes but themselves became a source of competitive advantage and integral parts of the organizational core (Karemente, Aduvo, Mugejjera and Lubega., 2009). Emphasis was now placed on how laptop computers could add value to the generic functions of company sales forces (sales, orders, reports, services, consulting) by ensuring the effective dissemination of information about customers, accounts, products, prices, technology, market trends, and institutional memory. Accordingly, the effects of automation were analyzed in terms of five key variables: time management, quality of corporate communications, knowledge management, structural reconfiguration, and motivation and corporate culture (Cronin & Davenport, 1990).

It was also recognized that knowledge itself consists of many components, including data, restrictions, queries, transactions, and derivation rules, though data is the only one of its components that can be managed effectively in large quantities. At the time, effective tools and techniques for storing, implementing, and executing other components of knowledge, as well as issues of user specification and design, were still in their infancy. Thus, efforts to manage all components of knowledge in large quantities took the approach of reducing them to data (Orman, 1993).

However, the 1990s also saw the massification of the Internet (Schafer & Thierry, 2018). Specifically, towards the middle of the decade, growing Internet usage motivated the orientation of KM towards the use of Web-based systems. Then, in the late 1990s, Learning Management Systems (LMSs) were developed as platforms in the style of Web portals but oriented to formal educational contexts, integrating certain kinds of communication services, messaging, and information storage.

In the mid-1990s, and with an organizational economic focus, Nonaka and Takeuchi (1995) developed a model of KM (The Knowledge Creating Company) also known as "the spiral of knowledge". This model had the capacity to create new explicit knowledge for the organization, derived from the tacit knowledge of its members, and to disseminate it throughout the organization so that it could be incorporated into products, services, and systems. At the same time, Kaplan and Norton (1996) formulated the Balance ScoreCard, which, although not always considered a KM proposal, certainly considers knowledge and learning as intangible assets that generate competitive advantages.

Other KM frameworks were developed at this time by Huber (1991); Wiig (1994); Petrash (1996); Choo (1996); Szulanski (1996); Saint-Onge (1996); Grant (1996); Meyer and Zack (1996); Alavi and Leidner (1999); Klobas (1997); Van der Spek and Spijkervet (1997); Mayo (1998); Friedman, James, and David (2012); Skyrme (1998); O'Dell, Grayson, and Essaides (1998); and Hansen, Nohria, and Tierney (1999). More recent studies on KM in terms of the effect of the Internet were carried out by Hurley et al., (2002); Flavián and Guinalíu (2005); Barto and Diaz (2013); Tianhong, Zhongkai, and Yiping (2008); Illic (2010); and Bae, Lee, Cheon, and Choi (2012).

3.5. The new century: the 2.0 era and the emergence of personal knowledge management

The new millennium arrived with the evolution of multiple services and products based on the use of the Internet and mobile technologies, starting with the consolidation of the so-called "2.0 culture", which emphasizes the participation of the individual within the dynamics of a networked society. This development left a very particular imprint on research about knowledge management. A review of studies published in the first decade of the 21st-century reveals the coexistence of two parallel perspectives: firstly, one concerned with the continued formulation of frameworks focused on the organizational dimension and intellectual capital; and, secondly, the emergence of a fresher perspective focused on the management of personal knowledge.

In the first perspective, the emphasis is placed on the formulation of a large number of frameworks that deal with very similar KM processes but that also have distinctive elements. Among these are numbered the works of Bontis, Chua Chong Keow, and Richardson (2000); Bukowitz and Williams (2000); Hahn and Subramani (2000); M'Rad and Wyeme (2000); Calaberese (2000); Alavi and Leidner (2001); Earl (2001); Jinxi and Jisheng (2001); Birkinshaw and Sheehan (2002); Lee and Hong (2002); McElroy (2003); Rollett (2003); Okunoye (2003); Awad and Ghaziri (2004); Becerra-Fernandez, Gonzalez, and Sabherwal (2004); Abdulla, Selamat, Sahibudin and Alias (2005); Heisig (2009); Nickols (2000); Holsapple and Joshi (2002); and Sağsan and Zorlu (2010).

On the other hand, the second perspective considers the need to articulate the organizational type of knowledge management with another, more "on-demand" type. In this latter, through adaptive systems, e-learning schemes and the use of mobile devices, it becomes possible to manage both the learning of the organization's members and feedback on processes regarding company culture and operation. Examples of this perspective are found in Grundspenkis (2007); Zhang and Ma (2009); Li and Li (2009); Ji, Fang, and Yang (2009); and Liu, Zuo, and Zhang (2008).

3.6. The 2010s: The 4.0 economy and the challenges for Knowledge Management

Although the issues that characterized work on KM during the first decade of the 21st-century have remained relevant in the following decade, new elements have also appeared, especially in relation to the so-called "4.0 economy". On this matter, Rodriguez Fernández and Pérez del Prado (2018) suggest that the current era of digitalization points towards drastic changes in present and future working conditions for many sectors of the economy and society, with a marked accent on innovation (Bai, An, Bai and Deng, 2015; Chen, 2011; Girniene, 2013). Already, the "4.0 economy" is generating new ecosystems of personal and organizational interaction that are projected through trends or technological developments such as the Internet of Things, Big Data, learning analytics, social media, and artificial intelligence.

In this context, digitization to support KM ecosystems involves major adjustments to the ways that organizations and their members identify, select, capture, share, store, interpret, and apply information, as well as how it is translated into useful knowledge to develop personal performance and at each organization's level of competitiveness.

In this respect, Wang and Sha (2015) argue that Big Data poses great challenges for the strategic management of the interrelations between three of KM's structural components: management, culture, and information technology. Likewise, Abdullah and Christos (2017) approach the management of large amounts of data applied to the education sector through processes of learning analytics, considered appropriate approaches through which educational institutions, especially in higher education, can start building their own KM systems.

Moreover, ongoing developments in artificial intelligence, the semantic Web, and social media are increasingly considered as integrated or articulated components of Knowledge Management Systems since they imply changes in the ways that knowledge transformation and interactivity relations are generated between the

members of organizations and their management support systems (Avdeenko, Marakova and Klavsuts, 2016; Mamorobela & Buckley, 2018; Paschek, Mocan, Dufour and Draghici, 2017). The situation also applies to the context of formal education since the strategies implemented within the perspective of a digital ecology would guide teacher's professional development, establishing a knowledge management system for their professional development, and promoting team learning, cooperation in teaching, and the exchange of knowledge.

Some of the relevant KM frameworks published during the present second decade of the 21st century have been Dalkir (2013); Evans and Ali (2013); and Evans, Dalkir and Bidian (2014). Recent studies that refer to knowledge management in terms of "4.0 economy" are Santoro, Vrontis, Thrassou, and Dezi (2018); Zhang, Sanin, and Szczerbicki (2016); Vega Escobar, Santamaria, and Rivas Trujillo (2015); Yuen, Choy, Lam, and Tsang (2018); Domagala (2019); and Reddy (2015).

4. Discussion

A number of conceptual frameworks related to KM have the potential to provide valuable lessons that could be applied to some of the highly complex processes (e.g. teaching or assessment) that mark the field of education. Particularly relevant are the studies by Shongwe (2015); Karemente at al., (2009); Holsapple and Joshi (2002); Lai and Chu (2000); and Rubestein-Montano et al. (2001). These studies address the main characteristics of multiple conceptual frameworks and often synthesize them in relation to common processes such as (1) *knowledge transfer*, (2) *knowledge storage*, (3) *knowledge application*, (4) *knowledge creation*, and (5) *knowledge acquisition*.

These kinds of knowledge-management processes could be readily transferred and interpreted as the components of an ICT-based teaching strategy. In this sense, the first and the fifth of those processes, *knowledge transfer* and *knowledge acquisition*, concern linking external agents to the process of knowledge communication to overcome the limitations of a model in which knowledge is transferred exclusively from teacher to student. With this in mind, teaching should consider the "environment" or "context" in which other educational stakeholders can add value to teaching by contributing to processes such as "searching", "extracting", "interpreting" or "contextualizing". Indeed, such processes could be transformed into parts of learning activities associated with a given teaching strategy.

Turning to the second process of *knowledge storage*, this places special emphasis on the importance of existing knowledge, which in regard to its application in teaching could be understood to refer to a student's existing knowledge but, perhaps more broadly, can be conceived as referring to the body of knowledge relevant to a given course. Such knowledge would be at risk of being lost if, for example, the teacher in charge of that course left the institution. Yet if the knowledge relevant to a course is the basis for its operation and there is a risk of it being lost, then it should be stored to safeguard it, preferably in ICT-based systems, in such a way that learning generated by the course's students is preserved even after a given course or academic period ends. In this way, the knowledge associated with the course would be constantly updated and, consequently, the activities to be performed with a new group of students would likewise be updated.

With regard to the third process, *knowledge application*, teaching strategies based on ICT should require a student to apply or use the knowledge they have learned. Necessarily this implies externalizing the learned knowledge although, depending on the type of knowledge, its externalization can be manifested differently. For example, if the knowledge is declarative, it can be externalized through orality or writing; if the knowledge is procedural, it can be manifested through the accomplishment of tasks; or if the knowledge is conditional, it can be externalized through decision-making. Moreover, if the knowledge is axiological, it can be identified through the way that decisions are made or tasks performed.

Finally, *knowledge creation*, in alignment with Nonaka and Takeuchi (1995), can be explicitly applied in a teaching strategy as a common thread that both unites the other four processes and serves as their common goal: (1) students share their tacit knowledge, (2) concepts are created as part of the classroom dynamics, (3) concepts are justified, (4) prototypes are generated, and (5) resultant knowledge is then passed on to other educational agents (cross-leveling knowledge), all in a cyclical or spiral scheme.

In summary, what has been mentioned in this section should be considered as an example of the application of lessons learned from KM to a teaching or learning process. A prospective exercise on these issues would indicate the potential existence of various elements of the different KM frameworks that could be transferred to the design of digital-environment-based teaching strategies, as a way to relate two common topics that historically have been developed separately: KM and formal education.

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