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Scientific Associations as Communities of Practice for Fostering Collaborative Knowledge Building: Case Study of IAKM

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Abstract: Knowledge building is a social process that is driven by the willingness of people to share their expertise and create new knowledge. Scientific Communities of Practice (CoPs) are communities of professors and researchers whose aim is to foster scientific knowledge generation. In the KM literature, research concerning this kind of CoPs has been substantially neglected so far. The present research analyses the case study of the International Association for Knowledge Management (IAKM) seen as a scientific CoP where members are mostly academics with research interests in developing and promoting knowledge management. Based on a collection of quantitative and qualitative data about member collaborations and scientific production, the study investigates the structure of interactions and the collaborative processes of IAKM members and the specific mechanisms of knowledge building within this CoP, seen as a paradigmatic example of scientific community. Members were asked to respond to a survey regarding their collaborative activities carried out with other IAKM members in the period of 2011 – 2020. The descriptive analysis revealed the kind of collaborations, the distribution of interactions across the community, and the dynamic patterns over time. A follow-up social network analysis was used to provide deeper insight into the community structure and dynamics. The research found that a CoP can really be useful for progress in a scientific field because it can provide a platform for trust and mutual acquaintance that reduces barriers to collaboration and knowledge building across different universities, professional roles, countries, and cultures, which is increasingly important for the progress of science. Most importantly, IAKM exhibited a cohesive and active core membership with pivotal roles played by a number of active members, which contributed significantly to the growth of the Association and, in general, to the advancements in the field of KM through collaborative knowledge building.

Keywords: collaborative knowledge building, knowledge sharing, scientific community of practice, social network analysis, case study

1. Introduction

Knowledge building is a process of production of knowledge by means of continual improvement of ideas that have a value for a community (Scardamalia and Bereiter, 2003). As Jakubik remarks "knowledge is embedded in human relations and it is created in a heuristic process when individuals interact in a social context" (Jakubik, 2008, p. 6). Therefore, knowledge building is substantially a process of "collaborative knowledge building", in other words it is a concept that reflects a constructivist perspective on social knowledge generation (Gilbert & Driscoll, 2002; Hmelo-Silver, 2003; Hmelo-Silver & Barrows, 2008; Putambekar, 2006).

Indeed, the source of any knowledge, that becomes a seed for knowledge building, is an individual's mind. However, while knowledge is born in the body and the mind of an individual, when it is shared in a network of social relationships it becomes a subject of collective restructuring and developing. Knowledge becomes a dynamic entity which stems from the contributions of those who participate at a given time in a certain social context.

The characteristics of this social context clearly influence the process of collaborative knowledge building. Its effectiveness can depend on the attitude or motivation of each participant to share his/her experience and expertise, or on the psychological or trust climate that exists (Hardwick et al., 2013). Also, it can be influenced by the structure of interactions and networking patterns that develop between participants (Philip, 2010), or by the mechanisms and tools that are used for sharing knowledge.

A popular organizational context often analysed in knowledge management (KM) is the Community of Practice (CoP), a "group of people who share a concern, a set of problems, or a passion about a topic, and who deepen

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their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger et al., 2002, p. 4). CoPs are environments where the processes of collaborative knowledge building can develop effectively (Alamantariotou et al., 2014).

A particular context for collaborative knowledge is scientific research. Here, a proper balance must be found between richness of diversity in specialisations on the one hand, and commonality of interests and existence of a common ground for effective communication on the other hand. (Guimerà et al., 2005). Scientific Associations are a particular example of CoPs in science, involving scholars who share a scientific interest but work in different scientific institutions.

Indeed, as the tragedy of the COVID pandemic clearly shows (Hensher et al., 2020), there is (and there has probably always been) a need for scientists to cooperate freely all around the world. For this reason and, in addition, considering that the mechanisms and structures of scientific associations as CoPs have been more rarely analysed in the KM literature, the goal of this paper is to provide insights into this topic by means of a study of the case of the International Association for Knowledge Management (IAKM).

The purpose is to shed light into the structural conditions and enabling mechanisms that can favour collaborative knowledge building in scientific CoPs. An empirical analysis of IAKM members' engagement in collaborative knowledge building processes is performed. Based on data collected by means of a questionnaire survey, the structure of interactions and cooperations has been framed. In addition, a content analysis of IAKM's main publication outlets has been conducted, to gain a better insight into the nature of the community's knowledge building outcomes.

This analysis aims at revealing how collaborative knowledge building can really develop within a Scientific Community of Practice when there are appropriate conditions that favour fruitful knowledge exchanges. It is also intended to provide support to the argument that, while knowledge remains the result of a cognitive process of individuals, a proper organisational setting can play a vital role in amplifying the creation of new knowledge in science through collaboration. Finally, we examined whether and how collaboration processes in a CoP can be facilitated by the existence of active and pivotal members that can attract and boost interpersonal interactions with other members, and to what extent these mechanisms are driven by the formal organisation.

The structure of the paper is as follows: the second section recalls the main literature references, and section 3 presents IAKM as a Scientific Community of Practice; section 4 describes the empirical methodology and section 5 the main results. Section 6 (Discussion) and 7 (Conclusion) highlight the main contributions of the study.

2. Literature review

Scardamalia and Bereiter (2003) define knowledge building "as the production and continual improvement of ideas of value to a community, through means that increase the likelihood that the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts" (p. 1370). The authors underline the importance of a social synergy requested by the nonlinearity of the knowledge building process, and of the cultural environment. This leads to the notion of collaborative knowledge building, a generic concept for all the processes of knowledge creation based on the assumption that knowledge is a complex construct that involves both individual minds and social contexts (Hmelo-Silver, 2003; Kali, 2006; Scardamilia & Bereiter, 2006; Singh et al., 2007).

Social knowledge is a dynamic result of the contributions of the many who take a part in this and, therefore, can depend on various elements that pertain to the individual or to the social group. It is enabled by the motivation of each participant to share his/her experience and expertise in a certain activity domain, but that motivation can be stimulated or inhibited by the psychological climate in the given social context, because knowledge sharing may lead to either a winning or a losing game. Trust and a certain learning interest are additional factors that can affect an effective attitude towards knowledge sharing and, by this means, collaborative knowledge building.

There are several models describing this social construction and explaining knowledge dynamics (Nissen, 2006; Nonaka & Takeuchi, 1995; Nonaka et al., 2008; Stacey, 2001). As Wenger et al. remark, "What managers have been missing so far is an understanding of the kind of social structure that can take responsibility for fostering learning, developing competencies, and managing knowledge" (Wenger et al., 2002, p. 11).

A comprehensive model was conceived, among the first researchers, by Nonaka (1994), developed then by Nonaka and Takeuchi (1995), and revisited with upgrades by Nonaka and Takeuchi (2019). In the first version, the knowledge creating dynamic model had two dimensions: epistemology and ontology. In this model, knowledge is broadly defined "as a justified true belief that is created and practiced by people, through their interactions with others and the environment, and in a specific situation or concept" (Nonaka & Takeuchi, 2019, p. 60). The metaphor used by these authors for understanding knowledge is the iceberg. The visible part of the iceberg that is situated above the water surface refers to the *explicit knowledge*, and the hidden part of the iceberg that is covered by the water the *tacit knowledge*. The SECI model contains four basic processes: Socialisation (S), Externalisation (E), Combination (C), and Internalisation (I). *Socialisation* contains tacit knowledge – tacit knowledge sharing within the social context, *externalisation* contains tacit knowledge – explicit knowledge conversion at the individual level, *combination* refers to explicit knowledge – explicit knowledge building up within the social context, and *internalisation* refers to explicit knowledge – tacit knowledge conversion at the individual level (Nonaka & Takeuchi, 1995; Nonaka et al., 2008). Externalisation that reflects articulating explicit knowledge and internalisation that reflects embodying tacit knowledge develop along the epistemological dimension. Socialisation that reflects empathising with people through tacit knowledge and combination that reflects the social connecting and interaction through explicit knowledge develop along the ontological dimension (Nonaka & Takeuchi, 1995; Nonaka et al., 2008). Thus, knowledge is built up ontologically from the individual to the team, then to the organisation, and finally to the community.

In their revisited SECI model Nonaka and Takeuchi (2019) introduce time as an explicit dimension, such that knowledge building becomes a three-dimensional process looking like a spiral. "The SECI Spiral occurs as knowledge creation is carried out repeatedly over time. In essence, the SECI Spiral is an extension of the SECI process in which knowledge is ceaselessly created, amplified, and practiced, and more knowledge that is created and disseminated is converted into action" (Nonaka & Takeuchi, 2019, p. 71). The authors integrate knowledge creation with knowledge practice revealing the role of *phronesis* or practical wisdom in decision-making. Metaphorically, knowledge creation and knowledge practice look like the two sides of the same coin. This feature of the SECI Spiral model reflects very well the knowledge building process within CoPs, especially within the scientific CoPs like IAKM.

In the model proposed by Nissen (2006) the focus is on *knowledge flow*. Changing the metaphor used in the first phase of knowledge management (Andriessen, 2008), from physical objects to fluid flows, Nissen shows how knowledge is building up within a social context: "To the extent that organisational knowledge does not exist in the form needed for application or at the place and time required to enable work performance, then it must flow from how it exists and where it is located to how and where it is needed. This is the concept *knowledge flows*" (Nissen, 2006, p. xx). The SECI Spiral and the knowledge flows models can be integrated in practice (Nonaka et al., 2008).

Going beyond Nonaka and Takeuchi (1995, 2019), and Nissen (2006), Bratianu and Bejinaru (2019, 2020) introduce the *energy metaphor* and a thermodynamics approach in conceptualising knowledge transformation and knowledge building within social contexts. According to their model, there are three fundamental fields of knowledge: rational, emotional, and spiritual. Rational knowledge is the result of our rational thinking and it is expressed as explicit knowledge. Emotional knowledge reflects the wordless knowledge generating within our body as a result of the experiential learning. Emotional learning is processed by emotional intelligence that is an important component of the social intelligence (Goleman, 2007; Kahneman, 2011). Spiritual knowledge reflects our beliefs and values which influence the decision-making process (Nonaka & Takeuchi, 1995; Zohar & Marshall, 2004). It is processed by the spiritual intelligence, which together with emotional intelligence determines the behaviour and adaptation capacity of people within social contexts. Thus, the knowledge building process along the ontological dimension can be better explained if one considers the contribution of rational intelligence, emotional intelligence, and spiritual intelligence, which act interactively and iteratively (Briskin et al., 2009; Goleman, 2007).

All of the models above show that there are some organisational settings, intentionally designed, where people overcome the emotional barriers in developing mutual relationships more easily and reach a shared understanding more efficiently, which results from the community shared values (Ali et al., 2019; Nahyan et al., 2019; O'Dell & Hubert, 2011; Stahl, 2000; Wenger, 1998). In these contexts, collaborative knowledge building is a complex process that can also be well-supported by an appropriate IT infrastructure (Chee, 1996; Li, 2006; O'Dell & Hubert, 2011).

Those groups of people where trust and shared learning interests have a stimulating role in knowledge sharing and building, tend to develop a certain identity and gravity force in time. This is exactly what characterises a Communities of Practice (CoP). According to Wenger et al., "Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger et al., 2002, p. 4). CoPs may have a name or not, a formal status or not, a well-defined boundary or not, a management team or not, but nonetheless their common characteristic is their stimulating role in knowledge sharing and knowledge building due to a shared set of values accepted by all members (Bolisani & Bratianu, 2018; Wenger et al., 2002).

Therefore, CoPs can be regarded as an environment where processes of collaborative knowledge building can occur and be nurtured (Alamantariotou et al., 2014). Their effectiveness depends on a set of conditions and characteristics of i.e.: a) the social, psychological, and trustworthy context that can influence members' active participation and willingness to share experience and expertise (Hardwick et al., 2013); b) the dynamics of networking, interactions, and the kind of knowledge exchanges (Liu et al., 2005); c) the emerging structures and pivotal nodes that can play an essential role in stimulating interactions in the whole group (Oshima et al., 2012; Philip, 2010), and d) the tools that are used for sharing knowledge (Alamantariotou et al., 2014).

A particular context where collaborative knowledge building develops in peculiar forms is scientific research. Here, there is a need to incorporate individuals with different ideas, skills and resources: indeed, creativity often develops when innovations are introduced into new domains, for solving new problems and inspiring fresh thinking. But it is also necessary that a proper balance is found between diversity – which may potentially spur creativity but can also lead to conflict and miscommunication (Guimerà et al., 2005) – and homogeneity – which favors knowledge sharing but reduces the space of innovations. Scientific Associations can be a particular kind of CoP where collaborative knowledge building can occur between scholars who share a discipline or research field but also work in different institutions. In addition, scientific CoPs generally gather people not only of different specialisations but also cultures. This is particularly important to consider, because designing collaborative knowledge building environments should use an integral or integrative approach (Kirman et al., 2011; Murray, 2006; So et al., 2010) and incorporate cultural dimensions when CoP members come from different cultures. Many intercultural projects failed so far because they ignored these cultural dimensions which integrate emotional and spiritual knowledge (Haig, 2003; Hong et al., 2010).

Although in the KM literature there are many examples of CoP, there is a scarcity of papers focusing on Scientific Associations as CoPs. Their mechanisms and structures – and the knowledge dynamics that occur in them - have been rarely analysed. Filling this gap is the main goal of this paper.

3. The case study: IAKM as a Scientific CoP

In this section we will focus specifically on three main points: first, what a scientific association is; second, if a scientific association can be considered as a CoP and under what conditions; third, if IAKM – which is our case study - can be considered a CoP.

In regards to our first point, it can be easily affirmed that Scientific Associations have a long history (Eamon & Paheau, 1984) that can be traced back at least to the 16th century when the "Academia Secretorum Naturae (Accademia dei Segreti)" was founded in Naples by the mathematician Giambattista Della Porta. In these associations, scholars "looked for a more satisfactory intellectual environment outside the walls of the university, seeking protection and patronage from rulers who hoped to enhance their own prestige as benefactors of the new learning"; these societies "fostered the idea of cooperative scientific effort and became centres for the dissemination of scientific information" (Eamon & Paheau, 1984). In short, Scientific Associations became communities where scholars shared a common interest and sought for mutual cooperation, with the purpose of enhancing scientific knowledge. They rapidly acquired a key role in the development and dissemination of scientific knowledge not only in t academia but, more broadly, in societies. There are some paradigmatic examples like the UK's Royal Society (www.royalsociety.org) which clearly show this.

Over the centuries, a lot of Scientific Associations were created with similar characteristics, as a forum of independent scholars who share an interest in a branch of science and seek for collaboration beyond the limits of their respective organisations, universities, and nations. Scientific Associations have been created in all areas of science. They may have different structures and operative mechanisms, but they all share the original features and goals (maybe declined in a more modern language), e.g.: favouring the development of a scientific discipline, consolidating its academic or professional recognition, facilitating the connection between scholars of different organisations, organising workshops and conferences, editing publications, providing reference to younger researchers, designing and maintaining websites, mailing lists, and document repositories, etc.

Can a Scientific Association be considered a "CoP" the way this notion is generally defined? As mentioned, in KM, the term was introduced by Wenger and colleagues (Lave and Wenger, 1991; Wenger et al., 2002) and, if we examine the literature, this concept has been applied in different ways (Bolisani & Scarso, 2014). Nevertheless, the practical implementations (in companies, public organisations, or even across organisations) often have some common characteristics: they can include amateurs as members, but are generally targeted to experts or professionals in a knowledge domain; they often are, to some extent, deliberately planned, but have some light "management structure", whose purpose is mainly to set the general rules of interpersonal interactions (for example, to guarantee a "democratic" debate), to facilitate people's knowledge exchange, and to manage some service activities for the benefit of their members (for example, running a communication system, organising virtual or in-person workshops, etc.). As for Scientific Associations, although there is little or no sign of studies that analyse them as CoPs, if we consider the notion of Scientific Association that we mentioned above it can be easily concluded that these organisations are, indeed, CoPs – even if their Statutes and formal/informal documents never mention this term. Indeed, a Scientific Association is created to facilitate the exchange of knowledge of its members; it focuses on a particular subject, discipline, or domain; it collects people that have some professional interest in it; and it has a "management group" whose goal is to favour interactions of members for the benefit of the whole Association (and, secondly, of the public). All this well fits the definition of CoP and the characteristics that are generally ascribed to it, as was mentioned earlier.

Finally, considering IAKM, this is a non-profit organisation designed to promote KM and to contribute through its members to the advancement of knowledge about managing knowledge and wisdom (see www.iakm.net for details and supporting documentation). IAKM has a well-defined membership, a legal statute, and declared mission to stimulate collaborative knowledge building among its members and a flow of knowledge towards other academic communities, societies, and business environments. The great majority of members are university professors and researchers (although there are also some business professionals in the group), and they share the same willingness for learning and knowledge building, as well as its dissemination through specialised journals, books, conferences, exchange programs, doctoral boards, and many other activities (Bolisani & Handzic, 2015; Bolisani & Bratianu, 2018; Bratianu, 2014; Petrides & Nodine, 2003).

Its history and development show that this organisation is, indeed, a CoP even though this term has never been used explicitly in the official papers. IAKM was initiated in 2011 and formally founded in 2012 by 11 scholars of various universities; it progressively grew and now it reaches around 80 members, internationally spread: all members share a common interest in a scientific domain (i.e.: knowledge management) and this interest is substantially professional – because members are scientists whose research area is KM, or practitioners that work in the field. The Association has a light management structure (a Board, a President, and occasional service roles) whose main goal is to facilitate interactions of members - without restrictions due to different career position, age, or scientific recognition, to promote open debate in hot topics for the discipline, to favour the sharing of information about opportunities for research in the field, and to promote all possible forms of dissemination of the scientific results obtained by any member. All these issues – that are, by the way, typical of any Scientific Association – are also characteristics of a CoP as we defined it earlier.

IAKM typically pursues its goals with a mix of formal activities and informal initiatives: on the one hand, IAKM workshops and meetings are organised regularly for the benefit of members that can share information and opinions about their respective work; in addition, the Association promotes a Book Series where all members are invited to cooperate as authors, editors, or reviewers. But all this is gained through active participation and volunteering: regardless of the (light) formal activities and roles that IAKM, as any other scientific Association, has, it is mainly an "informal container" that gives the opportunity to members to reinforce their interpersonal knowledge and, in this way, to create opportunities of cooperative scientific work in the form of joint projects, publications, invitations to seminars and conferences, etc. A website, an email newsletter, and a Youtube channel are the digital platforms also used to exchange materials and disseminate information to the public.

4. Research methodology

Case studies are considered particularly suitable for exploring community-based problems as they enable researchers to examine social and behavioural questions in real-life contexts and rely on multiple quantitative and qualitative data analyses (Yin 1994). Hence, this was our preferred choice of a research method for the current investigation. Specifically, an empirical analysis of IAKM members was conducted with the purpose of investigating the mechanisms and structures of this CoP and how these have favoured the processes of collective knowledge building. These were the specific goals: a) reconstructing the networks and intensity of interactions and collaborations that IAKM members developed over time; b) identifying structural patterns and pivotal roles in these networks; c) examining the types of collaboration, and d) analysing the production of collaborative knowledge in the form of produced publications. A combined approach including a quantitative IAKM membership survey followed by a qualitative IAKM publications' analysis (i.e., the main outcomes of collaborative knowledge building in science) was adopted to enable better understanding of key concepts.

All IAKM members were invited to provide a synthesis of their contributions to the main processes of knowledge building and insert them into a certain framework. Data collection was carried out in January 2020. Specifically, members were asked to fill in a questionnaire form distributed by email. Then all their inputs were analysed by using some specialised software for social network analysis, and the results were graphed and interpreted. In addition, content analysis of IAKM's main publication outlets was conducted to gain a better insight into the nature of the community's knowledge building contributions. In this way, it was possible to produce a broad picture of IAKM's collaborative knowledge development since its initiation in 2011 to date.

The questionnaire written in a MS Excel sheet included the following questions: (a) names of all collaborating members, (b) type of collaboration (e.g., joint publication or event), (c) year and (d) short description. Joint publications covered journal articles, conference papers, books, book chapters, presentations etc. Joint events covered panels, workshops, forums, conferences, special tracks/sessions, projects etc.

Subjects for this research were all members of IAKM whose name was in the official records of the Association. The questionnaires were distributed to the recipients by email together with a short explanatory statement about the study aim and instructions for completing the survey. Data collection lasted one month. A total of 19 responses were received from 76 questionnaires distributed, reporting a total of 50 different collaborating members from around the world.

The collected responses were combined in one MS Excel sheet. They were cross-checked and duplicates were eliminated from further analysis. In addition, various reported collaborative activities were classified into research, teaching and professional support categories. Then, relevant descriptive statistics were calculated and presented visually using three different software programs (MS Excel, Palladio and Gephi).

This quantitative analysis was further supplemented by a qualitative content analysis of a selection of publications produced by IAKM members. This selection is based on the book series "Knowledge Management and Organisational Learning" (https://www.springer.com/series/11850), which is the official book series of the Association and where there are a lot of contributors of the various members. This can help to build a significant picture of the results of collaborations by singling out some key contributions to knowledge production in IAKM. The results obtained from both types of analysis are described in the following section.

5. Results

An initial analysis of the collected data revealed that a two-third majority (66%, 50 out of 76) of the IAKM membership collaborated in one or more research, teaching or professional support activities over the past decade. Collaborators spread over 25 different countries from 5 different continents. These were more prominent in Europe (as visible in Figure 1), which well reflects the statistical composition of the current IAKM membership, where the major part is compounded by Europeans.

Figure 1: Geographic distribution of collaborating members

The number of members who collaborated in different activities varied from 2 to 21 as shown in Figure 2. Typically, collaborative activities involved only 2 members (113), followed by 3 members (28) and 4 members (19). Larger groups of 5, 6, 7 and 8 members were less frequent (7, 8, 7 and 3 activities respectively). One group of 12 members was involved in 2 activities, while three groups of 11, 13 and 21 members collaborated in 1 activity.

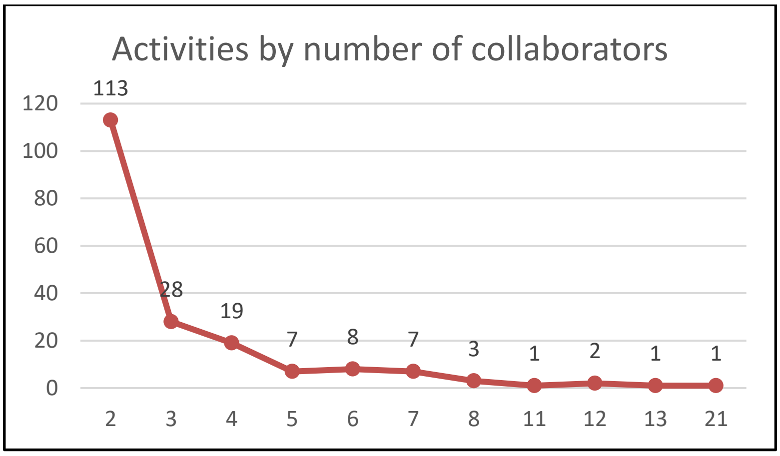

Figure 2: Frequency of collaborative activities by number of collaborators

With respect to the main types of members' collaborative activities, Figure 3 reveals the greatest focus on research. The majority of members (72%) co-authored conference papers (54) and journal articles (44), followed by books (10), book chapters (4) and other various publications (3). They also participated in various collaborative workshops (8), panels (4) and project applications (4).

Some members (21%) offered important professional support in terms of jointly organising various communication activities (12), conferences (10) and meetings (3). They also participated in various committees (10) and acted as co-editors of book series (1), journals (1), special journal issues (1). A smaller number of members (7%) were involved in collaborative teaching activities such as preparing delivering seminars (6) and courses (2), students exchanges (3) and joint theses supervision (1).

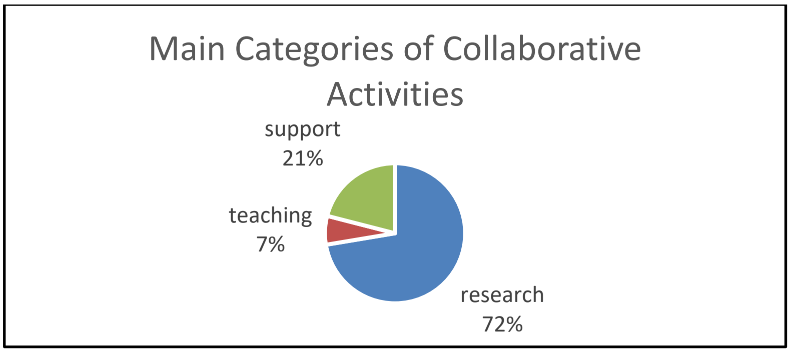

Figure 3: Distribution of main categories of collaborative activities

Results of the trend analysis of members' collaborations over time are presented in Figure 4. The figure shows a steady increase in the number of collaborative activities from 7 to 41 in the period 2011-2018 and a slight decrease from 41 to 32 activities in year 2019. Data for 2020 are incomplete (they refer only to a small part of that year).

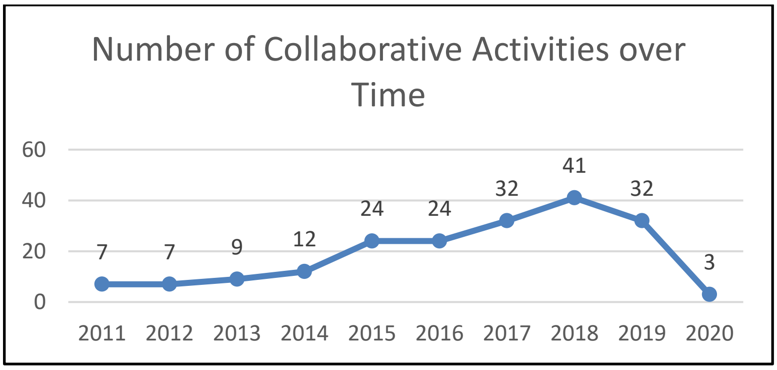

Figure 4: Trend in number of members' collaborative activities over time

Deeper analysis of the IAKM dynamics using social network analysis (SNA) discovered a key role of the IAKM's founding president (id29) in initiating and participating in a wide range of collaborative research, teaching and professional support activities. The results of SNA presented in Figure 5 also show a highly active core group of other 9 members (id27, 19, 3, 59, 45, 25, 7, 54, 12). They represent mostly past or current board members.

Further analysis of the community's structural composition revealed 3 large and 2 small sub-groups. These are presented in Figure 6. With respect to 3 large groups, the figure shows that the largest one (violet nodes) consists of 21 members (id4, 11, 57, 43, 39, 24, 58, 34, 14, 73, 3, 42, 76, 63, 74, 35, 65, 69, 61, 28, 33). Their identities reveal that they come from all around the world. The figure also suggests an important role of one member (id3), in establishing these worldwide relationships. The second large group (green nodes) consists of 15 members. Their identities reveal mostly founding and long-term members (id47, 72, 38, 54, 15, 31, 36, 62, 7, 59, 29, 45, 27, 46, 66). Here, the role of (id29) is particularly visible in maintaining intensive collaborations with the IAKM's core members. The third large group (blue nodes) has 10 members (id19, 25, 32, 67, 68, 12, 71, 5, 2, 49). According to their identity numbers, these members come predominantly from Romania. One member of this group, the current IAKM's president (id19), plays a visible role in mobilising other members (who are his nationals in the community). With respect to 2 small groups, the first one (orange nodes) is completely isolated and consists of 2 members (id9, 16) from the same institution in China. The second group (black nodes) of 2 members (id8, 13) appears connected to the largest group (violet nodes) and thus may be treated as its integral part.

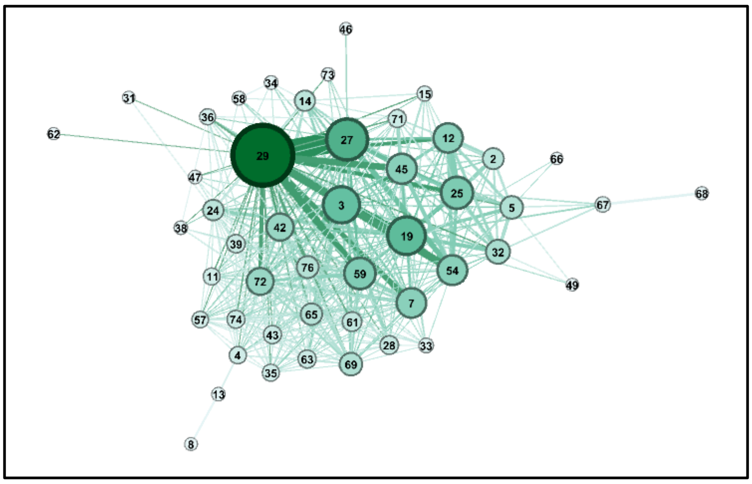

Figure 5: Intensity of community members' collaborations

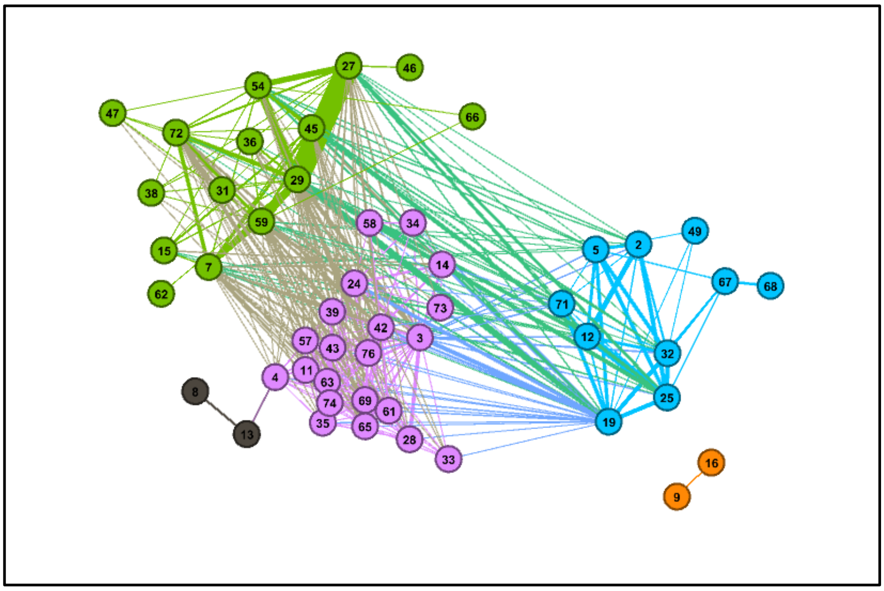

Figure 6: Structural composition of the collaborative community

The results of the qualitative analysis of IAKM's book series Knowledge Management and Organisational Learning (KMOL) are presented in Table 1. The content analysis of KMOL's nine volumes reveals a variety of topics and issues addressed. Two volumes examined the entire KM domain (Vol. 1 & Vol.4). Another two early volumes addressed two major KM sub-domains, hard technical (Vol 2) and soft social (Vol.3). One volume was dedicated to a particular category of stakeholders within the project KM domain, namely project managers (Vol .5). Finally, several later volumes examined KM in the context of economy (Vol. 6), arts and humanities (Vol.7), education (Vol. 8) and industry (vol. 9).

Table 1: List of titles and characteristics of KMOL series volumes

Volume	Characteristics
1.Advances in Knowledge Management: Celebrating Twenty Years of Research and Practice	-Tracks knowledge management development over two decades -Provides essential reference to key studies and scholars -Includes lessons learnt from state-of-the-art KM applications in business, government, and civil sectors
2.Corporate Knowledge Discovery and Organisational Learning: The Role, Importance, and Application of Semantic Business Process Management	-Provides a new way to knowledge discovery and extraction from business processes -Introduces ontology-based adaptive testing and learning -Illustrates three different application cases
3.Social Knowledge Management in Action: Applications and Challenges	- Combines knowledge management and social media with a focus on applications that makes it worthwhile for practitioners as well

Volume	Characteristics
	- New insights on applying social media in organisations - Selected set of empirical research papers by experts in their field
4.Emergent Knowledge Strategies: Strategic Thinking in Knowledge Management	- Fresh perspective on knowledge management and strategic thinking - New reflections on the emerging domain of knowledge strategies - Critical analysis of organisational knowledge dynamics
5.Knowledge and Project Management: A Shared Approach to Improve Performance	- Offers a fresh perspective on benefits and outcomes of merging Knowledge and Project Management -Reviews relevant concepts and models integrating Knowledge and Project Management - Unifies art and science of both fields
6.Knowledge Management in the Sharing Economy: Cross-Sectoral Insights into the Future of Competitive Advantage	- Helps readers to achieve insights into the interaction between KM and sharing economy - Provides cross-sectoral and cross-national approaches to compare and distinguish industry and country specific nuances - Addresses both current phenomena and future challenges
7.Knowledge Management, Arts, and Humanities: Interdisciplinary Approaches and the Benefits of Collaboration	-Provides empirical evidence on benefits of cross-breeding KM with arts and humanities -Demonstrates how traditional methods from arts and humanities help in knowledge creation and evolution -Shows how KM models and practices provide valuable benefits in a digital environment for these fields
8.Connecting Adult Learning and Knowledge Management: Strategies for Learning and Change in Higher Education and Organisations	- Extensive survey of the challenges for adult education in a knowledge-based society - Shows how knowledge management can be of use in educational practice - Provides case studies and best practices of new methods experimented “in the field”
9.Knowledge Management and Industry 4.0: New Paradigms for Value Creation	- Provides evidence on how Industry 4.0 and KM interact to create value - Highlights changes in value chain relationships and activities due to new technologies - Presents modern conceptual frameworks and a road-map for new innovation strategies

Furthermore, Table 1 reveals the use of a wide variety of research methods ranging from traditional literature reviews, through scholars’ personal views and opinions, to empirical surveys and formal case studies. Overall, these results point to gradual change in approaches to KM research from conceptual to performative which suggest the field’s progression towards maturity.

6. Discussion

This section analyses and interprets empirical data from the survey of the IAKM members’ collaborative knowledge development activities. Based on the examination of the community’s outcomes and contributions to the KM academic body of knowledge and its delivery to the wider context of KM researchers and practitioners, it can be said that the Association has proved to be a successful scientific CoP, and it has really enabled fruitful interactions among its members which resulted in an enhanced process of collaborative knowledge building. The research also sought to establish how the dynamics of these interactions evolved, and what structural elements may have influenced this.

As mentioned, the findings suggest that IAKM is really a successful scientific CoP, as is evidenced by the high percentage of collaborating members (66% members), collaborations not limited to colleagues of the same country but also international (25 countries from 5 continents), prime focus on research (72% activities), steady growth over time (activity increase by 5 times), and the number of scientific outcomes produced. Apparently, the community contributed significantly to the KM academic body of knowledge and its delivery to KM practitioners. This is also evidenced in the comprehensive coverage of the book series topics and issues across the entire KM domain, in a variety of contexts and serving different classes of stakeholders. It also results from the balanced study of theoretical concepts and their empirical examination in practice. Most importantly, the community contributed to the recognition and progress of KM as a discipline by developing KM’s distinctive intellectual core, by extending its interdisciplinary reach and by providing highly relevant lessons learnt to practitioners. All this testifies that the model of open scientific CoP that IAKM represents can favour this role in promoting the development of the scientific discipline.

An important point to notice is that collaborative knowledge building mainly involved dyads (60%) or triads (15%) of members. This is comparable with earlier findings reported by Handzic (2015) regarding the number of co-authors publishing in KM journals. This may signal that, on the one hand, the preferred interactions for collaborative knowledge creation are still between 2 or 3 people (probably for the reason of efficiency and focalisation) as it normally occurs in this scientific field. In addition, as was also found in previous studies, there is a greater number of collaborations among members of the same geographical area (e.g., European countries, and sometimes more local areas, e.g., Romania, or even the same institutions – like in the case of a Chinese university). Here, probably, cultural proximity still mattered.

On the other hand, an important result of our analysis is that an effective scientific CoP can also really facilitate networking between large groups of scientists across universities, countries, and continents, which are generally more complex to build up: the survey also shows some collaborative activities involving large and very large number of members (around 25% of collaboration involve 4 or more members, very often of different countries and areas). It may therefore be argued that the climate of trust and mutual acquaintance that members were able to create over time in IAKM can favour collaborative knowledge building in large groups across nations and cultural domains.

With respect to significant structural elements influencing IAKM dynamics, this study discovered that some people (3 in particular) played a key role in steering IAKM's current course: the founding president of IAKM, who managed to attract a group of volunteers and enthusiasts who established a core KM community, another founding member, whose extensive international collaborations across continents contributed substantially to IAKM's expansion, and the current president, whose mobilising activities contributed to significant enlargement of the community especially in a local area (i.e. through his own nation). Therefore, their role could have been favoured by different elements: for two of them, it may be their exposure, due to their formal role in the Association; for the third person, it was probably the personal popularity which counted. In any case, it is important to notice that, although IAKM is a free CoP where any member can propose collaborative activities to others, the presence of some particularly active members can function as "glue" and can, especially, boost collaboration processes in larger groups. The most effective collaborative knowledge building processes, in substance, may require some pivotal nodes in the CoP, whose role will emerge over time thanks to their proactive attitude, and not necessarily thanks to a formal role that is assigned to them.

In addition, the analysis identified several subgroups where people collaborate more intensively with one another than with the rest of the community. This also suggests that scientific CoPs can operate successfully if they are let free to adapt dynamically to the complex structure of interactions that develop dynamically over time, based on the specific interests, attitudes, and capabilities of members.

7. Conclusions

This paper reported the results of a study aimed at examining IAKM as a case of scientific CoP based on its collaborative knowledge building activities and their contributions to the body of KM knowledge. The main findings revealed that a CoP can allow wide geographical-spread, large-sized and research-focused collaborations between members, with a growing trend over time. All this indicates that a scientific CoP can really have a central role in a successful research community. In addition, the findings identified that interactions among members follow dynamic paths due to specific contingencies, attitudes, and interests of members, that may tend to aggregate into different subgroups within IAKM, where interactions become more frequent and intense. This suggests that scientific CoPs can operate successfully if they are let free to operate as complex dynamic structures in the frame of a light formal configuration. Finally, the findings indicated important influencing of some leading roles, but also ordinary members. This implies that there may be some pivotal nodes in the community, especially capable of attracting members to large collaborative knowledge building activities, but the active life of the community must count on the active participation of many individual members for pushing its progress.

The case study shows a healthy interest in the KM discipline, as is indicated by the growing IAKM membership and the number of scientific outcomes that this CoP has apparently made it possible to produce. This statement contrasts earlier reports noting a decline in the volume of yearly studies on KM topics since 2015 (Serenko, 2021). Therefore, it is confirmed that participating in a scientific CoP like IAKM can really be beneficial for members, because it can boost collective knowledge building and, by this way, scientific production even higher than the average of scholars in the same field. While the extent of IAKM members' collaboration may depend on local connections and opportunities, the chance to reach and work with diverse individuals and groups may stimulate creativity, ensure effective use of expertise, expedite scientific discovery, enhance research visibility, avoid duplication, and enable knowledge transfer to less developed areas or scientific communities. In summary, all this suggests that a scientific CoP can really have a significant role in the production of scientific knowledge.

7.1 Implications for research and practice

The paper indicates that seeing a scientific association as a CoP can be useful for understanding their functioning. In addition, it opens a new field of study for KM research, because scientific associations, although they are a key element in science, have never been explicitly treated as CoPs.

This study shows how collaborative knowledge building can really develop within a scientific CoP and demonstrates that while knowledge creation is an individual cognitive process, knowledge amplification and development represents a social process, where a favourable organisational setting plays an essential role. Generally intended as social structures that can stimulate knowledge sharing and knowledge building due to their capacity of lowering the psychological barriers between participants, in practice CoPs can actually stimulate or slow down the dynamics of knowledge building depending on the specific conditions that develop in them, and that can only in part depend on their formal structure or management functions (which remains important as the general frame) but is also influenced by the active role played by its participants.

This study can also provide an opportunity for reflecting on the history of IAKM as a pointer for defining its future agenda. In addition, it can provide general lessons for creating scientific associations as effective CoPs and for developing proper methods for their management in the best way so that their capability as a platform for social interaction, knowledge exchange and mutual learning can be enhanced.

7.2 Limitations

While the above reported findings shed some light on the questions of interest to this study, they should be interpreted with caution due to some limiting factors. Firstly, since not all members responded to the survey, it is possible that some collaborations were not recorded. Secondly, only collaborations among IAKM members were analysed in this study. A much fuller picture of IAKM could be obtained by examining the trend of collaborative activities with non-members. Also, data were collected only for the period of 2011-2020, and some members started their collaboration much earlier. Therefore, it would be important to clearly detect the cases where the IAKM membership really improved the collaboration capability of scholars. In addition, the community's contributions to knowledge building were assessed solely based on its book series. Other collaborative publications in conference proceedings and journals could add to the accumulated significant work. Finally, it must be considered that the authors are also members of IAKM, which surely facilitated data collection but may also have led to some bias in the analysis. Overall, future research is necessary to eliminate these limitations and extend this current line of research.

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Wisdom from Experience Paradox: Organizational Learning, Mistakes, Hierarchy and Maturity Issues

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Abstract: Organisations often perceive mistakes as indicators of negligence and low performance, yet they can be a precious learning resource. However, organisations cannot learn from mistakes if they have not accepted them. This study aimed to explore how organisational hierarchy and maturity levels influence the relationship between mistakes acceptance and the ability to change. A sample composed of 380 Polish employees working in knowledge-driven organisations across various industries was used to examine this phenomenon. Data collection occurred from November to December 2019. Data were analysed through OLS regression, using PROCESS software. The findings revealed that the acceptance of mistakes positively influences adaptability to change. Moreover, because of mistakes acceptance, knowledge workers in organisations with a low-level hierarchy adapt to changes more effectively than those who work in strongly (or high-level) hierarchical companies. Additionally, higher levels of hierarchy result in lower adaptability to change, which is particularly visible in mature organisations. The study's essence is the empirical proof that a high level of organizational maturity and hierarchy can be a blocker of the adaptability to change if the organisation stays on the single-loop of learning (does perfectly what it used to do). Mistakes acceptance and thanks to this, also learning from mistakes, supports organisational change adaptability. Change adaptability is vital for double-loop learning (organizational actions re-framing). Moreover, this study has exposed the paradox of 'wisdom from experience' empirically. Namely, it is expected that experience and maturity result in positive outcomes and increased organisational leverage. Whereas more prominent, experienced, and mature organisations face serious difficulties when changing their routines and behaviours.

Keywords: constant learning culture, hierarchy, maturity, mistakes acceptance, change adaptability, organisational learning, single-loop learning, double-loop learning, knowledge workers

1. Introduction

Change is not only a key characteristic of today's business environment; it is also a major outcome of learning. 'Learning rarely happens without mistakes' (Downs, 1971, p. 1). That is why making mistakes can foster adaptability to change. When we learn, we change our perception of things through this extended knowledge. This should apply to both individuals and organisations. Organisational learning and change are interconnected (Argyris, 1982; Watad, 2019). Nadim and Singh (2019) noted that change, as a phenomenon, is tied to continuous learning. Garvin, et al. (2008) stressed that a learning organisation is characterised by openness to change when needed. Errors are the essence of organisational learning (Zappa and Robins, 2016). Moreover, Klingenberg and Rothberg (2020) have called for sustainable knowledge. Learning from mistakes can be a very promising action that supports the sustainability of knowledge processes. Mistakes, as a common human experience, can be a sustainable source of learning. There is no knowledge without learning, more effective learning results in more effective adaptability. Hence, it is beneficial to know how many mistakes are accepted by companies, as a first step in learning from mistakes and facilitating adaptability to change as a part of organisational learning routines.

Organisational learning is a process of identifying and modifying mistakes that have resulted from interactions between co-workers (Argyris and Schön 1997). Organisational hierarchy reflects the structure of relations that determine formal interactions between employees. Thus, it is vital to know how hierarchy influences the organisational ability to adapt to change through mistakes acceptance, as a part of organisational learning. Peter Senge (2006) claimed that if people want to learn, they must be ready to be wrong. The value of learning via mistakes is also highlighted by Anselmann and Mulder (2018). Yet 'learning from mistakes' seems more like a popular slogan than a popular attitude. Mistakes are controversial. The essence of this mistakes' paradox is that we cannot learn without making them, but they are never welcome. They can be useful for those who want to learn. This is why the mistakes acceptance factor in a learning culture is so vital. Without accepting mistakes, we cannot learn from them. Additionally, there is the problem of mistakes denial. Kalender, et al. (2020) and Anderson and Abrahamson (2017)—similarly to Zhao and Olivera (2006)—noted that a critical problem of organisational learning from mistakes is the lack of reporting. Mistakes denial, and trivialization might block the groupthink and knowledge creation (Mnasri and Papakonstantinidis, 2020). Therefore, this study compares the influence of mistakes acceptance on adaptability to change across industries, in the context of organisational

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maturity and hierarchy levels. To do this, the study starts with the conceptual framework and the method presentation. The results are then described and discussed. The limitations and implications of the research precede the conclusion.

2. Conceptual framework

Errors, mistakes and failure—these terms refer to actions whose final effect is unintended. Industry perceptions often determine different approaches to perceiving, defining, and managing mistakes. In production management, errors are associated with deviation from a specific norm; therefore, this term is often used in error management studies concerned with production (Seifried and Hopfer, 2013; Seckler, et al., 2017; Love, et al., 2018; Yao et al., 2021). Mistakes are usually associated with a wrong decision (Mangels et al., 2006). The concept of failure is often linked to the desired result of a significant undertaking not being achieved. The failure may have resulted from avoidable mistakes or from the unavoidable and negative results of risks undertaken, such as through experiments or new venture creations (Cannon and Edmonson, 2001; Politis and Gabrielsson, 2009). Therefore, errors, mistakes and failures can be caused equally by negligence or diligence (when acting under uncertain conditions). These situations can be characteristic of organisations in their early stages (e.g. start-ups), or mature organisations creating new business opportunities and adapting to constant changes in the business environment. Positive examples of learning from mistakes come from entrepreneurship studies, especially in relation to entrepreneurial learning from business failures (e.g., McGrath, 1999; Shepherd, 2003; Politis and Gabrielsson, 2009; Cope, 2011; Cardon, et al., 2011; Eggers and Song, 2015). An interesting background for the current study's aims is provided by the latest studies of failure in change management (e.g., De Keyser et al., 2021; Vardaman et al., 2021; Heracleous and Bartunek, 2021). These studies, and all examples given in the introduction, confirm that mistakes and change implementation are interrelated. Therefore, considering the current organisational demands for adapting to change, alongside the necessity of organisational learning for company growth, this study provides an in-depth exploration of these relationships. Specifically, this study explores how organisational hierarchy and maturity levels influence the relationship between mistakes acceptance and organisational ability to change.

2.1 Organisational learning and change adaptability

Mistakes might be a great source of learning (Kucharska, 2021). However, mistakes are surrounded by controversy, this topic is not a popular one. Some organisations want to be known as 'learning organisations', but they often exclude an employee's right to make mistakes. Husted and Michailova (2002) noted many uncertainties that encourage managers and other employees to put mistakes into the 'shadows'. This uncertainty is related to many elements, including colleagues' reactions to failure, the perceived risk of negative career consequences that discourages people from admitting to mistakes, the risk that failure may result in financial penalties, and the general uncertainty regarding cultural acceptance of mistakes and possible hostility towards those who make them. Lee, Peterson and Tiedens (2004), aligning with Heider's (1958) attribution theory, stressed that managers prefer to associate themselves with success rather than failure. As a result, mistakes are not exposed, discussed, or accepted, despite the positive learning outcomes that may arise. Watkins and Marsick (1993) noted that the first step in building a learning organisation is to create the ability to learn and change. Argyris and Schön (1997), Senge (2006), Garvin et al. (2008), and Rebelo and Gomes (2011; 2017) also highlighted that a learning culture must include acceptance of mistakes. This enables people to leave their comfort zones and solve problems by developing new approaches. Hind and Koenigsberger (2008) and Thomas and Brown (2011) argue similarly and have also stressed that higher levels of mistakes acceptance foster a learning process that is visible in the effective adoption of inevitable change. Mainga (2017), Kucharska and Bedford (2020a) argue that a consistent learning culture should not comprise just a learning-based environment but should also incorporate the acceptance of mistakes. Based on the outlined scholarship, the following hypothesis has been developed:

H1: Acceptance of mistakes influences adaptability to change positively.

2.2 Moderators

To explore the relationship between mistakes acceptance and the ability to change, it is vital to consider specific conditions that might moderate it. Moderators are vital to conditional processes examination. Specifically, a moderator is represented by a variable that explains the conditions under which a particular, examined causal effect occurs. Moreover, a moderator is a factor thanks to which the mentioned causal effect can be the subject of change. This is why moderated effects examination is vital for scientific development (Hayes, 2018). The current paper aims to verify how organisational maturity and hierarchy levels moderate adaptability to change, driven by learning through accepting mistakes. Namely, the effect of learning through accepting mistakes on organisational adaptability to change is interesting in the case if both factors occur simultaneously. Figure 1 presents the study's idea graphically. A justification for the imputation of both nominated moderators is outlined in the following section.

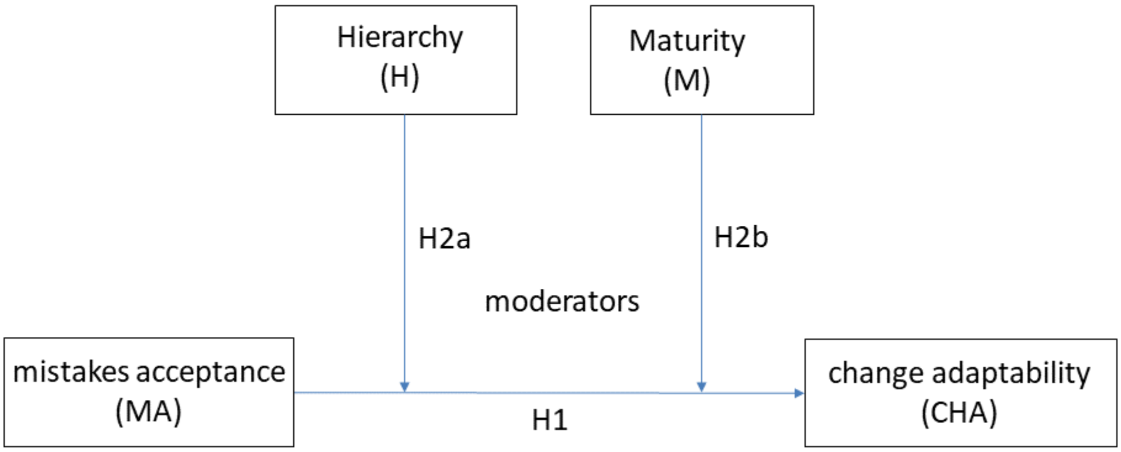

Figure 1: Theoretical framework

2.2.1 Organisational hierarchy

Post-bureaucratic organisations are characterised by a culture of learning and continual reflection that promotes organisational flexibility and responsiveness, dialogue, and consensus rather than formal authority and hierarchy (Harris and Hopfl, 2006; Laloux, 2014; Lee and Edmondson, 2017). Company culture matters for change adaptability and management (Baek et al., 2019; Brandt et al., 2019). Cameron and Quinn (1999) offered an organisational culture taxonomy that considers the following orthogonal organisational dimensions: 'flexibility and discretion' versus 'stability and control' and 'internal focus and integration' versus 'external focus and differentiation'. Next to a clan, adhocracy and market culture, the authors also identified a culture based on a hierarchy characterised by internal focus and integration, along with stability and control. In these organisations, employees are expected to strictly follow formal rules and policies, and adhere to their assigned positions, roles, and responsibilities. Security, conformity, predictability, stability, permanence, and deference to authority are desired. In a hierarchical environment, success is measured by dependability, efficiency, and cost-cutting.

A hierarchy is a complex dynamic that incorporates both vertical and horizontal organising practices. The vertical draws on and reproduces a formal organisation, whereas the horizontal orders people based on their knowledge and initiatives (Lundholm et al., 2010). Hierarchical dynamics depend on the social and epistemic distance of formal managers from operative work processes. Hence, it is worth knowing how a hierarchy (low- or high-level) may influence and moderate the adaptability to change via the acceptance of mistakes.

Moreover, Avent-Holt, et al. (2020) have noted that workplace occupations and positions often form the backbone of social stratification systems, providing a basic structure into which social resources flow. They form a fundamental variable in the social sciences for determining an individual's life chance. These authors also note that workplace hierarchies are more influential than national hierarchies because they constitute the local spaces within which individuals live and work together. The negative effects of being placed low in a hierarchy occur through everyday social interactions and relationships. Therefore, a local hierarchy can affect people's wellbeing more than a national one (according to the overall perceived positioning of a particular job). Hence, the hierarchy factor is significant. According to Parker (2012) and Vijayakumar and Padma (2014), hierarchy is a relevant factor that affects organisational learning, and it may also influence change (Kellogg et al., 2006; Barmby, et al., 2012; Turco, 2016). Hence, the following hypothesis has been developed:
H2a: The level of hierarchy moderates the relationship between mistakes acceptance and adaptability to change.

2.2.2 Organisational maturity

Organisational maturity is reflected in the implementation level of managerial and operational processes and systems that align with organisational aims (Verweire and Van Den Berghe, 2004; Albu and Panzar, 2010).

Moreover, Verweire and Van Den Berghe (2004) claim that a misalignment between maturity and aim is a key reason behind the failure of many change initiatives. Therefore, an organisation's maturity level also appears vital to the relationship between mistakes acceptance and change adaptability. An organisation's maturity level, combined with its experience, should be advantageous to its business performance (Mullaly, 2014). The latest studies (e.g., Uskarci and Demirors, 2017; Andreasen and Gammelgaard, 2018; Grossman, 2018; Muszynska, 2018; Johansson et al., 2019; Marques, et al., 2019), along with most existing organisational maturity models (e.g. Paulk, 1993; Fischer, 2004; Harmon, 2004; Rosemann and de Bruin, 2005; Gunsberg, et al., 2018) include organisational maturity indicators such as communication and knowledge management levels, technology development and processes that—if constantly optimised—enable organisations to grow. Accordingly, an organisation's maturity level reflects its intra-organisational advancement. Therefore, it is vital to verify whether maturity levels, as well as the hierarchy model, moderate the relationship between mistakes acceptance and change adaptability. Figure 1 visualises the theoretical assumptions outlined here.

Hence, the following hypothesis has been developed:
H2b: Maturity moderates the relationship between mistakes acceptance and adaptability to change

3. Method

This study used a sample of 380 cases. Data collection occurred from November to December 2019. Data were analysed with ordinary least squares (OLS) regression, using PROCESS software. Respondents were recruited from Polish employees working in knowledge-driven organisations across industries, via a research panel recruited by answeo.com (see Appendix A). Only knowledge workers employed for a minimum of one year in a single company met the qualification criteria. As a result of this qualification process, most sample participants are male (50%), aged 25 to 34 years (43%), working in small and medium companies (56%) in the information technology (30%), sales (12%), finance (11%) and production (9%) industries.

The study questionnaire began with a short introduction presenting the study's purpose. All terms were defined to ensure participant understanding of the questions. To measure mistakes acceptance and change adaptability, participants responded to statements using a 7-point Likert scale (adapted from Kucharska and Bedford, 2020a). Next, composite variables were created to apply the measures to the OLS regression analysis. A company's maturity was measured by applying Verweire and Van Den Berghe's (2004) 4-level criterion (start, low, medium, and high maturity level), using respondents' assessments of this in organisations, and linking this with the duration of an organisation's existence. The same 4-level assessment was applied to measure the hierarchy (extremely low, low, medium, high). To verify the sample quality, total sample variance was extracted at the 72% level; a Kaiser-Meyer-Olkin test of the sample's adequacy at 0.81 confirmed the sample's good quality (Cerny and Kaiser, 1977; Hair, et al., 2010). Furthermore, a Harman single-factor test (Podsakoff and Organ, 1986) was run. A result of 35% confirmed no bias was present. After this positive assessment of sample quality and scale reliability and validity (see Appendix B), composite variables were created to analyse the relationships hypothesised above, using the OLS regression PROCESS procedure for SPSS Version 3.4 (Hayes, 2018).

Bearing in mind the study aim, namely, exploring how organizational hierarchy and maturity levels influence the relationship between mistakes acceptance and change, OLS regression seems sufficient. Specifically, OLS regression adapts the least-squares criterion (a measure of the accuracy of a straight line in depicting the data that was used to generate it) to create multiple linear causal effects. As a result, the best fitting model to the data set is calculated to present the power of ties of expected causal effects. Consequently, in this study, based on the collected data set, it is measured how simultaneously hierarchy (H) and maturity (M) affect the causal relation of change adaptability (CHA) driven by mistakes acceptance (MA). In other words, how the effect between these two (CHA-MA) depends on the hierarchy (H) and maturity (M)factors -simultaneously.

4. Results

First, the fundamental hypothesis (H1) of this research—namely, that mistakes acceptance supports change adaptability—is confirmed because of the direct relationship between the effect of mistakes acceptance on change adaptability. However, this study also explored how organisational hierarchy and maturity levels influence the relationship between mistakes acceptance and an organisation's ability to change. Therefore, the moderated effects of maturity and hierarchy factors were first examined separately and then simultaneously (with both moderators' imputations). The results show that separately, each moderator is significant. When analysed simultaneously, the total effect of both remains significant, but the moderated power was transferred to the maturity factor. Namely, the maturity-moderated effect was strengthened, whereas the hierarchy factor was not significant when moderators were analysed simultaneously. However, the moderated effect of both is significant. This means that to understand the explored phenomena in greater depth, both moderators are needed. Moreover, both factors are important, but the maturity level is critical. To clarify these results, Figure 2a visualises the hierarchy-moderated effect (H2a), Figure 2b visualises maturity (H2b), and Figure 2c visualises both. Appendices C, D, and E present the measurement details. Table 1 presents the hypothesis verification.

Table 1: Hypotheses verification

Hypothesis		β	t-value	p-value	Hypothesis verification
H1	MA- > CHA	.34	3.37	***	supported
H2a	hierarchy moderation on MA- > CHA (MA^x H)	.10	2.94	**	supported
H2b	maturity moderation on MA- > CHA (MA^x M)	.08	2.34	*	supported

Note: n = 380 * p < .05 ** p < .01 ***p < .001. Standardised coefficients are not available for models with moderators; levels of confidence for all confidence intervals in the output: 95.0000; PROCESS procedure for SPSS Version 3.4 output details available in Appendices D & E.

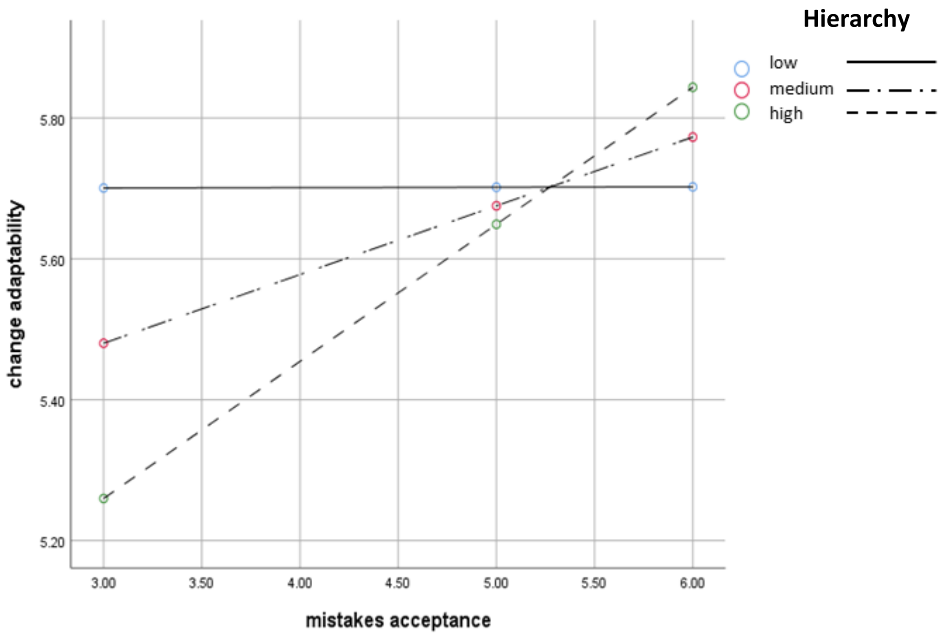

Figure 2a: Moderated effect of hierarchy level on change adaptability driven by mistakes acceptance

Note: level of confidence for all confidence intervals in the output: 95.0000; values low, medium, high reflect the 16th, 50th, and 84th percentiles; effects not standardized. Source: Kucharska and Bedford (2020b).

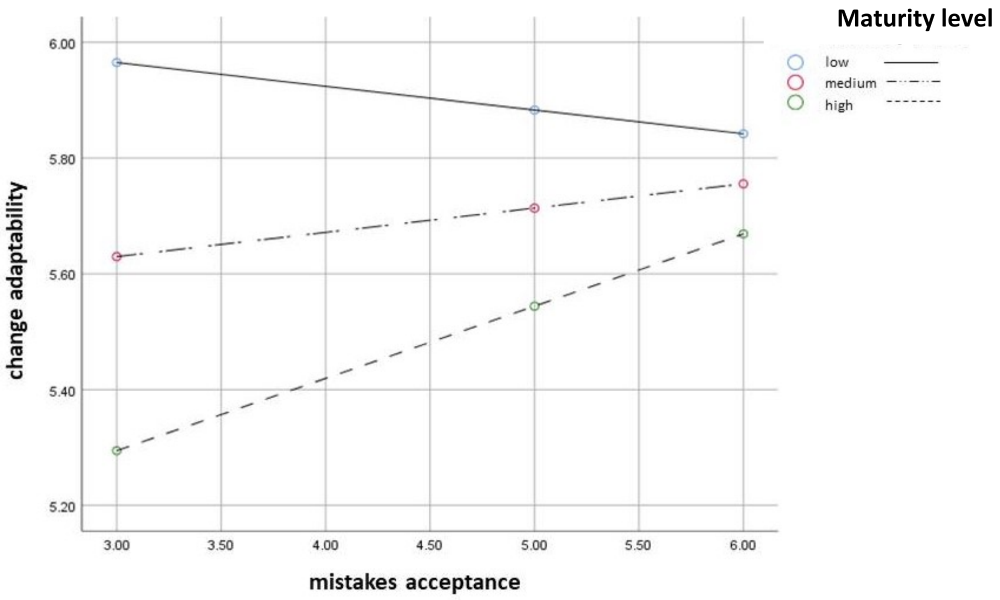

Figure 2b: Moderated effect of maturity level on change adaptability driven by mistakes acceptance

Note: level of confidence for all confidence intervals in the output: 95.0000; values low, medium, high reflect the 16th, 50th, and 84th percentiles; effects not standardized. Source: Kucharska and Bedford (2020c).

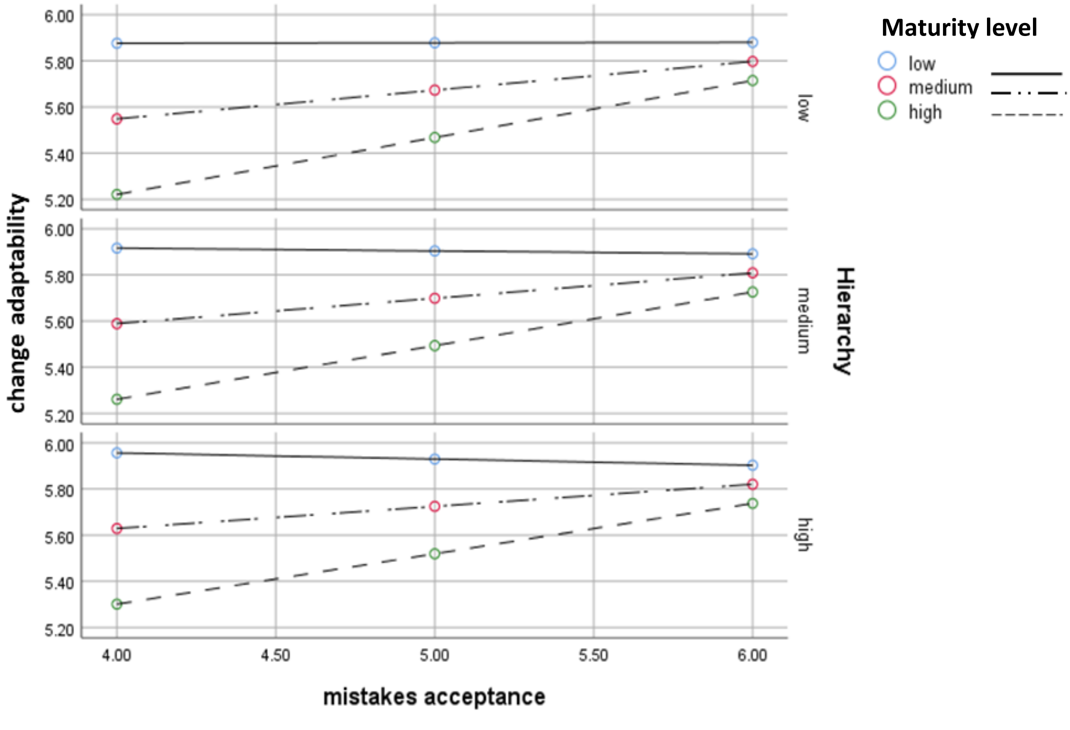

Figure 2c: Moderated effect of hierarchy and maturity level on change adaptability driven simultaneously by maturity and mistakes acceptance

Note: level of confidence for all confidence intervals in the output: 95.0000; values low, medium, high reflect the 16th, 50th, and 84th percentiles; effects not standardised.

Figure 2c visualises the details of the hierarchy and maturity effects simultaneously. In addition, the simultaneous moderated effect is only significant for medium and high levels of maturity and hierarchy (see conditional effects of the focal predictor at values of the moderators in Appendix C). Consequently, it is apparent that a low-level hierarchy working environment is characterised by high adaptability to change; however, the mistakes acceptance level does not influence the adaptability to change at all. Thus, the relationship between mistakes acceptance and change adaptability remains unchanged, and so is not significant for this relationship. For medium- and high-level hierarchies and maturity levels, the positive effect of mistakes acceptance on change adaptability is significant, but it is stronger in less mature organisations. Namely, a more mature organisation will have a lower effect of change adaptability improvements that result from accepting mistakes. Furthermore, for organisations with high levels of hierarchy, the influence of mistakes acceptance on adaptability to change is more substantial. Notably, employees working in organisations with lower hierarchy levels adapt to change more effectively than those working under higher levels of hierarchy. However, when highly hierarchical, mature organisations accept mistakes, they can achieve greater adaptability to change than organisations with low- and medium-level hierarchies.

5. Discussion

From the results described above, it might be concluded that employees working in low-level hierarchy organisations adapt to change much better than those in strongly hierarchical companies. Regarding mistakes, accepting them improves the adaptability to change significantly. Therefore, high-level hierarchy organisations that accept mistakes achieve better results in relation to adaptability to change than do low- and medium-hierarchy organisations. However, the lower an organisation's hierarchy level, the lower the significance of mistakes acceptance will be for adaptability to change (and it appears to not be significant at all). Hence, the conclusion is that strongly hierarchical organisations may adapt to change only if they accept errors. However, this is only true if the mistakes acceptance level is high (see Figure 2a). When this acceptance is low, a strongly hierarchical organisation's adaptability to change will also be very low.

The analysis of an organisation's maturity level–moderated effects on mistakes acceptance (see Figure 2b) and change adaptability has revealed that the higher an organisation's maturity level, the lower their change adaptability will be, even if mistakes acceptance is high. In the light of Organizational Learning Theory (Argyris, 1976, Argyris and Schon, 1996), the findings suggest that organisations, even if they do learn from mistakes, do so at the single-loop level (i.e. they improve standard acting) (Argyris, 1976, p. 367). If mature organisations with well-developed processes and policies learn from mistakes, they do so by modifying actions and maintaining their existing rules. In other words, they learn to operate more effectively, but do not question the fundamental aspects of their organisational design. To do so would incorporate what Argyris has termed a higher-level double-loop of organisational trial-error learning (Argyris 1976, p. 367). Therefore, the observed levels of adaptability to change in mature organisations are lower than those observed in less mature organisations. More mature organisations have lower adaptability to change, and this is especially visible for strongly hierarchised organisations (see Figure 2c). They are good at standard acting improvement but have problems with adaptation and re-framing. In the light of the presented findings, learning from mistakes supports organizational change adaptability even when the hierarchy is high, which is vital for double-loop learning (organisational actions re-framing). It can be explained by the common problem of high hierarchical organizations where the "boss never makes mistakes and does not accept them." In such organizations, everybody naturally avoids them, but if they happen, hide them to avoid a negative judgment. Kalender et al. (2020), Anderson and Abrahamson (2017), similarly to Zhao and Olivera (2006), noted that the critical problem of organizational learning from mistakes is lack of reporting. Therefore, they highlighted the need for organizations to change their attitude towards errors. Based on Ferguson (2017), Zabari and Southern (2018), and Robertson and Long (2018), the error reporting problem might stem from the organizational "culture of blame and shame." If the mistakes stay hidden, they cannot be a lesson for anybody except the person who made them. Presented findings revealed that if highly hierarchical organizations accept mistakes and learn from them, they adapt to change better. Thus, mistake acceptance supports double-loop learning.

This study has exposed the paradox of 'wisdom from experience' empirically. It is expected that experience and maturity result in positive outcomes and increased organisational leverage, similarly to the effect that experience and maturity has on individuals (Saint-Onge, 1996). However, in the context of organisational innovativeness, things are not this simple. Goncalves, et al. (2020) highlighted that smaller and less experienced organisations (specifically, start-ups) are flexible, fast, more agile, and more innovative than larger and better-resourced organisations. Thus, more prominent, experienced, and mature organisations experience more difficulties when changing their routines and behaviours.

6. Limitations and implications

The most important limitation of this study is that mistakes acceptance is treated as a proxy for learning from mistakes. Acceptance of mistakes does not equate to learning from mistakes, but without mistakes acceptance, learning from mistakes might be difficult or even impossible (Van Dyck et al., 2013).

Moreover, another limitation worth discussing is that the current study links the measurement of a company's maturity level to the duration of its existence. Kumar, et al. (2013) proposed a more refined method that, if applied, may have led to more accurate results. Another limitation is that learning from mistakes is often an informal and therefore a subconscious phenomenon. Consequently, the low R-sq = 0.078 obtained for the entire model (see Appendix C) is not surprising. Since the process is so specific, perhaps choosing a method other than the self-reported questionnaire would enhance further exploration of this problem.

Moreover, the findings demonstrate the importance of studies on mistakes acceptance by learning organisations. It is apparent that mistakes acceptance should be investigated in greater depth. The results of this study are based on a Polish sample; additional nationality-based studies are needed. As Kucharska (2021) noted, mistakes acceptance might be affected by a nation's culture. Therefore, national differences might exist in relation to learning from mistakes. Exploring this phenomenon more deeply could provide interesting directions for future studies.

Moreover, the applied data set is composed of cases gathered from different industries. Therefore, all presented findings are generalisations specific to Poland. Still, it is proved (Kucharska and Erickson, 2020) that because usually industries' business operation conditions vary considerably, it is worth exploring some phenomena from a cross-sector view. Therefore, for future research it would be beneficial to study in-depth the phenomenon in a specific sector context. The current data set is too small to present such cross-industry comparison keeping the scientific rigor. Therefore, further studies are needed.

7. Practical implications

The most important practical implication of the present study applies to mature organisations. An acceptance of mistakes would allow them to better adapt to change. Hence, mature organisations should create mechanisms that support learning from mistakes. As noted in the introduction, errors are commonly perceived as a phenomenon to be eliminated, and that is why employees often conceal their mistakes. Since everybody makes mistakes, and most people hide them, a kind of illusion is created. The study's findings encourage mature organisations to be responsible. They can do this by developing internal mechanisms that will take advantage of the mistakes employees make, transforming the mistakes into 'lessons learned'. Mistakes are a valuable source of new knowledge, which is important if we want to achieve better adaptability to change. Organisations with a low maturity level are characterised by a high level of change adaptability. This is because they develop mainly by adaptation to market rules and standards imposed by market leaders (mature organisations). If the low maturity level companies want to win a market share, they must set and maintain minimum standards and should aim to exceed these standards. This is why the effect of mistakes acceptance on less mature companies is opposite to the effect on mature organisations.

Based on the above, another important practical implication of the present study relates to managers. In consideration of the study's findings, managers should support employees in the process of learning from mistakes. This is because a strongly hierarchical organisation may adapt to changes in a significant manner only if the level of mistake acceptance is high. If they do not adapt, the organisational learning process is at risk. From a practical perspective, this is not always easy: organisations do not like accepting mistakes. This is one of the biggest paradoxes of 'learning organisations' today. The present findings also suggest that an effective manager working in a hierarchical learning organisation should be a training leader, coach and patient teacher, rather than a 'mistakes a hunter'. This is the challenge for managers working in learning organisations: to be someone who inspires, motivates, and supports learning. The issues of error, leading and learning to change were raised by Bligh et al. (2018) and Harvey et al. (2021).

8. Conclusion

This article, similarly to Kucharska and Bedford (2020a-c), exposes the paradox of ignoring mistakes by today's learning organisations. The findings show that mature organisations may adapt to change significantly better if they learn from mistakes. If companies do not accept mistakes, the observed adaptation levels are low. This explains why mature (often big and strongly hierarchical) organisations are slower to develop and less agile in their responses than non-hierarchical organisations. This study demonstrates that for less mature organisations to survive and advance in a particular industry, they must adapt quickly, and therefore must not allow mistakes to happen. On the other hand, mature organisations that have been around for a long time can only grow by learning from their errors, because they set the business standards for a branch of the industry, or an industry as a whole. The most significant player always dictates the terms to its followers. Of course, both less and more mature organisations must adapt to constant technological, societal, cultural, political, and other environmental changes if they want to grow. However, in the case of mature and experienced organisations, new errors may be a valuable symptom of something that has changed or is worth changing.

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Appendices

Appendix A: Description of samples

	SAMPLE
Gender	Female: 40% Male: 60%
Age	18–24 (15%) 25–34 (43%) 35–44 (23%) 45–54 (15%) 55–74 (3%) >75 (1%)
Company size	Small (25%) Medium (31%) Big (21%) Large (12%)
Industry	IT (30%) Sales (12%) Finance (11%) Production (10%) Service (9%) Education (8%) Construction (7%) Healthcare (4%) Logistics (3%) Others (3%)
Maturity	level cases 1 107 (28%) 2 143 (38%) 3 85 (22%) 4 45 (12%)
Hierarchy	level cases 1 47 (12%) 2 117 (31%) 3 137 (36%) 4 79 (21%)

Appendix B: Scales

Scale	Composite variable mean/S.D.	Reliability
"Mistakes acceptance" dimension of constant learning culture (MA) • people know that mistakes are a learning consequence and tolerate them to a certain point • most people freely declare mistakes • we discuss problems openly without blaming • mistakes are tolerated and treated as learning opportunities (Kucharska and Bedford, 2020a)	5.13/1.42	Cronbach α = .85
Personal change adaptability (CHA) • I am flexible to changes • I can adjust to changes • I adapt to changes easily • I am used to changes (Kucharska and Bedford, 2020a)	5.67/1.1	Cronbach α = .88

Appendix C: Process output

```
Run MATRIX procedure:

***************** PROCESS Procedure for SPSS Version 3.4 *****************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2018). www.guilford.com/p/hayes3

**************************************************************************
Model  : 2
    Y  : change adaptability (CHA)
    X  : mistakes acceptance (MA)
    W  : Maturity
    Z  : Hierarchy

Sample
Size:  380

**************************************************************************
OUTCOME VARIABLE:
 CHA
Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .2808      .0788     1.1286     6.4021     5.0000   374.0000      .0000
Model
              coeff         se          t          p       LLCI       ULCI
constant     6.4917      .5255    12.3535      .0000     5.4584     7.5250
MA           -.0919      .1019     -.9024      .3674     -.2923      .1084
Maturity     -.8172      .2278    -3.5870      .0004    -1.2651     -.3692
Int_1         .1224      .0428     2.8637      .0044      .0384      .2065
Hierarchy    -.1115      .1618    -2.1624      .0114     -.9296     -.1735
Int_2        -.0990      .0330     2.1491      .0035      .0321      .1619

Product terms key:
Int_1    :        MA       x        Maturity
Int_2    :        MA       x        Hierarchy

Test(s) of highest order unconditional interaction(s):
        R2-chng        F        df1        df2          p
X*W       .0202     8.2006     1.0000   374.0000      .0044
X*Z       .0003      .1150     1.0000   374.0000      .7348
BOTH      .0247     5.0166     2.0000   374.0000      .0071
----------
    Focal predict: MA        (X)
          Mod var: Maturity  (W)
          Mod var: Hierarchy (Z)

Conditional effects of the focal predictor at values of the moderator(s):

   Maturity  Hierarchy     Effect         se          t          p       LLCI       ULCI
     low      low           .0019      .0534      .0351      .9720     -.1032      .1069
     low      medium       -.0124      .0698     -.1781      .8587     -.1496      .1248
     low      high         -.0267      .1022     -.2616      .7938     -.2277      .1742
     medium   low           .1243      .0432     2.8769      .0042      .0393      .2093
     medium   medium        .1100      .0447     2.4596      .0144      .0221      .1979
     medium   high          .0957      .0755     1.2683      .2055     -.0527      .2441
     high     low           .2467      .0673     3.6635      .0003      .1143      .3792
     high     medium        .2324      .0528     4.4027      .0000      .1286      .3362
     high     high          .2181      .0678     3.2167      .0014      .0848      .3515

********************** ANALYSIS NOTES AND ERRORS ************************

Level of confidence for all confidence intervals in output:
  95.0000
W, Z values in conditional tables are the 16th, 50th, and 84th percentiles.
------ END MATRIX -----
```

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Three-Dimensional Assessment of the Knowledge Production System: Region-City-Organization

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Abstract: Conceptualization of the region as an integral territorial system of knowledge production has formed a widely used research strategy for innovation studies within regional boundaries. Regional level studies are supported by detailed innovation statistics, which is unavailable for smaller administrative-territorial units, such as municipalities or settlements. The development of spatial scientometrics gave impetus for a new round of research on knowledge and innovation geography with a closer approximation in the context of cities and urban agglomerations. The scope of recent research also includes individual organizations that generate new knowledge or innovation. Despite the topic prominence, the entire array of studies is fragmented, and connections between different levels are not established: region – city – organization. Whereas this is critically important for the implementation of an effective innovation policy. In this regard, in this study, we test the hypothesis that the aggregate data obscures a wide variety of knowledge nodes, which are represented by a dominant knowledge centre. In the case of the region, such centres are often the largest cities, and in the case of cities – the largest organizations. The research design is focused on assessing the knowledge production at a multiscale level – organization, city and region, using the method of spatial scientometrics. The example of the Russian Federation illustrates well the territorial and institutional diversity in the distribution of knowledge production centres of different levels due to its great length and complexity of the structure of the national innovation system. This fact determines the high degree of heterogeneity of the Russian innovation space at the interregional, intercity and inter-organizational levels. The research results show a strong correlation between the knowledge profiles of regions and their primary knowledge-generating cities (KGCs). In cases of a strong central-peripheral structure of the regional knowledge production system, the regional profile completely coincides with the profile of its primary KGC. The knowledge capacity of second-tier cities remains hidden. At the city level, the identified trend is exacerbated. The absence of a pronounced leader among knowledge-intensive organizations (KIOs) against organizational diversity leads to a strong blur of the effectiveness of the knowledge production capabilities of a city. The example of Khabarovsk shows that the research profile of a city in a given situation may not repeat the most productive KIO, but, on the contrary, a weak one. Thus, the three-dimensional region-city-organization approach captures local specifics and organizational diversity, encompassing the entire set of elements of a regional knowledge production system. The study concludes with recommendations for a knowledge management policy at a tiered level.

Keywords: innovation geography, geography of knowledge, spatial scientometrics, knowledge production system, excellence centre, research centre, knowledge-intensive organization

1. Introduction

Knowledge has come to the centre of attention across disciplines and concepts for being the most valuable asset of growth and competitiveness. The ability to manage knowledge is increasingly recognized to be critical in today's shift towards a knowledge-based and innovation economy. National and regional policies foster the knowledge production function of the territorial innovation systems with numerous public and private initiatives driving innovative activity and supporting knowledge-intensive organizations – KIOs (Perret, 2019; Sawant and Jain, 2017; Stejskal and Hajek, 2016). Most of these initiatives are taking place on a *regional level*, which is generally conceived as an optimal scale for capturing the aggregate and a holistic overview of the knowledge-generating ecosystem (Bathelty and Cohendet, 2014; Scaringella and Radziwon, 2018; Tödtling and Trippl, 2018).

Overall, regional level studies dominate the research design on knowledge-based and innovation-driven economies, providing input for state policies. With that, researchers increasingly raise concerns on significant limitations related to this generalized outlook on innovation systems. As knowledge is unevenly distributed both at inter- and intra-regional space, regional innovation systems can be highly divergent and asymmetrical in its spatial context (Asheim et al., 2019; Davids and Frenken, 2018; Isaksen and Trippl, 2017). Strong polarization is often observed towards large cities. *Cities and urban agglomerations* increasingly become a focus in knowledge and innovation studies as the nodes where a major part of regional intellectual capital being generated and

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accumulated (Carrillo et al, 2014; Sánchez-Moral et al., 2018; Yigitcanlar, 2009; Yigitcanlar and Lonnqvist, 2013). However, the fact of spatial clustering alone is not enough as dedicated policies should be in place for creating a favourable innovative climate and an innovative milieu with a clear understanding of *stakeholders* – innovative firms, research-intensive organizations, science and technology institutions, academia, knowledge-intensive public organizations, etc. (Uyarra et al., 2017; Yigitcanlar, 2014).

When describing an innovation potential of a region or a city, researchers and practitioners often refer to particular organizations – Google, Apple, Xerox, Cisco, Amazon in Silicon Valley (Berger and Brem, 2016), Astra Zeneca, Lundbeck, LEO Pharma, and Novo Nordisk in Oresund cross-border region (Czarny, 2017; Park, 2016), Ericsson, IBM Svenska, Telia-Sonera in Stockholm agglomeration high-tech sector (Solesvik, 2017). This is due to the significant role of an institution played in the geography of innovation (Shearmur, 2017). Some knowledge production and innovation systems are more diverse and poly-centric than others; some have established a coherent structure with aligned aspirations and strategic priorities, while others lack solidarity and consistency in numerous public-private initiatives. It is therefore important to develop *multi-hierarchical knowledge management* to account for the knowledge production system at regional, urban, and organizational levels combined (Carayannis et al., 2018; Clarke et al., 2016; Järvi et al., 2018). Innovation policies require both a broader perspective on the features of the regional innovation system and a narrower perspective in order to focus on the specific innovative needs of knowledge cities as its major elements – the knowledge-generating institutions.

The purpose of this study is to assess the divergence in the knowledge production domain of Russia by conducting a multiscale comparative analysis of research activity. We focus on identifying and comparing the research profile of regions with the profiles of knowledge-generating cities (KGCs) scattered across its territories, as well as with knowledge-intensive organizations (KIOs) concentrated in the urban space. The *hypothesis* of the study is that regional level study on knowledge production systems is informative only being represented by a single core – a dominant KGC. In the case of a distributed knowledge production system featured by multiple KGCs of a similar scale, the outlook should be held at the city level. Otherwise, when studying aggregated data for regions with distributed knowledge production systems across multiple KGCs, the results are greatly distorted, thus, decreasing data validity for managerial purposes. We also believe that this hypothesis will be valid at a lower hierarchical level – in relation to the city (KGC) and its knowledge-intensive organizations (KIOs). It is expected that understanding the limits of data generalisation will improve the efficiency of knowledge management and resolve the issue of information distortion for decision-making.

2. Literature review

2.1 Spatial scope in studying the knowledge production system

Knowledge production is found to be place-dependent, rooted in context, and differentiated among locations (Heimeriks and Boschma, 2014). Regional studies dominate the research landscape on knowledge production and innovation systems. Regional clusters, innovative milieux, new industrial spaces, innovation districts, learning regions, regional innovation systems, and other territorial innovation models analysed in a regional context outline the established territorial capital (Camagni, 2017; Fernandes et al., 2020; Prokop and Stejskal, 2018), reveal the existing inter-organizational networks within the 'triple-quadruple-quintuple helix' framework (Carayannis et al., 2018; Leydesdorff, 2012; Mikhaylov, 2018), and enable building projections over the regional innovation trajectories (Capello and Lenzi, 2018) for developing place-sensitive development policies. The prevalence of regional-level data is largely supported by the availability of statistics representing the innovative activity (Taques et al., 2021), as well as policy recommendations drawn from the research results are easier adopted on a regional level due to administrative and political structure of most countries. Despite the aforementioned advantages of regional studies, the results can be found too generalized and averaged.

Recent research on the geography of knowledge and innovation conclude that cities are the main locus of knowledge production, thus, cities are the optimal scale in capturing the elements and features of innovative activity (Breschi and Lenzi, 2016; Edvardsson et al., 2016). The concepts of knowledge-based urban development (KBUD) and knowledge city have recently emerged as a central topic of scholarly communication and the primary agenda of policymakers (Makkonen and Weidenfeld, 2016; Penco et al., 2020). Cities are defined as locomotives of economic growth integrating and concentrating research activities, technological capacity, and innovative capabilities (Carrillo, 2015; Esmaeilpoorarabi et al., 2016). Urban environments are found to be the natural locus for the hyper-concentration of talents, ideas, competencies, expertise, know-how, the knowledge-intensive and innovative organizations, as well as related public institutions that contribute to the generation and diffusion of knowledge by cross-fertilization and synergies (Mikhaylova and Mikhaylov, 2016; Yigitcanlar and Bulu, 2016). The related variety and the institutional thickness present in major cities are particularly decisive in the continuous process of sourcing, aborting and reengineering knowledge, which is essential for creating innovative goods and services with high added value (Edvardsson et al., 2016; Metaxiotis and Ergazakis, 2008).

Studies on knowledge cities and city-region innovation systems have enabled to identify the diversity of the national innovation system being generally highly divergent and limited to a few globally competitive urban innovation systems (for example, Barcelona, Copenhagen, Dubai, Dublin, Helsinki, Istanbul, Melbourne, Montreal, Moscow, Shanghai, Singapore, Stockholm, etc.; Carrillo et al, 2014; Sánchez-Moral et al., 2018; Yigitcanlar, 2009; Yigitcanlar and Lonnqvist, 2013). Above all, a closer look at the elements of the knowledge production system highlights the significance of individual institutions. It is often the case that a few large knowledge-intensive organizations (KIOs) dominate local economies and determine the established knowledge research landscape (Szulanski, 2002; Kogler and Whittle, 2018).

2.2 Measuring the spatial patterns of the knowledge production process

One of the prominent research issues is to find an optimal set of indicators and methods to identify, evaluate, monitor, and manage the codified knowledge base of a territory (city, region, country) and its elements (firms, research institutes, universities, etc.). Looking back at the numerous research articles published we can define dozens of quantitative and qualitative measurements of science, technology and innovation (STI) performance. For example, Dziallas and Blind (2019) present a list of 82 unique indicators being either company-specific or reflecting the contextual dimensions of the innovation process. Overall, the STI indicators have developed over time with the evolution of the market, our understanding of the knowledge production and innovation process, the development of statistics, and the spread of ICT (Freeman and Soete, 2009). The choice of indicators used also strongly depends on the scope of the study and the knowledge production cycle – S&T ('knowledge input') and innovation ('knowledge output').

Innovation activity that implies the commercialization of knowledge has received a considerable development with knowledge(innovation)-output indicators, such as advanced production technologies, the volume of innovative products, the cost of innovation, the number of companies conducting innovative activities (product or process innovation), the balance of export-import of technologies, etc. These indicators are generally sourced from national and international statistics and indicate the innovation performance and productivity (Mohnen, 2019). Research activity that determines the 'knowledge input' stage is focusing on the capacity of the territorial innovation system to generate knowledge for possible subsequent commercialization or the 'knowledge innovation potential' (Liu et al., 2020). A patent-based method (patents for inventions, industrial designs, utility models) is used most often providing legal records of novel and economically valuable ideas (Stek, 2020; Kogler et al., 2018). Kogler et al. (2018) further indicate that patents provide information on the technological details, insights on inventors and knowledge-generating entities, which enable to outline the diversity and scope of the knowledge production system. However, there are limitations related to the propensity of patenting in high-tech or knowledge-intensive industries. Scientific publications, on the other hand, provide a rich data on knowledge that is not yet commercially exploited making it an increasingly popular source of S&T information (Heimeriks et al., 2019).

With the development of electronic abstract and citation databases available online (Scopus, Web of Science, Google Scholar, Dimensions, Lens, Microsoft Academic, PubMed, Semantic Scholar) the use of bibliometrics has become widespread in research on knowledge and innovation. Application of bibliometric analysis with geographical coordinates to the spatial aspects of knowledge production domain is called spatial scientometrics (Frenken and Hardeman, 2009). Due to the nature of the metadata being displayed in the systems and the complexity of attributing geotags, most studies are limited to single hierarchical level (Bornmann & de Moya Angeon, 2019). One of many methodological complexities with regards to using spatial scientometrics for multi-dimensional studies is described by Csomos (2018, p. 548): "…some large organisations (universities, multinational corporations, national or international research institutions) house their semi-autonomous but scientifically productive units (university hospitals, corporate research centres) in one city and their command and control centres in another city (corporate headquarters, universities' main campuses, etc.)." Our study enjoys the benefits of using bibliometrics while addressing the limitations of using spatial scientometrics in three-dimensional context – region-city-organization.

3. Methodology

Implementation of the multiscale approach to assessing the knowledge production system required collecting three scientometric datasets – in the context of regions, individual cities, and research-intensive organisations. The method of spatial scientometrics is applied using the Elsevier's Scopus database as the data source (www.scopus.com), covering a publication period of five years – from 2013 to 2017, and citations of 2013-2020. The three-years publication-citation gap ensures the sufficient time for citations to be accumulated. The research scope of this tiered level study on the national knowledge production system covers 83 regions[1] and 1,118 urban settlements of the Russian Federation listed by the Federal State Statistics Service of the Russian Federation (Rosstat; www.gks.ru). Russia has a strong inter-regional divergence in STI, making it an ideal case for testing the hypothesis set.

The total number of cities affiliated with Scopus-indexed publications over the research period equals to 440, which are defined as Knowledge-Generating Cities – KGCs. The fractional counting approach is not applied in this study, thus, a document affiliated to institutions from multiple cities is fully identified to each city. However, the regional level assessment excludes duplicates. Therefore, there are examples when the sum of articles by cities in a region is greater than the number of papers attributed to this region. This would indicate that researchers from different cities of the same region have co-authored publications. Similar is true for the organisational level of assessment when processing data for knowledge-intensive organizations (KIOs).

The data is collected by generating independent queries for each spatial knowledge production system (organisation, city, region).

The regional-level query string incorporates data on cities and individual institutions. The example of Stavropol region: *"**AFFILCOUNTRY**(Russia*) OR **AFFILCITY**("Stavropol" OR "Georgiyevsk" OR "Yessentuki" OR "Kislovodsk" OR "Lermontov" OR "Mineralnye Vody" OR "Nevinnomyssk" OR "Pyatigorsk" OR "Svetlograd") OR (**AF-ID**("North Caucasus Federal University" 60070541) OR **AF-ID**("Stavropol State Agrarian University" 60084650) OR **AF-ID**("Stavropol State Medical University" 60021640) OR **AF-ID**("Stavropol Research Institute for Plague Control Rospotrebnadzor" 60105240)) AND PUBYEAR > 2012 AND PUBYEAR < 2018"*.

The city-level query string is limited to publications affiliated with a particular city and/or institutions located this that city. The example of Kaliningrad: *"**AFFILCOUNTRY** (Russia*) AND **AFFILCITY** ("Kaliningrad") OR (**AF-ID** ("Immanuel Kant Baltic Federal University" 60031254) OR **AF-ID** ("Kaliningrad State Technical University" 60018744)) OR **AFFIL(ORG**("AtlantNIRO") AND PUBYEAR > 2012 AND PUBYEAR < 2018"*. Search by city enables to allocate organizations that do not have validated profile in Scopus, but feature publications affiliated with the city (as shown in an example of *AtlantNIRO*). The search results are exported to Excel for defining additional institutions in order to refine the query string. The threshold value for the number of publications indexed by Scopus for organizations is set at 10.

Given the volume of KIOs identified in Scopus, an in-depth evaluation of KIOs performance against KGCs is done using 4 sample cities – Kaliningrad, Perm, Khabarovsk, and Nalchik. These cities are selected for being located in different parts of Russia with a different type of structure of their territorial knowledge-generating systems. Taking into account the established threshold value for publications, the final sample of organizations included in the study is limited to 32.

Figure 1 shows the distribution of KGCs by region and KIOs by four cities used for in-depth analysis.

[1] Note that the collection of data by region implied delimitation of autonomous areas (e.g. the Nenets Autonomous Okrug, the Khanty-Mansiysk Autonomous Okrug - Yugra, the Yamal-Nenets Autonomous Okrug) from their respective regions – Arkhangelsk and Tyumen regions. Therefore, the knowledge production systems of the three autonomous areas are taken into account independently. The two partially recognized regions of Russia – the Republic of Crimea and the city of federal significance Sevastopol, are excluded from the assessment due to methodological limitations in data collection.

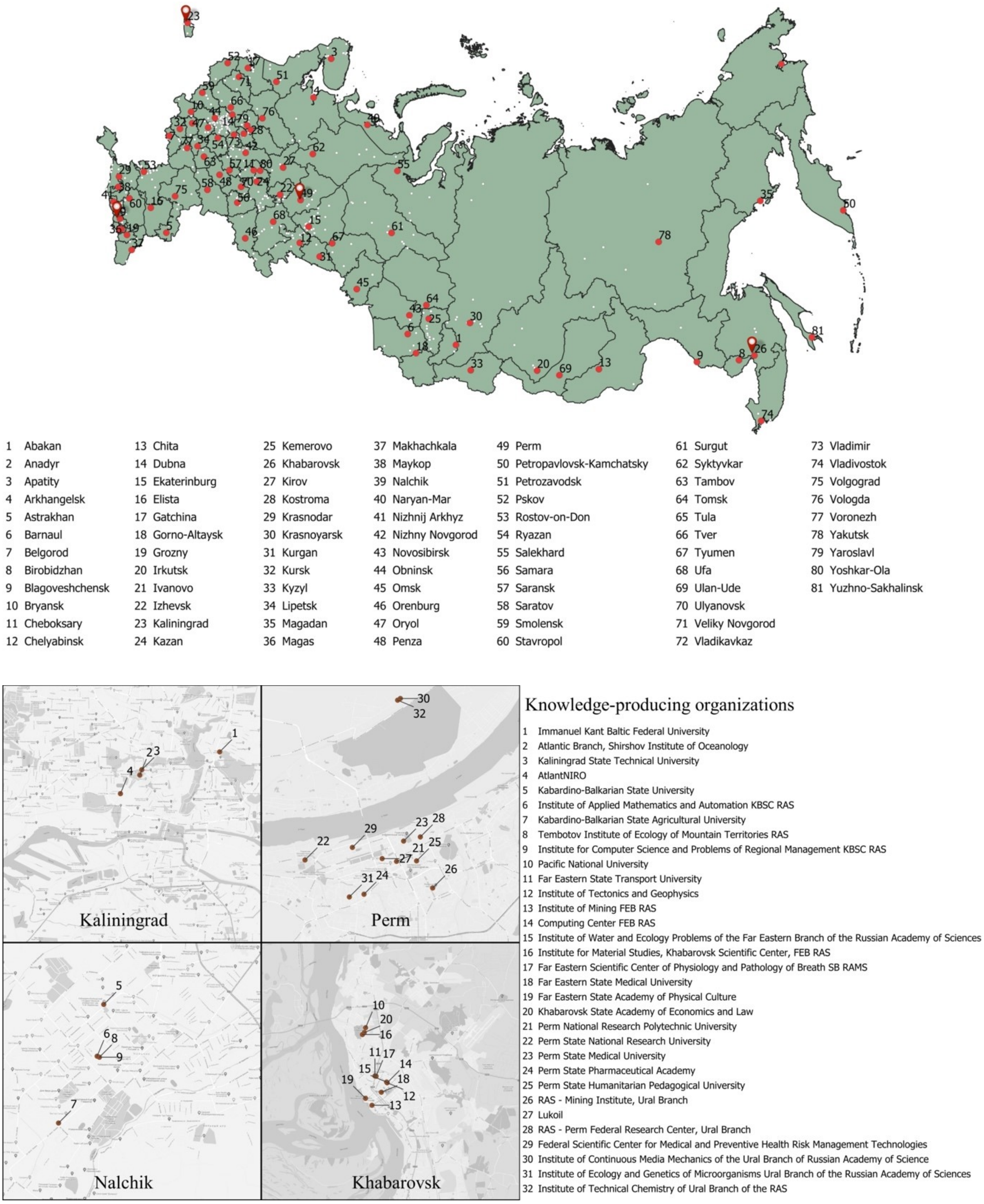

Figure 1: The spatial scope of research on the national knowledge production domain

Data is exported to the SciVal analytical tool (www.scival.com) for conducting bibliometric analysis using the following six indicators: citation per paper; field-weighted citation index (FWCI); share of publications written in international co-authorship (i.e. international collaboration); share of publications written by authors from various institutions of the country (i.e. national collaboration); share of articles published in the Top 10% Scopus journals by CiteScore (i.e. top journals percentiles); and the volume of scholarly output. The indicators applied ensure comparability between different hierarchical levels – institutions, cities, regions, country, thus, enabling the (de-)fragmentation of the national knowledge domain into multiple levels.

The research design is structured into five stages.

At the *first stage* of the study, at the regional level, all KGCs are aligned with their respective regions, while the regions are classified depending on the number of KGCs located on their territory. At the institutional level, all knowledge-intensive organizations (KIOs) are tied to their cities, and cities are classified according to the number of organizations concentrated in them.

The *second stage* is focused on differentiating primary and secondary KGCs based on the number of publications affiliated with institutions within a region. The number of secondary KGCs within one region ranges from 1 to 54. By a similar method, primary and secondary KIOs were identified for each city. In the four sample regions used for in-depth analysis, there are the following number of secondary organizations: Kaliningrad – 3, Nalchik – 4, Khabarovsk – 10, and Perm – 11.

The *third stage* of data evaluation shows the contribution share of the primary KGC to the total number of publications in the region. This is calculated as the ratio of the number of publications affiliated with the primary KGC to the aggregate number of publications in the region. The publication shares of primary KGCs in the total number of publications on a regional scale ranged from 30.8 to 100% depending on the region. Naturally, for regions with a single KGC, the research profile of the KGC fully repeats the research profile of the region. Similar calculations were performed for KIOs within the cities under study. The share of the main KIO in the total number of research output on an urban scale ranged from 24.8 to 74.4%.

At the *fourth stage,* we have used the F-test function with a two-tailed probability testing the variances in the array of scientometric indicators for regions against KGCs, as well as data for cities against KIOs. The data sets include Field-Weighted Citation Impact, Citations per Publication, International Collaboration, National Collaboration, and Top Journal Percentiles. Overall, the difference in values for this indicator ranges from 0.305 to 1.0 for city-region comparison, and 0.763 to 0.906 for organization-city comparison.

Finally, at the *fifth stage*, a correlation analysis is conducted of the relationship between the contribution of the primary KGC to the total volume of research output in the region (X is a factor attribute) and the value characterizing the degree of difference between the scientometric portrait of the region and its primary KGC (Y is a dependent attribute). The relationship between the contribution of the primary KIO to the total volume of research output in the KGC (x is a factor feature) and the value characterizing the degree of difference between the scientometric portrait of the city and its primary organization (y is a dependent feature).

As part of the correlation analysis, the coefficients of correlation and determination, the average approximation error, and the Fisher's F-test are calculated by the following formulas:

1. correlation coefficient

$$R = \sqrt{1 - \frac{??(y_i - y?_{-i})^2}{??(y_i - ??)^2}} \qquad (1);$$

2. coefficient of determination R^2 as a squared correlation coefficient;
3. average approximation error

$$\bar{A} = \frac{1}{n}\sum \left|\frac{y_i - \hat{y}_i}{y_i}\right| * 100\% \qquad (2);$$

4. Fisher's F-test (actual)

$$F = \frac{R^2}{1 - R^2} * \frac{k_2}{k_1} \qquad (3).$$

4. Research results

The knowledge-generating cities (KGCs) of Russia are highly heterogeneous in their research capabilities and spatial distribution. Figure 2 shows the distribution of the primary KGCs in the regions of Russia, indicating their regional share and the divergence in scientometric indicators.

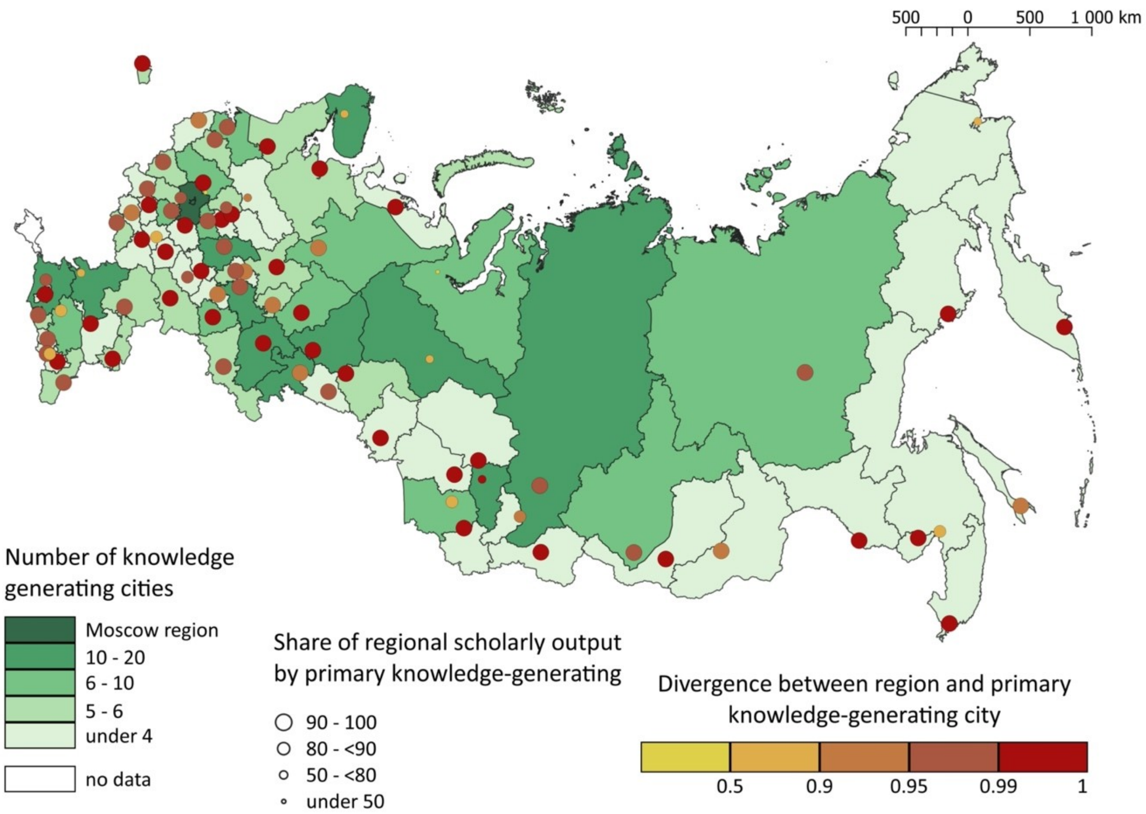

Figure 2: Distribution of primary knowledge generating cities in the regions of Russia, 2013-17

The cubic regression equation is further applied to measure the correlation between the input share to the knowledge production system of primary KGCs to regional total research output and the difference in scientometric portraits of regions and their primary KGCs (Fig. 3). The following equation is used:

y?_ $= -0.002x^2 + 0.1493x - 2.7347$ (4)

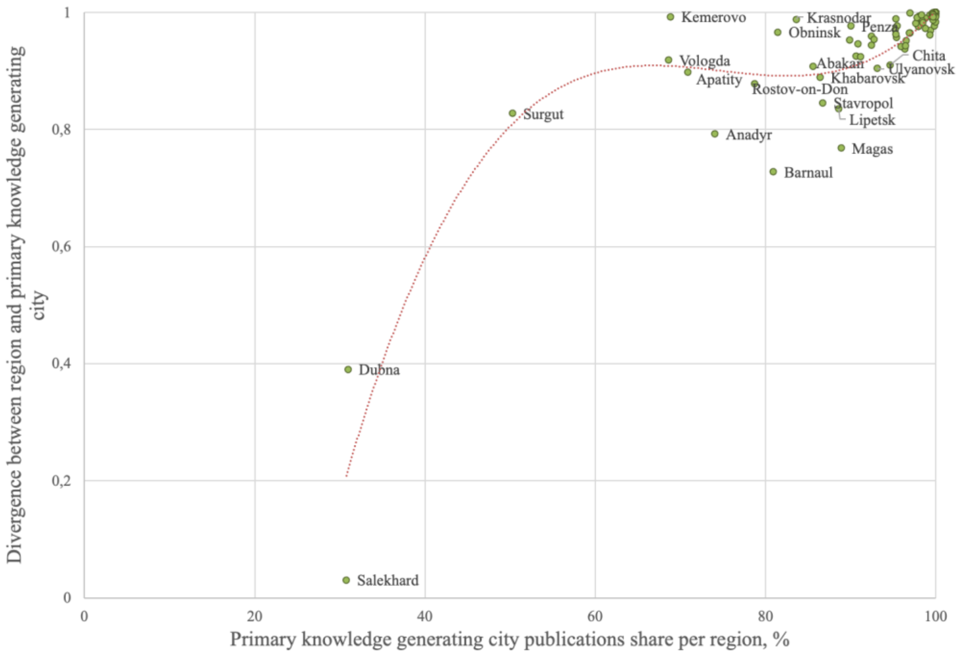

Figure 3: Interdependence of scientometric profiles between primary knowledge-generating cities and regions by input to knowledge production system, 2013-17

The relationship between the studied characteristics is established by calculating the correlation coefficient (1), the value of which is 0.9371. This indicates a direct dependence between the studied characteristics, and the strength of the relationship on the Chaddock's scale is very high. In other words, the difference between scientometric portrait of the region is highly dependent on the contribution of its primary KGC to the total volume of research affiliated with the region.

The coefficient of determination (denoted by R2) calculated by the formula (2) is equal to 0.8782. This means that factor X determines 87.82% of the variance of the dependent variable Y. In other words, the share of publications of the primary KGC in the total volume of publications in the region is a determining factor for the degree of difference between the scientometric portrait of the region and its KGCs.

The average approximation error characterizing the adequacy of the regression model is calculated by formula (3) and amounts to 10.1249%. Since the value of the average approximation error is less than 15%, this indicates a well-chosen model of the equation. The significance of the regression model is tested using Fisher's F-test. Since the actual value (185.0027) of the F-test criterion turned out to be more than the tabular (2.7233), the constructed model is proven significant.

Next, we modelled scientometric portraits of 4 Russian KGCs in the mirror of KIOs concentrated within urban boundaries, with the total number of Scopus publications for 2013-17 above the threshold value. Table 1 illustrates the scientometric characteristics of organizations in relation to the aggregate values of the city's indicators, highlighting the primary and secondary organizations.

Table 1: Scientometric analysis of knowledge-intensive organisations in Kaliningrad, Khabarovsk, Perm, Nalchik

Institution	Authors	Scholarly Output	Citations	FWCI	Citations per	International	National collaboratio	Publications in Top Journal
	for the city in units. for organizations in % of the city							
1. City Perm	**5734**	**4017**	**14463**	**0.4**	**3.6**	**12.3**	**40.9**	**2.7**
Including knowledge-intensive organisations:								
Perm National Research Polytechnic University	36.6	41.8	35.2	0.5	3.0	8.4	34.7	1.8
Perm State National Research University	28.3	27.2	29.8	0.4	4.0	17.2	46.2	5.6
Institute of Continuous Media Mechanics of the Ural Branch of Russian Academy of Science	11.3	16.2	26.2	0.6	5.8	23.8	56.7	8.4
Perm State Medical University	15.7	7.2	4.5	0.2	2.2	6.5	59.8	1.0
Institute of Technical Chemistry of Ural Branch of the RAS	5.0	5.5	6.3	0.3	4.1	7.7	87.4	3.6
Institute of Ecology and Genetics of Microorganisms Ural Branch of the Russian Academy of Sciences	5.3	5.3	8.5	0.5	5.8	6.2	89.1	4.3
Perm State Pharmaceutical Academy	4.3	4.1	3.7	0.2	3.3	6.1	63.8	0.0
RAS - Mining Institute, Ural Branch	5.7	3.6	2.8	0.4	2.8	11.9	48.3	3.5
Perm State Humanitarian Pedagogical University	3.2	3.5	2.7	0.3	2.8	5.0	44.0	1.4
Federal Scientific Center for Medical and Preventive Health Risk Management Technologies	2.4	1.9	1.7	0.3	3.2	1.3	71.1	1.3
Lukoil	1.6	1.5	0.8	0.3	1.9	0.0	56.5	0.0
RAS - Perm Federal Research Center, Ural Branch	0.6	0.9	0.8	0.4	3.3	0.0	82.9	0.0
2. City Khabarovsk	**2330**	**1208**	**7640**	**0.6**	**6.3**	**15.9**	**53.9**	**5.6**
Including knowledge-intensive organisations:								
Pacific National University	20.9	24.8	10.7	0.4	2.7	11,7	59.9	1.0
Far Eastern State Transport University	22.0	23.7	51.2	1.3	13.7	26,9	45.8	14.0
Institute of Tectonics and Geophysics	10.8	11.6	12.0	0.5	6.6	18,6	64.3	7.1
Institute of Mining FEB RAS	9.0	9.3	5.3	0.3	3.6	0,9	75.0	0.9
Computing Center FEB RAS	5.1	8.9	5.4	0.6	3.8	6,5	59.8	1.9

Institution	Authors	Scholarly Output	Citations	FWCI	Citations per	International	National collaboratio	Publications in Top Journal
	for the city in units. for organizations in % of the city							
Institute of Water and Ecology Problems of the Far Eastern Branch of the Russian Academy of Sciences	11.2	8.7	10.5	0.5	7.6	18,1	64.8	3.8
Institute for Material Studies, Khabarovsk Scientific Center, FEB RAS	4.1	7.1	3.7	0.3	3.3	2,3	81.4	2.3
Far Eastern Scientific Center of Physiology and Pathology of Breath SB RAMS	2.4	6.5	6.6	0.4	6,5	34,6	44,9	2,6
Far Eastern State Medical University	11.3	5.6	3.1	0.2	3,4	23,5	50,0	5,9
Far Eastern State Academy of Physical Culture	1.2	1.7	0.1	0.1	0,4	0,0	33,3	0,0
Khabarovsk State Academy of Economics and Law	1.5	1.7	0.5	0.7	2,0	30,0	45,0	0,0
3. City Kaliningrad	**3334**	**1217**	**8636**	**0.7**	**7.1**	**36.2**	**38.1**	**9.1**
Including knowledge-intensive organisations:								
Immanuel Kant Baltic Federal University	66.9	68.9	65.7	0.7	6.8	36.6	41.7	9.5
Atlantic Branch, Shirshov Institute of Oceanology	10.0	12.1	13.4	0.8	7.9	31.3	55.8	9.5
Kaliningrad State Technical University	1.4	12.6	6.2	0.4	3.5	21.6	32.0	0.0
AtlantNIRO	2.8	1.4	2.2	0.7	11.1	23.5	23.5	0.0
4. City Nalchik	**1110**	**712**	**1886**	**0.35**	**2.6**	**7.4**	**45.5**	**1.7**
Including knowledge-intensive organisations:								
Kabardino-Balkarian State University	72.0	74.4	69.9	0.4	2.5	6.6	50.9	0.6
Institute of Applied Mathematics and Automation KBSC RAS	4.2	9.4	16.0	0.6	4.5	6.0	6.0	4.5
Kabardino-Balkarian State Agricultural University	10.2	6.9	4.2	0.3	1.6	4.1	87.8	0.0
Tembotov Institute of Ecology of Mountain Territories RAS	6.0	4.5	3.2	0.2	1.9	9.4	62.5	3.1
Institute for Computer Science and Problems of Regional Management KBSC RAS	6.7	3.2	5.8	0.4	4.8	26.1	21.7	13.0

Source: calculated by the authors based on data from the Scopus database

The cities with a higher diversity of KOIs (12 and 11) – Perm and Khabarovsk, do not have a pronounced leader among organizations in terms of the scholarly output. The share of the leading Perm National Research Polytechnic University among Perm KOIs is 41.8%, and the Pacific National University in Khabarovsk is 24.8%. In Kaliningrad and Nalchik, the picture is different: there is a small number of KIOs and against their background a strong leader in the volume of publications stands out – Immanuel Kant Baltic Federal University in Kaliningrad and Kabardino-Balkarian State University in Nalchik. In order to better see the differences between the cities under study in the formation of their scientometric portraits, we assessed the distribution of KIOs in relation to their share in terms of the volume of research output in the city-wide volume and the degree of similarity with the city in terms of the array of scientometric indicators (Fig. 4).

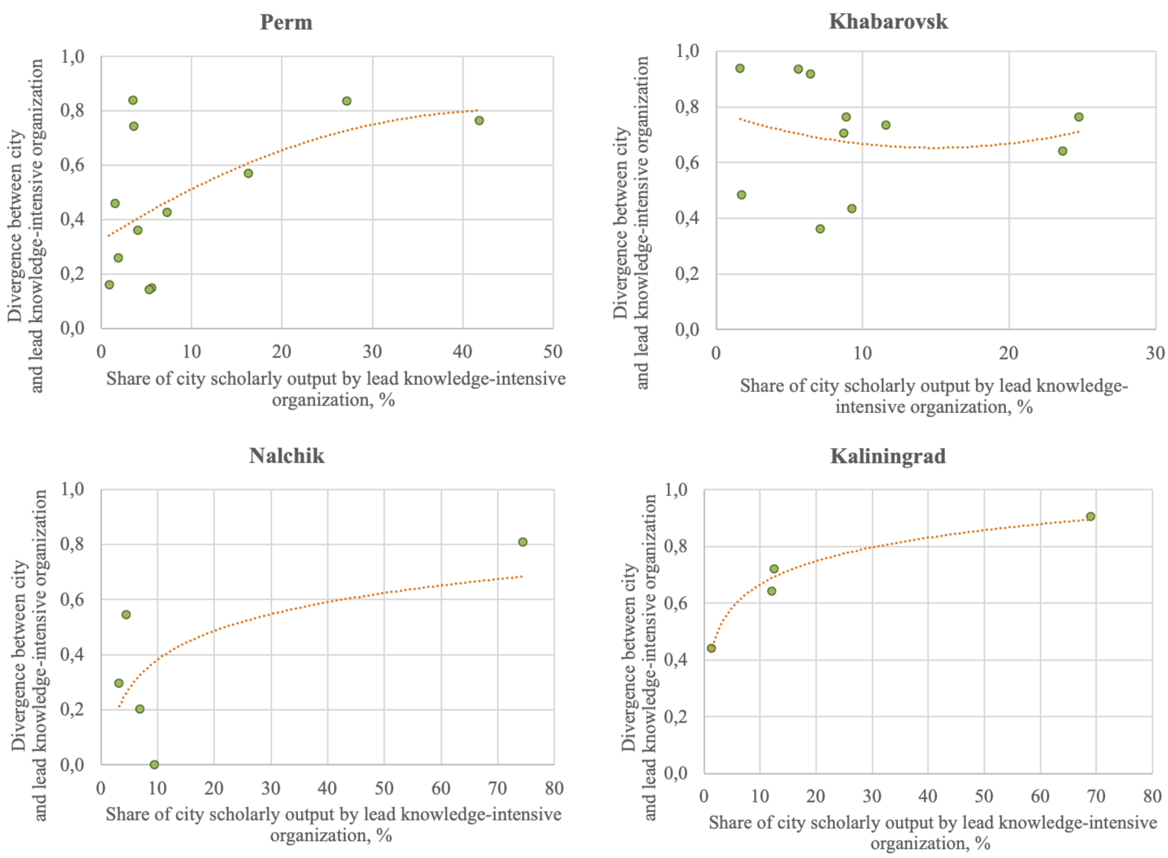

Figure 4: Interdependence of scientometric profiles between primary knowledge-generating cities and knowledge-intensive organisations by research output, 2013-17

The correlation coefficient between the "divergence of KGC and KIO" and the "share of KGC research output by lead KIO" is 0.717, and between the "divergence of KGC and lead KIO" and the "share of KGC research output by lead KIO" is 0.734. This indicates a strong relationship between these indicators. We have identified an interesting pattern: if there is one leading KIO (examples of Nalchik and Kaliningrad), then it almost completely determines the knowledge profile of the city. In this case, the divergence between city and lead knowledge-intensive organization is over 0.8. However, when the knowledge production capacity of the city is scattered across numerous organizations without strong polarization (examples of Perm and Khabarovsk), the KIO with the greatest contribution to the volume of research output of the city ceases to have such a tangible impact on its scientometric portrait. The average scientometric indicators of the city tend to repeat the features of the least productive organizations, each occupying less than 10% of the total volume of publications.

5. Discussion

This study examines the poly-scale structure of the regional knowledge production system. We have analysed a dataset for 83 regions of Russia through the prism of 440 scientometric portraits of their cities – Knowledge-Generating Cities (KGCs). Additionally, 4 cases of Russian cities located in different geographic regions and having a different structure of the regional knowledge production system were studied to assess the intracity heterogeneity in the generation of scientific knowledge. Data suggests that Russia has significant gaps between regions and within them by knowledge production indicators, which is ideal for studying inequality of the knowledge landscape in its diversity. In Russia, there are regions where there is only one KGC, and regions with a high concentration of KGCs – more than 10, and even up to 56 in Moscow agglomeration. Similar gaps are typical for the inner-city knowledge production space of Russian cities, which have a different number of knowledge-intensive organizations (KIOs): the gap is more than double in the studied examples.

Given such a variety of setups in regional knowledge production systems, there cannot be implemented a unified "one-size-fits-all" approach, method, or tools to knowledge management. A place-sensitive territorial development policy should be in place (Heimeriks et al., 2019). Meanwhile, the aggregated regional data is heavily used for administrative purposes at the federal, regional, and city levels. Our study shows that in order to increase the effectiveness of knowledge management in terms of creating a more adequate information base for decision-making by regions, it is necessary, firstly, to evaluate the model of the regional knowledge production system formed. If it has a distributed, scattered character, then the level of the region is uninformative, and it is necessary to evaluate individual KGCs for effective knowledge management. If the model of the knowledge production system of the region is described by a pronounced centre-peripheral pattern, then the scientometric dynamics of the region and its primary KGC will repeat each other. In this case, the city level assessment will unveil numerous small secondary KGCs that are invisible beyond the scale of the primary KGC but, as previously defined by Isaksen and Trippl (2017), these cities form a 'mosaic of regional innovation patterns'.

Secondly, moving down to the level of the city, one should understand what knowledge-intensive organizations form its knowledge production system. We have identified two main urban models: polarized – when there is a lead KIO that provides over 80% of all publications of the city; distributed – when there are several KIOs holding similar positions in terms of contribution to the total volume of research output of the city. In the first case, the dynamics of the city's knowledge production is set by its main research centre. In the second case, a detailed analysis of the existing KIOs is required, since the average level of scientometric indicators of a city often translates the image not of its leading organization, but of those lagging behind.

The results obtained verify the research hypothesis put forward. The knowledge portrait of the region almost completely reflects the portrait of its primary KGC in the case when there is a significant gap between the primary and secondary KGCs by the scientometric indicators considered. Moreover, the pattern is true for regions with different numbers of KGCs, both mono- and poly-centric. Thus, when scientometric analysis applied for studying regional knowledge production (research) capabilities, the two options are possible. a) Evaluation done through the prism of region's primary KGC obscures secondary KGCs in the case of a strong centre-peripheral model of knowledge production. b) Given the case of a distributed regional knowledge production system with several KGCs of similar size, the regional scientometric portrait is distorted and the results obtained do not reflect the knowledge generation dynamics in any of its cities – KGCs. In our opinion, the regional scale assessment generates a false idea of the region's knowledge production system in cases when a single KGC does not generate 80-90% of the total research output. This could explain the identified 'stubborn path-dependencies' by Klochikhin (2012) and partially determine the 'cold spots' defined by Bornmann and de Moya Angeon (2019).

A similar situation is observed when we try to model a knowledge portrait of a city, which is also an aggregated representation of reality. The high polarization of the urban knowledge production domain makes it possible to build direct links between the indicators of the city and its most productive organization. At the same time, not one, but several KIOs may be located in a city, most of which will be small in research output. In the case when the knowledge space is developed more evenly and has a higher organizational density, the distortions of the aggregated indicators of the city are rather high and do not reflect the real picture, which requires lowering the analysis to the organizational level. This was relevant, for example, in relation to Khabarovsk.

6. Conclusion

Unrepresentative data is a significant obstacle to the implementation of effective knowledge management policies. This could partially explain the overwhelming path-dependencies of regional innovation trajectories registered in the knowledge landscape as the aggregate regional level data is highly resistant to local change, blurring the recent initiatives and trends behind the long-lasting mainstream (Cooper 2006; Crescenzi and Jaax, 2017; Klochikhin 2013). In such cases, the city level is more informative, since there is less distortion when aggregating scientometric data representing the knowledge production domain of the innovation system.

The research results are consistent with the findings that emphasize the importance of studying the geography of knowledge at the city level (Ivaldi et al., 2020; Lever, 2002; Penco et al., 2020). Moreover, we support the conclusions made by Chica and Marmolejo (2016) that determined the tendency of knowledge-based industries to be spatially concentrated in the large metropolitan cores along with universities and innovation complexes. As well as Pancholi et al. (2019), who argue for an even higher density of innovation and knowledge-intensive activities within the knowledge and innovation spaces. Given the inequality and divergence being verified by most studies across the globe, supporting the everlasting concept of core-periphery, a similar poly-scale approach has to be applied at intra-urban level – between city districts. For instance, a study of Zandiatashbar and Hamidi (2018) suggest that knowledge intensive business services are more likely to locate in the largest cities, clustered in central business districts.

Our study shows that the asymmetry of information on knowledge capital increases if data is limited to one hierarchical level – organisation, city or region. Single scale datasets negatively affect the decision-making, thus, influencing the quality of knowledge management. Developing knowledge policies based on an aggregated outlook of the knowledge landscape is like manoeuvring a ship between icebergs without a clear picture of their actual size, quantity, or location. Shortage or inaccuracy of information increases the probability of collision with an iceberg, i.e. managerial failure. Moreover, the 'helicopter view' provides poor prospects of smaller locations driving into false conclusions of these places being insignificant and of "no future" (Rodríguez-Pose, 2018). The results of our study suggest that the multiscale approach allows reducing information uncertainty, on the one hand, demonstrating inter-regional dynamics, and on the other, intra-regional specifics. This unveils the territorial knowledge system more holistically, and therefore see and forecast its growth nodes or identify bottlenecks that hinder the exponential growth of the knowledge-based economy.

Further studies could benefit from widening the region-city-organization sample and expanding on to other countries. The identified pattern of multilevel overlaps could be further verified using other sources of data, such as patents. Moreover, the qualitative dimension could be further analyzed, considering the specialization and other parameters.

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Digital Transformation Designed to Succeed: Fit the Change into the Business Strategy and People

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Abstract: Digital transformation has become a necessity in our volatile, uncertain, complex and ambiguous (VUCA) world. In their 2019 report, APQC found that 75% of organizations are undergoing digital transformation. Successful digital transformation requires a strong foundation of people, process, technology and content. Selection of the right combination of strategies and deep stakeholder engagement is important in early phases of change when transformation initiatives inform leaders and users *why* change is needed. Top drivers for digital transformation have business (e.g., increased efficiency and productivity) and people (e.g., optimize user experience with knowledge discovery) facets. This paper illustrates an example of digital transformation in practice led by Knowledge Management, within Alberta Health Services (AHS). AHS is Canada's first and largest province-wide, fully integrated health system with more than 102,700 employees. Employees need a platform for collaboration on projects, as well as documents and idea generation to meet business needs and enable them to become more efficient and effective in their daily jobs. The design, development, and implementation of a collaborative platform within this large organization required close orchestration of strategies, stakeholders' commitments and engagement, represented by a continuum of stakeholders' engagement formats, relationship and trust-building. Setting the stage for successful implementation and post implementation required a preview of technological and workforce trends to anticipate the future of work and worker. Fitting the change into overall business strategy, developing the knowledge of how change would affect the workers, and setting up a mechanism to inform leaders about adoption and user engagement were added as overarching strategies to better align with the line of sight in digital transformation. The platform was implemented with 23 business areas that expressed interest; it has demonstrated the potential to enable system transformation if implemented organization-wide. Business value was demonstrated with an ROI calculation on time savings.

Keywords: Digital transformation, system and design thinking, future of work, business value, innovation, business stewards

1. Introduction

Why do some digital transformation efforts succeed and others fail? Digital transformation investments will approach $7.4 trillion by 2023 and 70% of the organizations that invested in 2019 for digital transformation initiatives fail to pay off. That's because the majority of the organizations focus on a specific technology, rather than finding the right *balance* of fitting the change into the overall business strategy, developing the knowledge of how this change will affect the workers, and setting up a mechanism to inform leaders about adoption and user engagement.

In the design and implementation of digital platforms, best-practice organizations demonstrated exceptional performance by employing strategies, governance models, knowledge flow processes and technologies.

Conducting a study to review and compare seven best-practice organizations, we have learned that each defined their strategy based on the organization needs. For example, Accenture developed *KM Social Learning* to enable employees to **learn from each other** through collaboration and knowledge sharing to bring best to the clients. US Department of State considered *e-Diplomacy* as strategy to enable employees to **tap into existing knowledge,** leverage experience and expertise within the organizational and regional boundaries, find news ways to connect, collaborate, find and share knowledge anytime, anywhere. KRAFT's strategy, *Knowing what we know*, enabled employees to **capture and transfer knowledge** in order to increase efficiency, improve decision making and avoid unnecessary reinvention. WIPRO, developed a *5 S Strategy: Simplify, Standardize, Segment, Secure, Sustain,* where employees are involved to **deliver innovative** solutions through collaboration, knowledge exchange across departments, functions, locations ensuring there is value in the knowledge being created and measuring KM's impact on the business and its customers.

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A technology analysis (applications in clinical or corporate domains, geographically dispersed teams, intranet/extranet, size of the organization, document management solution, etc.) was completed, studying seventeen organizations that successfully implemented digital initiatives. It concluded that SharePoint, integrated with different, other tools and technologies, was mainly used to respond to organization needs. Once the strategy was defined, a program was set up, and each best practice organization built their processes and frameworks to identify, capture, transfer, and manage application and use of critical knowledge. The study concluded that across the best practice organizations, similar success factors could be identified: sponsorship from senior leaders; partnership with Human Resources, IT, and Communication; strategy designed to address pain points; focus on people by enabling reward systems; and gamification. See Figure 1.

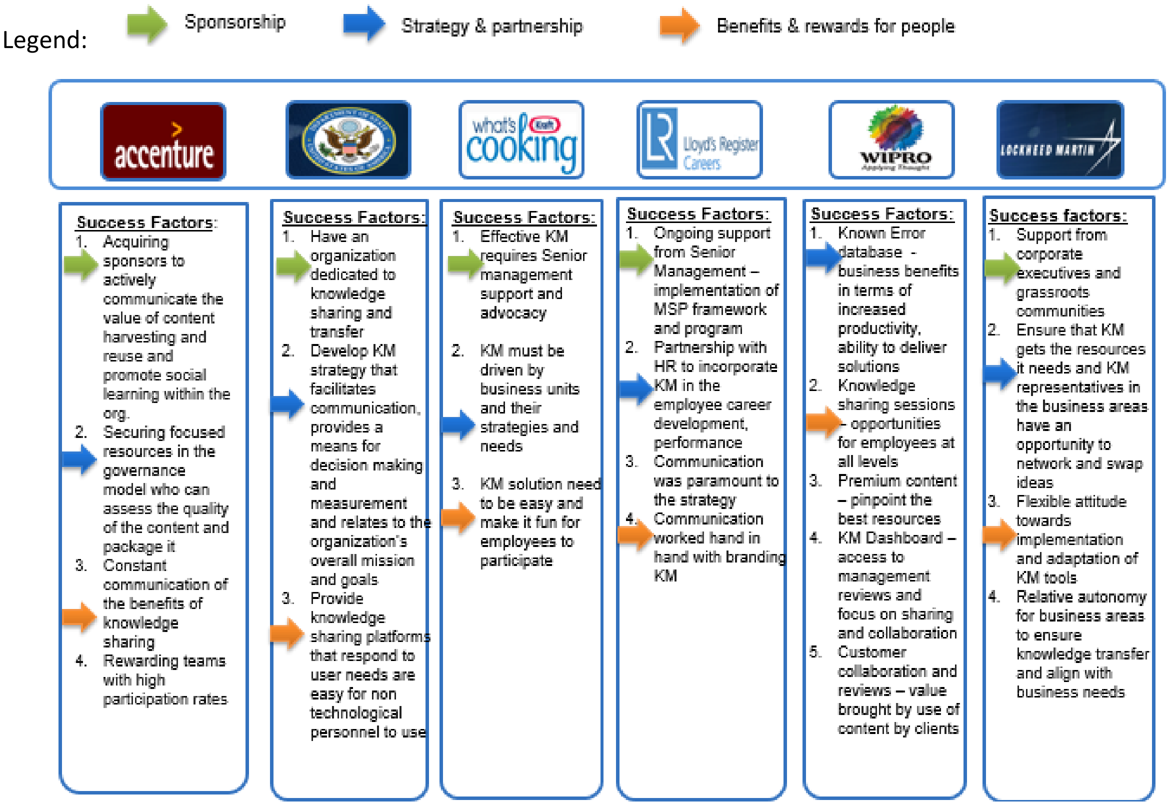


Figure 1: Best Practice organizations: Success factors for implementation of digital transformation initiatives

In this paper, the aim is to demonstrate the value of applying lessons learned from best practice organizations. This includes adopting and adapting strategies, models, and frameworks effectively used in other contexts, then using them in your organization's context. That's the path taken by AHS, described below.

We have discovered that among the variety of variables to consider when designing a digital transformation, organization maturity has proven to be critical. Other components (culture, process management, integration of people, process and technology, knowledge flow) become enablers to drive performance excellence. See Figure 2.

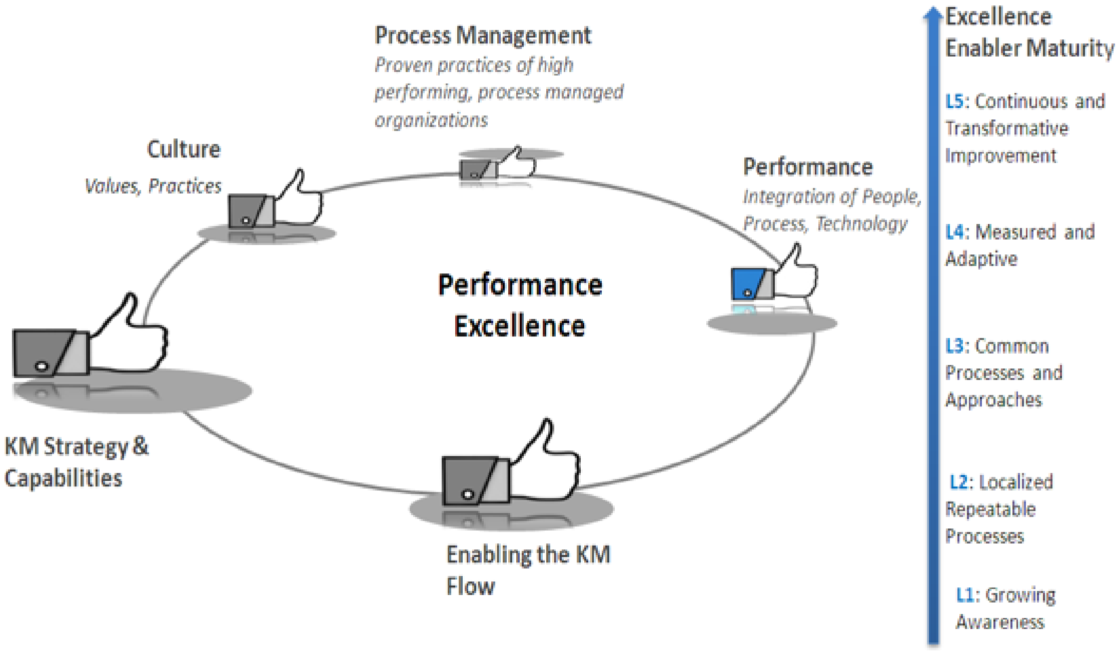


Figure 2: Knowledge management maturity level connected to performance excellence in organization

Collaborative Sites (CS) were designed with several factors in mind: organizational maturity, best practices, lessons from this study about conditions for success, and what technologies would fit and meet requirements. A range of approaches, frameworks, and applicable models is illustrated.

2. Background

As organizations implement digital technologies, the nature of work across industries and in organizations is rapidly transforming. Integrated digital platforms are changing where employees get work done and how they share information and learn together. These changes include digitizing data and information, automating processes, applying analytics, and enabling digital interactions.

The question is: *Are employees ready and enabled?* While some digital transformation initiatives involve only back-end IT work, the majority impact the employee experience in some way. Organizations need to manage expectations for the new ways of doing work and help people through it; otherwise, the experience may be negative. Of course, digital work does offer many positive benefits for employees, such as less time spent on repetitive tasks, better outcomes on document collaboration and sharing of expertise, and integrated online spaces for project work. To enable employees to quickly find the information they need, it is essential to improve findability and usability.

The other question is: *Are organizations ready to handle 'the express train' of content overload?* Organizations need to find ways to respond to employees' needs: 'Give me what I need, when I need it,' 'User friendly search and find,' 'Critical, relevant and up-to-date results.' Similar to the world of Formula 1 racing, every second counts in health care as well. Digital work is becoming the norm in the day-to-day work for the employees of AHS and the same questions need to be answered.

Healthcare is risk averse, implementation of digital transformation initiatives that disrupt the way employees do their daily work requires *careful orchestration*. What is the best way to mitigate the risk and find the right balance to lead digital business transformation and deliver financial results? ***Designing a roadmap*** to describe and understand the connection with business strategy, resources, and people required to plan and execute an effective digital business transformation initiative is essential. The design is informed by a toolkit of reviews of models, concepts, best practice organizations and their approaches, and is adapted in the context of the organization.

Fitting the change into the overall business strategy starts with talking to senior leaders, asking them about their business priorities and desired outcomes. The information collected about knowledge flow, what the organization measures today, leads to the goal of determining what is important, such as reducing response time to business opportunities, reducing errors, identifying subject matter experts, and assigning people on project more quickly. The tools and approaches implemented by the digital transformation team should be consistent with the business drivers, strategy, and resources; appropriate measures should be identified at this time. Qualitative and quantitative measures require a data collection system set up with methodology, technology, and data sources (HR, finance, participation and satisfaction, participation in social networking activities, content, text, and sentiment analysis). A step that is usually missed, but very important for continuous improvement and adoption, is to check after implementation with the business leaders to discuss the findings and jointly determine strategies to increase adoption of the change.

- A business engagement loop identified by the *Knowledge Analytics SM Process (Toolkit 1)* guides the KM professionals to align KM approaches with key business drivers and measures.

Organizational change is difficult. The analysis of complementarities can provide insights into organizational dynamics. For example, “even when senior executives have a clear vision of a new strategy for a company, managing the change can be difficult or impossible” (Argyris, 1982; Schein, 2004, Siggelkow, 2002).

Complementarity is an important concept in organizational analysis, and it is based on studying the interactions among pairs of inter-related decisions. If a company is evaluating a trio of decisions: “1) Whether to adopt a strategy that requires implementing frequent changes in its technology, 2) Whether to invest in a flexibly trained workforce, and 3) Whether to give workers more discretion in the organization of their work, the

- *Matrix of Change* can be used by leaders to assess the feasibility, scope, rhythm and unit of organizational change efforts” (Brynjolfsson, Renshaw and Van Alstyne, 1997). *(Toolkit 2)*

Developing the knowledge of how the change will affect the workers - “From Gartner’s perspective, ‘the transformation journey is taking large enterprises especially at least twice as long and costing twice as much as they originally anticipated.’ In large part this is due to cultural readiness, “53% of the organizations surveyed remain untested in the face of digital challenge and their digital transformation readiness therefore uncertain” (Gartner, Inc., 2020). Cultural readiness is usually connected to the organization’s digital business maturity which assesses the readiness for change and understands the required critical capabilities and competencies.

- *APQC's Levels of Knowledge Management Maturity SM*, presents a roadmap for moving from immature, inconsistent knowledge management activities to mature, disciplined approaches aligned to strategic business imperatives *(Toolkit 3)*.

Explaining ‘why’ the change is needed and creating captivating stories that detail the impact of the transformation and what are the benefits for the workers are also required to succeed in the implementation of a digital transformation initiative.

- *Communication strategies* with promotions and regular updates are part of the change strategy *(Toolkit 4).*

New processes are to be developed with input from users during pilots and proofs of concepts. Assessing the critical changes is required for setting up an infrastructure that can facilitate and support new digital business models. Continuously learn from best practice organizations that embed KM digital transformation programs, tools, and approaches into critical business processes and workflows.

Putting Knowledge in the Flow of Work Best Practice Study*),* presents how organizations like Alcoa World Alumina, MWH Global, Nalco, NASA, and Tata Chemicals have integrated knowledge sharing and collaboration into every aspect of their operations, creating a work cadre that are hardwired to collaborate and share what they know.

- Introducing the change into the flow of the work *(Toolkit 5)* incorporated knowledge-sharing behaviours in the worker performance goals and discussions. It also motivated the employee on a personal level to be recognized for subject matter expertise and career advancement.

Setting up a mechanism to inform leaders about adoption and user engagement - American Productivity Quality Centre (APQC), identified five organizations as “best practice”: EY, MetLife, MWH Global, Nalco, and Wipro Ltd. These organizations focus their measurement efforts on assessing employees’ level of engagement with available content as well as the overall user experience.

- *Connecting People to Content Best Practice Study (Toolkit 6)*, reported that the top-rated health measure among best-practice organizations is the number/percentage of employees accessing content, which two-thirds consider effective to evaluate content tools and initiatives. In addition, half the partners find it beneficial to conduct surveys in order to gauge employee satisfaction with content and systems.

Business will continue to transform. As we look into the future, we have to think of the *transformation as a benefit, not a threat*, and ask ourselves questions differently: Instead of “What technology is doing to us?” consider “What we will do with technology?” Instead of “It is an inexorable trend!” Consider “It’s a powerful tool.” And instead of “It’s an inevitable outcome.” consider “It’s a product of our choices.”

- MIT, Digital Business Strategy: Harnessing our Digital Future, 2020 *(Toolkit 7)*.

The IDC FutureScape webinar and research series for 2021 draws one clear conclusion: technology will play an even greater role in getting us all to the next Normal. Four major developments are listed:

> *“Acceleration: Identifying where the crisis and enterprises' responses are accelerating existing IT trends; Remediation: Identifying where enterprises will focus investments in the next two years to remediate shortcoming in existing IT environments exposed by the crisis as well as shortcomings introduced during initial emergency responses; Extension: Identifying where enterprises will seek to leverage technologies to take advantage of competitive and industry disruptions and extend their capabilities in the new normal and Ecosystem Transition: Identify how enterprise responses to the other three developments will alter the IT industry ecosystem itself.”*(IDC, 2021)

Designing the roadmap for digital transformation next includes three specific steps. In addition, an ongoing reference to the future of work and how trends are positioned should be factored in. See Figure 3.

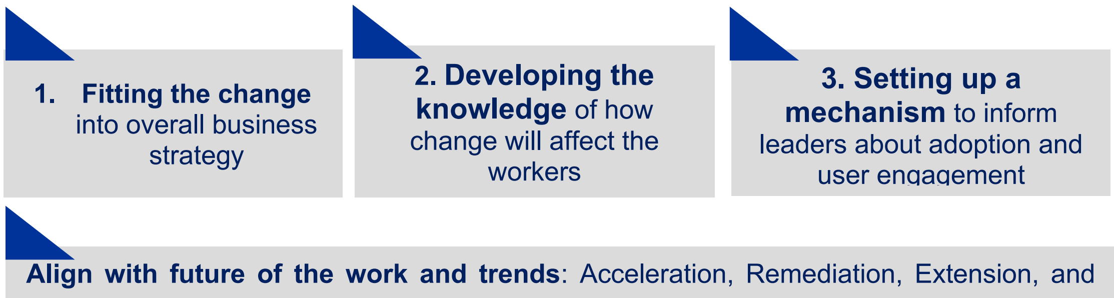


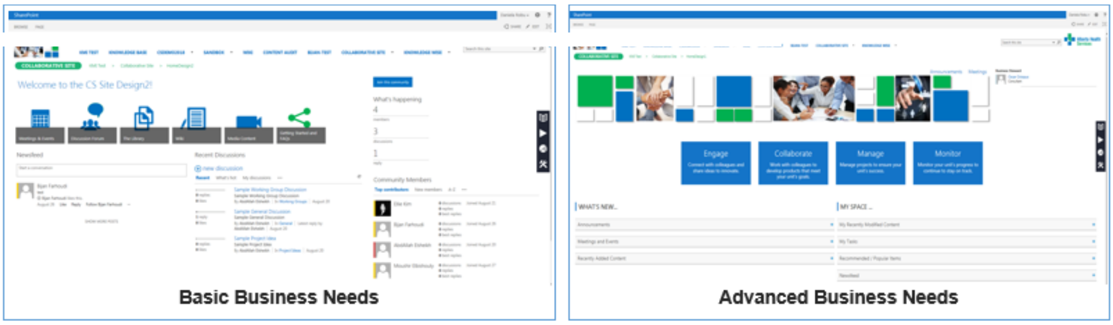
Figure 3: Roadmap for Digital Transformation

The roadmap augmented by the Toolkit of concepts, models, and best practices position organizations (in particular, healthcare) in better shape to succeed in digital transformation initiatives.

In 2016, the Knowledge Management (KM) team within AHS, in collaboration with IT and Web Communication, was tasked to determine if AHS-licensed technology met the current organization needs for information and knowledge management. In the same year, a project designed to answer this question was commenced. The design of the project was informed by prior consultation with leaders and technology end users to identify and prioritize pain points. It was also important to have a common understanding of the terms that were used for collaboration, engagement, access, etc. A key discussion for stakeholders’ buy-in was to clearly explain the ‘why’ and ‘how’ digital transformation could contribute to strategic business priorities and talent management goals.

This *pre-project phase* primed the right foundation in terms of people involvement and interest, and implicitly supported the need for a well-defined structure and process for the project moving forward. One year into the future, the output was defined, and the project team would deliver an online platform that integrated technology tools (SharePoint and Tableau) that responded to business needs (reflected in activities to access, engage, collaborate, manage and monitor) as identified by the stakeholders. The intent was to implement the project product on a trial basis for use by interested end-users and evaluate outcomes and ROI of the digital transformation experience for these end-users.

During the *project phase*, engagement had a significant importance as three layers needed to be balanced: within the project team members, the first cross-functional team of this nature in AHS (with expertise from KM, IT, Web Communication); between project team members and stakeholders; and between project team members and sponsor. Deep engagement starting in the early phases of change helped ensure processes were optimized and people were ready to embrace the benefits of digital transformation. Maintaining the stakeholders' interest during the project was possible by employing an Agile project management methodology that frequently required their input in product development. The sprints were designed to respond to the pain points (e.g easy find and search, improved document, meeting, project management and more engagement tools) identified by users. With this approach, the output, named *Collaborative Sites (CS)*, was ready for implementation in the business areas represented by stakeholders. See Figure 4.



End User Education

About SharePoint	Access and Navigation	Meeting Coordination	Document Collaboration	Document Management	Share ideas and expertise	Project Management
Beginner Teachable moment: • 5 min (1 video) Activities: 1. Learn what tasks you can complete in SharePoint that support your day to day work	**Beginner** Teachable moment: • 5 min (1 video) Activities: 1. Access your team site 2. Find documents of interest 3. Review meeting agenda, minutes and related documents 4. Read recent discussions on topics of interest	**Beginner** Teachable moment: • 10 min (2 video) Activities: 1. Set up a meeting 2. Create Agenda 3. Create Minutes during the meeting 4. Assign action items	**Beginner** Teachable moment: • 10 min (2 videos) Activities: 1. Create document and upload (classify, name) 2. Edit document properties 3. Review, approve documents 4. Publish documents (Insite)	**Developing** Teachable moment: • 10 min (2 videos) Activities: 1. Audit in Active Libraries 2. Archive in Inactive Library	**Developing** Teachable moment: • 5 min (1 video) Activities: 1. Use Blog for subject matter expertise 2. Use Discussion Forum for idea generation and decision making 3. Use Newsfeed to follow on ideas	**Advanced** Teachable moment: • 15 min (3 videos) Activities: 1. Plan Project Meeting 2. Document Project materials 3. Plan Project tasks, deliverables, milestones 4. Document in Risk log, issues Log and Lessons Learned
Support Learning Model: Webinar (30 min) and Classroom practice available						

Figure 4: Collaborative Sites

This next phase, transitioning from *project to operations*, required different engagement strategies. Leading a Collaborative Site implementation in the flow of the work required engagement of employees through effective communication about change while cultivating the skills and capabilities they needed for future success. Leaders also played a significant role in the implementation process. Knowing the priorities of their business areas and the user's maturity level from digital capabilities perspective, they carefully designed how to bring the new ways of completing their day-to-day work. Different implementation designs were deployed: phased implementation of functionalities (e.g., start with document management followed by meeting and project coordination), phased training for user groups (e.g., start with leadership followed by end-users) or full implementation of functionalities and training in the same time with a cut of date from old ways of doing their jobs.

Post-implementation phase highlighted different needs for users and business. It became evident that in addition to document, project and meeting management, each business area had specific processes (e.g., request log to capture intakes, operations log to assign tasks, education needs, repository of questions that require analysis, etc.) that guided their operations model. As users started to use the functionalities and resources provided to support their learning, different training requests were identified.

The evaluation and analysis of Collaborative Sites adoption, usage, efficiency, and quality required the selection of the most responsive Blended Solution (one or multiple interventions that address the same root cause). Content management lifecycle processes required attention as the number of documents created increased exponentially (e.g., audit and archive solutions needed to be designed and implemented). See Figure 5.

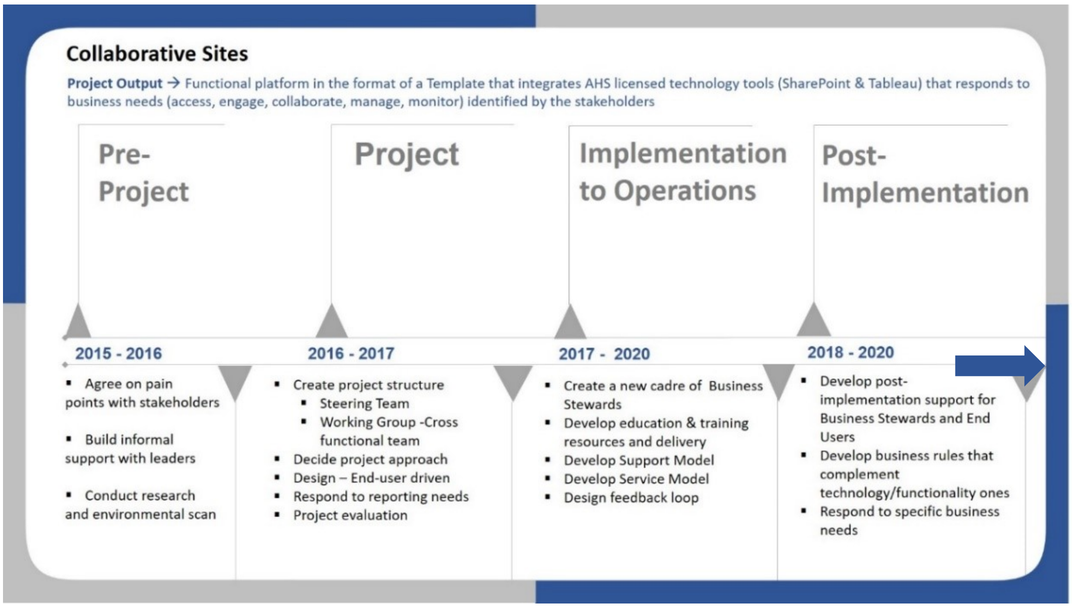


Figure 5: Collaborative Sites Phases

Successful digital transformation requires a careful orchestration of the following components: technology, people, process and content. This implies the design and deployment of different solutions, approaches, models, and methodologies at every stage. "True transformation will engage all, and will require tools, techniques and approaches to involve all in the proposed reforms" (Dickson & Lindstrom, 2010, p. 20).

3. Methodology

Digital transformation initiatives require future thinking and when selecting the methodology, the organizations need to consider where they want to be in three years from the moment of implementation, what business value the initiative will bring, anticipate the technology progress, predict dynamic changes in business priorities, and prepare employees for the future of the work. In order be well equipped with evidence for the approaches that were applied, the following steps were completed:

- *Environmental scan* that included a study of best practice organizations that were successful with the implementation of digital transformation initiatives (e.g., Accenture, Kraft Foods, US Department of Defense, Lloyd's Register, Lockheed Martin, Wipro) – comparing the strategies, processes, people and content that they have selected to respond to their organization's vision, mission, value *(Data collection: Literature review, synthesis; Format: Report)*
- *Interviews with stakeholders* represented a key step in informing the CS design and sprint planning. Thirteen departments were selected based on their interest in knowledge and information management, service needs, expertise, experience with use of technology, influencers in the organization. Thirty representatives were identified by department leaders. Eight focus groups (3 Strategic Clinical Networks, Health Information Management, Policy, Primary Care, Clinical Knowledge Content Management, Knowledge Management), were organized to gather details of the business requirements. Each focus group was equipped with the same Business Scenario template (included: scenario name, background, goals, desired outcomes, role/persona, stakeholders, process), and the activity during the focus group was to capture the story of their current processes and pain points for major initiatives and inform what their vision is for the future. The result produced eight complex business scenarios. The functions and processes identified from scenarios were grouped in common and specific business needs across the interviewed areas and captured in a checklist which represented the basis of the CS platform desired functionalities:
  - *Project/Initiatives*: a place in the platform where leaders can have a view of the numerous projects and initiatives, connected to goals to allow opportunity to inform decision making
  - *Document Collaboration:* one-stop shop for clinical knowledge content, clinical, and corporate policy aligned with the content flow from creation to publication; structured place for educational materials
  - *Engagement:* enable social media tools to allow patients, universities, health care professionals to share stories and expertise

- *Reporting:* ability to have three layers of reporting, strategic, tactical and operational, analytics for site activity and content contribution

The consensus from all focus groups was that all the above activities required creating a global lessons learned repository, reference libraries, best practice repository, and expertise locator space

- The analysis (Data collection: Interview checklist; Format: knowledge maps and database) - (APQC, 2018)
- Review of proven and emerging knowledge management approaches implemented in organizations and the impact of their implementation (Data collection: Literature review and synthesis; Format: Presentation)
- Frameworks integration to cover requirements both from performance and healthcare environment perspective (Data collection: Study analysis; Format: Integrated framework diagram)
- Agile Project Management Methodology – rigorously designed to meet the requirements related to project information creation, storage and sharing (Data collection: Site with tools for document, task, meetings, and risk management; Format: SharePoint site)
- Education models applied such as ADDIE (Assess, Design, Develop, Implement, Evaluate) and adult learning principles for reinforcing knowledge acquisition and reinforcement (Data collection: Objectives, learning activities, knowledge checks; Format: Curriculum) (APQC, 2020)
- ROI (Return on Investment) evaluation methodology to capture employees' reaction, application, business impact and consequently ROI calculation for time savings (Data collection: Surveys; Format: Graphs with trends of employees' adoption of new knowledge over time) (Phillips, Phillips, Stone & Burkett, 2007)
- Review measures to capture user engagement, CS use and adoption and process efficiencies (Data collection: Review of best practice organizations that implemented knowledge management systems; Format: Presentation)
- Review content management best practices (e.g., processes, procedures, technology, tools) implemented in organization and related audit policies (Data collection: Review of best practices, models to identify critical, relevant, and up-to-date content, frameworks; Format: Reports, publications (APQC, 2013, AIIM)
- Review change management models (strategic level: 7S model; project team: ADKAR model, users: ADKAR and Kotter/Lewin model) that are to be applied across the continuum of the initiative from pre-project to post-implementation

4. Collaborative Sites Platform

4.1 Innovation and System transformation

4.1.1 Fitting the change into overall business strategy

The Collaborative Sites (CS) journey required system thinking and systematic approaches to advance from innovation to system transformation. A non-conventional approach was considered to address the complexity of this type of initiative in healthcare. Two frameworks – LEADS (**L**ead self, **E**ngage others, **A**chieve results, **D**evelop coalitions, **S**ystem transformation; Dickson & Lindstrom, 2010) and HPT (**H**uman **P**erformance **T**echnology; Van Tiem, Moseley & Dessinger, 2012) – were integrated. See Figure 6.

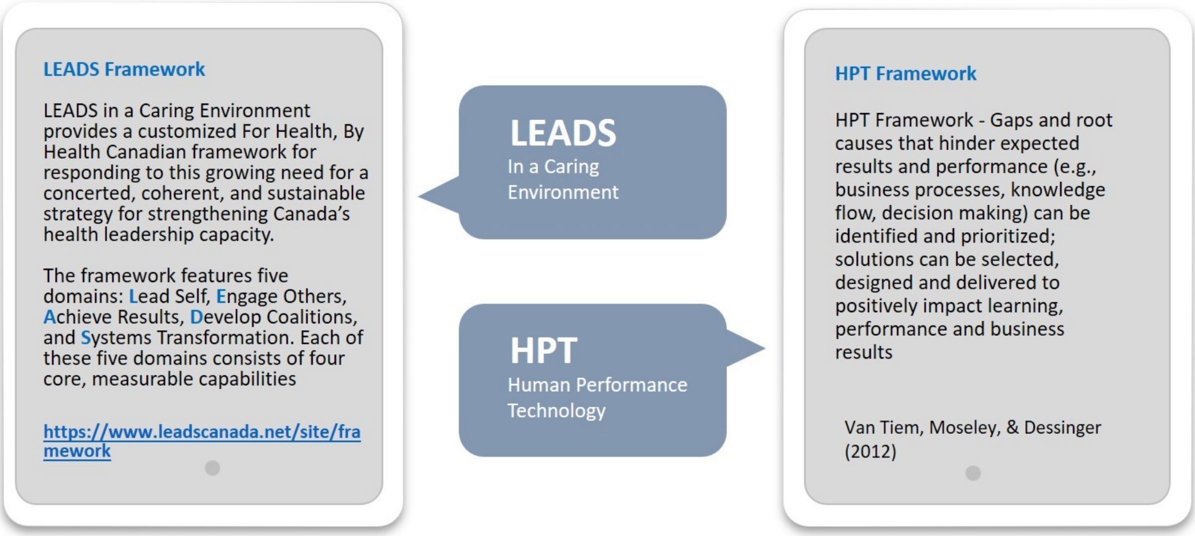


Figure 6: System Transformation: Concept - Integration of LEADS and HPT Frameworks

LEADS in a caring environment framework was integrated with the HPT framework to assist in two ways: identifying the intersection of different domains (Change Management, Knowledge Management and Performance Improvement) and selecting the best Blended Solution (BS) for the Collaborative Sites during the project and implementation in operations. A *Blended Solution* is distinctive (Lazar, Greenblatt, & Robu, 2017) in that it will likely:

1. include one or more simultaneous, integrated, interdependent, synergistic Interventions;
2. address the same root cause(s) redundantly;
3. require both qualitative and quantitative measures to design and measure effectiveness;
4. align multiple stakeholders; and
5. require faith, courage and stretch.

4.1.2 Steps from Innovation to Implementation

Many organizations dive into digital transformation initiatives without taking the appropriate steps to prepare for transformation. Also, a different mindset is required when it comes to the expectations for employees' performance – they must learn and apply new knowledge while executing (Edmondson, 2008).

How did we achieve performance excellence as a result of digital transformation?

Thirteen steps were considered in the Collaborative Sites initiative (see Figure 7). By integrating the LEADS framework with the HPT one, we ensured that in each phase of the initiative – pre-project, project, transition from project to operations and post-implementation – system transformation capabilities were linked to desired performance outcomes.

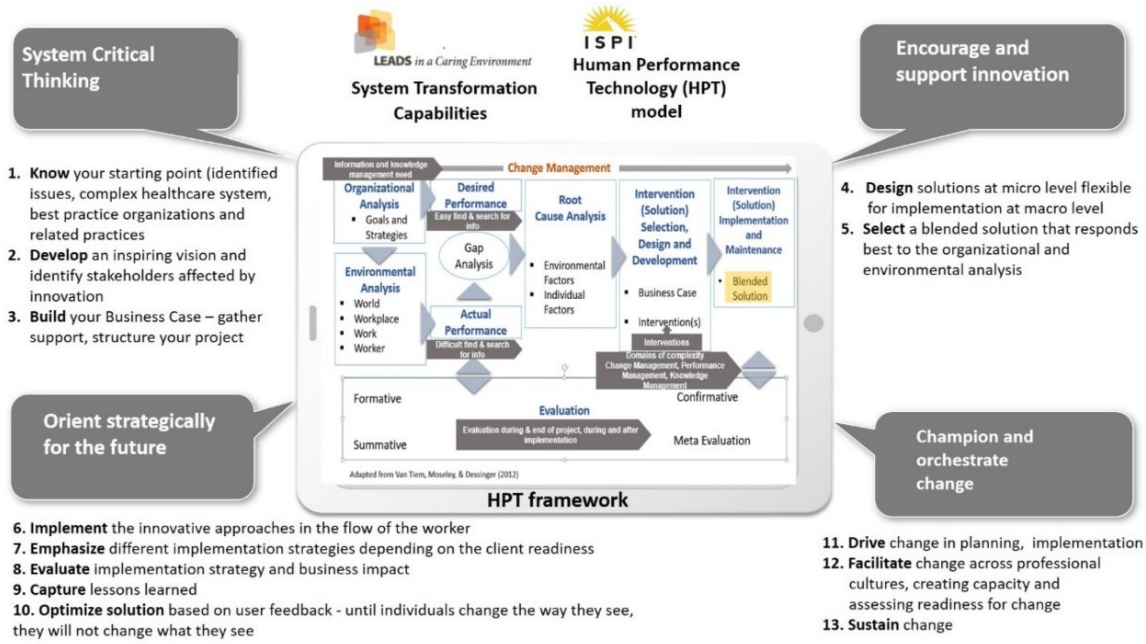


Figure 7: Innovation to System Transformation: Thirteen Steps

One question that has to be answered is how all these frameworks and methodologies really work together. In other words, how do they best blend to be integral parts of the solution and respond in the best way to the desired outcome. The following details attempt to demonstrate in a practical way how they were considered and used in the Collaborative Sites example.

1. Pre-project Phase - System Critical Thinking capabilities

Know your starting point (identified issues, complex healthcare system, best practice organizations and related practices) was designed with attention to stakeholder engagement by inviting them to participate in knowledge mapping. This is one of the most powerful knowledge management approaches to identify and understand the organization's critical information and knowledge management needs. The mapping clearly explained the "why" and "how" so that stakeholders understand how it contributes to business goals. This also helped with the identification of the pain points we needed to address with CS - Improved functionalities and tools for: access – navigation, user interface, engagement, collaboration, and management tools as well as My Space, an individual area that brings forward all the documents, action items and discussions that the employee was involved with (*Step 1*).

At this point, stakeholders could start to see the potential of the change and an important next step was to *develop an inspiring vision* and identify all the stakeholders affected by innovation. The best approach to continue to maintain the interest was to develop a prototype that showcased possible outputs of technology and how they responded to the pain points (*Step 2*).

Momentum was built and stakeholders were ready to support the next step of *building the business case and structure the project*. Governance for the project was determined by identifying the Sponsors (KM, IT), cross–functional Project Team (IT, KM, Web Communications, Identity Access Management) and Steering Team (participation from 13 departments). A project charter was prepared, and Agile Project Management Methodology adopted (*Step 3*).

These three steps are anchored in the HPT framework that relate to organizational and environmental analysis, present the gap between actual and desired performance, and identify root causes both at individual and environmental levels.

2. Project Phase - Encourage and support innovation

Future of digital work requires leaders to think how they balance the ratio between what technology does and what the worker does, how their business models change, and *design solutions at the micro level flexible for implementation at the macro level***.** Engagement strategy again played a very important role and required three layers of approaches: business stakeholders were invited to test prototypes and provide feedback on how well the functionalities responded to the identified gaps (five Agile sprints were planned and 16 prototypes refined, based on user feedback); cross-functional team brainstormed and developed different modalities to respond to the needs and regular check-ins with stakeholders provided design course-correction; Sponsors were deeply involved in ensuring the solution put forward met the agreement of all the stakeholders involved. (*Step 4*).

Multiple variables must be considered when designing a technological solution. It is about People and how the technology aids them in completing their day-to-day job, satisfaction and learning. This required the Project Team to *select a blended solution that responds best to the organizational and environmental analysis***.** Technology was approached from end user-driven design in prototyping, scanning of future trends in Business Intelligence and Artificial Intelligence and integration of proven and emerging knowledge management approaches. The People side was approached from competency development (creating a Business Steward role), roles and responsibilities needed to assist with CS adoption, change management, optimization, and ongoing management of the site (*Step 5*).

The HPT model proved helpful in identifying the steps in the selection of interventions and prioritizing the ones that create the bundle for the blended solution.

3. Operations Phase - Orient strategically for the future

Embedding digital transformation in organizations by implementing knowledge management approaches encourages engagement by making it easier for the worker to look for, capture, and transfer knowledge in the course of their jobs. Best-practice organizations drive knowledge management further into the flow of work by incorporating knowledge-sharing behaviors in employee performance goals and discussions. With CS clients, the approach was to *implement the innovative approaches in the flow of the worker*. This was achieved by mapping the CS functionalities and tools to their particular business scenarios from daily activities. It was similar to setting directions on a map from point A to point Z. These scenarios were made available in a Wiki and benefits were identified for each group of functionalities. This activity made the transition easier for staff, from current to new processes (*Step 6*).

The implementation for this type of transformation in operations involves the cross-functional team and Sponsors. They play different roles now in comparison to the pre-project and project phases and *emphasize different implementation strategies depending on client readiness*. The cross-functional team now operates following a Service Level Agreement put in place to clarify roles and responsibilities for the team and the type of requests that need to be addressed during the ongoing use of the CS sites. In the Operations phase, the Sponsor is represented by the leader of the business portfolio/department/area. For them, it was important to model different implementation strategies based on their current workload. For example, some Portfolio leaders decided to implement first at the department level (core set of Business Stewards that will master the usage, then bring the rest of the users on board) or Portfolio leaders decided to implement in all areas at once (assign Business Stewards for all areas and trained in the same time). Depending on their choice, different change management, education, site development approaches were used (*Step 7*).

To be able to *evaluate implementation strategy and business impact*, an enhanced support model for workers was developed. Lessons learned from previous implementation informed us that a self-serve model was not enough for the changes brought by digital transformation. The enhanced support model included: Request Log where Business Stewards submit their asks for troubleshooting, need for more training or functionalities to support specific needs; Frequently Asked Questions (FAQs) in the format of an online list that collates the questions and answers from business areas and is grouped on topics (access, security, content, how-to's, etc.); Webinars, conducted to transfer knowledge through simulations and case studies; and Touchpoints, online classrooms to assist with skills reinforcement using job shadowing. Self-Serve tools were also made available, such as Help and Training Library with 92 resources available based on topic, type of support tool (job aid, training bite, video, guideline) and role (Business Steward, End user) (*Step 8*).

A *lessons learned* repository was built to capture insights from the training with Business Stewards and users, implementation strategies, challenges and approaches to respond (*Step 9*).

As business areas started to use the Collaborative Sites, different performance tools were developed for them. The set of tools included: Service Model, a document that specifies the type of changes, updates the Business

Stewards can apply to CS or when they need to ask for support, as well as the approvals they need to obtain before applying changes; Business Rules, a document that specifies the management of the site (content audit and archive, user access and permissions, purpose of different tools, transfer of duties in case of transfers/turnover, etc.); and a Change Management Guide developed using the ADKAR (Awareness, Desire, Knowledge, Ability, Reinforcement) model to provide the business areas with a diagnostic tool and related interventions.

Training evaluation – conducted via surveys at the end of each training session, provided us with feedback on how to improve while we were provided training; CS platform evaluation – all the input provided by users was collected in an optimization list and during the first year of implementation, we addressed 40 bugs and improvements; Business impact – time savings, easy access to information were important output measures. An ROI calculation was completed for only one of the CS functionalities – meeting management. The result demonstrated that the new way of coordinating meetings was more efficient, with an ROI of 120%. The analysis of the usage of these tools assisted the team to *optimize a solution based on user feedback* (*Step 10*).

HPT framework was helpful in identifying the blended solution needed during implementation and maintenance.

4. Post-implementation Phase - Champion and orchestrate change

4.1.3 Setting up a mechanism to inform leaders about adoption and user engagement

Significant efforts were made to start the wheel of change and the switch from current ways of doing things to the new ways. How can we sustain and scale the adoption? *Drive change in planning and implementation* is one important strategy. Effective adoption and engagement measures have to be designed and implemented. Adoption becomes powerful when business areas become owners of the change. Structured mechanisms to continue the adoption of CS (monthly meetings with the CS leads and Business Stewards) were put in place. In this way, they could field the type of questions and issues that arise in the user community, address and deploy different approaches to respond. Knowledge management team attended the meetings to respond and provide guidance (*Step 11*).

Gamification features were enabled to showcase best content, author, contributor using badges, and ratings. These features developed new behaviors in the users and increased motivation to participate and contribute and overall *facilitated change across professional cultures, creating capacity and assessing readiness for change* (*Step 12*).

To *sustain change*, markers of success had to be identified. Best practice organizations measure the extent to which employees are actively contributing, sharing, accessing, and reusing content. Overall engagement rates represent good indicators of health since workers are likely to participate only if the tools are ready to use and content provides a tangible benefit (*Step 13*). In the CS instance, the analysis of the markers of success continuously informed us what the users needed to optimize in their flow of work. Examples included:

- Request log analysis identified thirteen specific needs that needed to be addressed for different business areas by building solutions to enable efficiency in operations (e.g Educators Hub, Operations and Tracking Log, Project Management Wiki, Course curriculum, registration and management, Research libraries, etc.)
- User Survey analysis identified the need to redesign the Help and Training resource to improve search and find based on user's feedback after 1 year of implementation (Categories: user's roles and group of resources, such as governance, document, project and meeting management)
- Request log analysis informed the implementation team on the type of requests and how to organize themselves in order to become quick in response and follow up actions. The analysis showcased that technical support was the top on the list, followed by education, access issues and enhancement requests
- Education needs analysis required the creation and delivery of an education offering focused on document organization
- Enhance the CS analytics to inform users and leaders about the usage of the site (storage, size of files, types of files). Dashboards and a Content Audit Guide with tools and checklist were developed to assist users in deciding which content to keep in the sites that is critical, relevant and up to date. See Figure 8.

Confirmative, meta-evaluation and communication plan elements from the HPT framework were applied in this context.

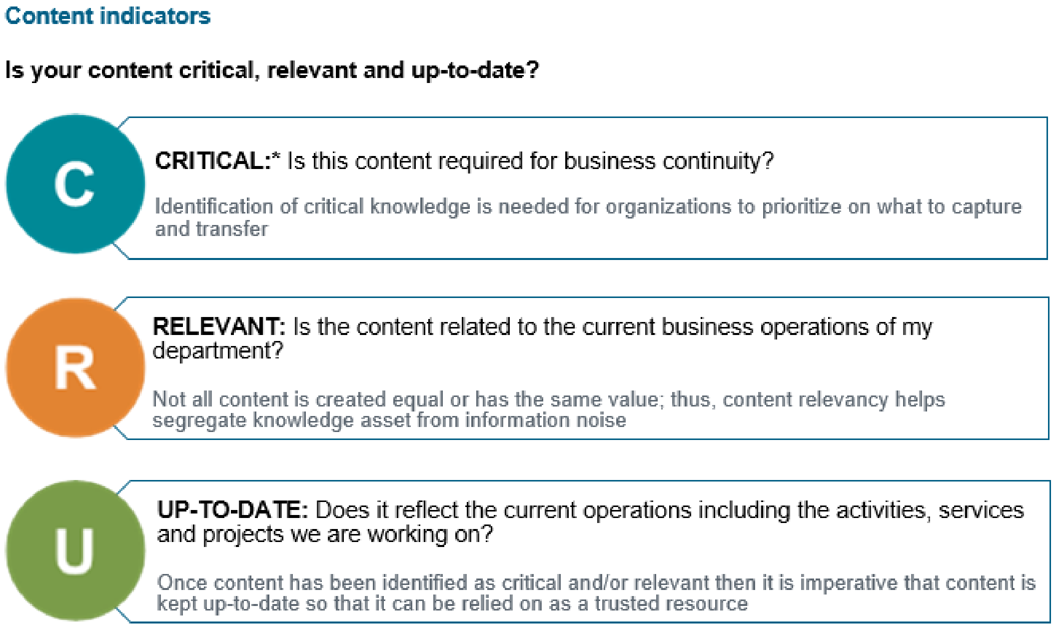


Figure 8: Content indicators that trigger audit actions

To sustain change, leaders and users need tools that measure and present in a snapshot the activities in the site at individual, tea, and department level. A content and web analytics framework was developed to respond to the leadership needs to visualize the status of the CS implementation in their areas (see Figure 9). A set of measures were identified to emphasize user adoption and participation, efficiency and quality, engagement and satisfaction.

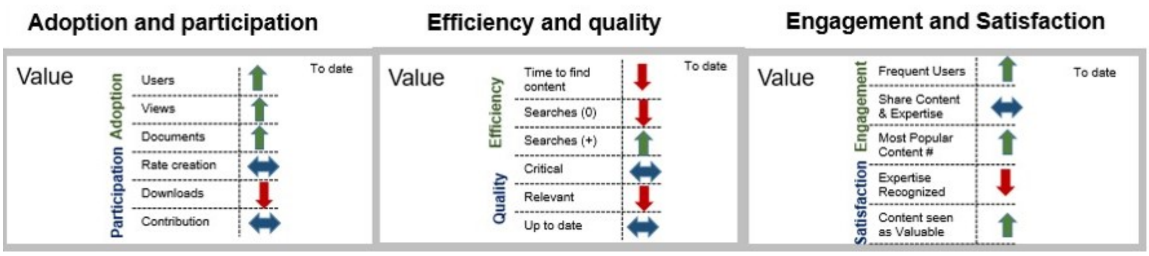


Figure 9: Business Value: Content and Web Analytics Framework

Dashboards and Information Sheets on how to interpret and intervene were developed and launched to the CS users after 2 or 3 years of implementation. For each measure, for example, "Adoption", the Information Sheet included details on: How do I interpret the data? Trends; How do I intervene to course correct? This became a handy diagnostic and treatment tool for leaders to decide the best path forward to improve adoption of digital tools.

4.2 People: Business Stewards Program

4.2.1 Developing the knowledge of how the change will affect the workers

A role called Business Steward was created to aid implementation of the technology (Collaborative Sites), ensure effective management of individual SP sites, and reinforce best practices. Online education and performance support tools were offered to increase their adoption and use. Business Stewards represented the direct connection between the business area (leaders, owners, end users) and Knowledge Management Team.

Their responsibilities are to: champion CS uptake; master CS functionalities (45 functionalities related to the engagement, collaboration, management of meetings, projects and reporting) by completing six training webinars; follow continuing education and training offerings; train team members (end users); follow the CS

Service Model to inform what requests; approvals are to be in place for changes to the CS; contribute to the evolution of the CS and works across teams for consistency; communicate with leads, owners about changes or newly identified needs; use the CS Education and Training resources; administer user access to the C; maintain CS, auditing site from content and access perspectives.

Business Stewards needed to be equipped with new knowledge and skills for the digital workplace. As Business Stewards learned new skills while completing other jobs for their role, which we call knowledge above the flow, a gradual learning path was developed to assist with easy learning and application (see Figure 10).

The training was divided by timing of delivery: *during* CS implementation with two layers of complexity (awareness and intermediate), and *after* CS implementation when the Business Stewards have learned how to use the functionalities and now are ready to accumulate more skills on how to manage the CS (advanced).

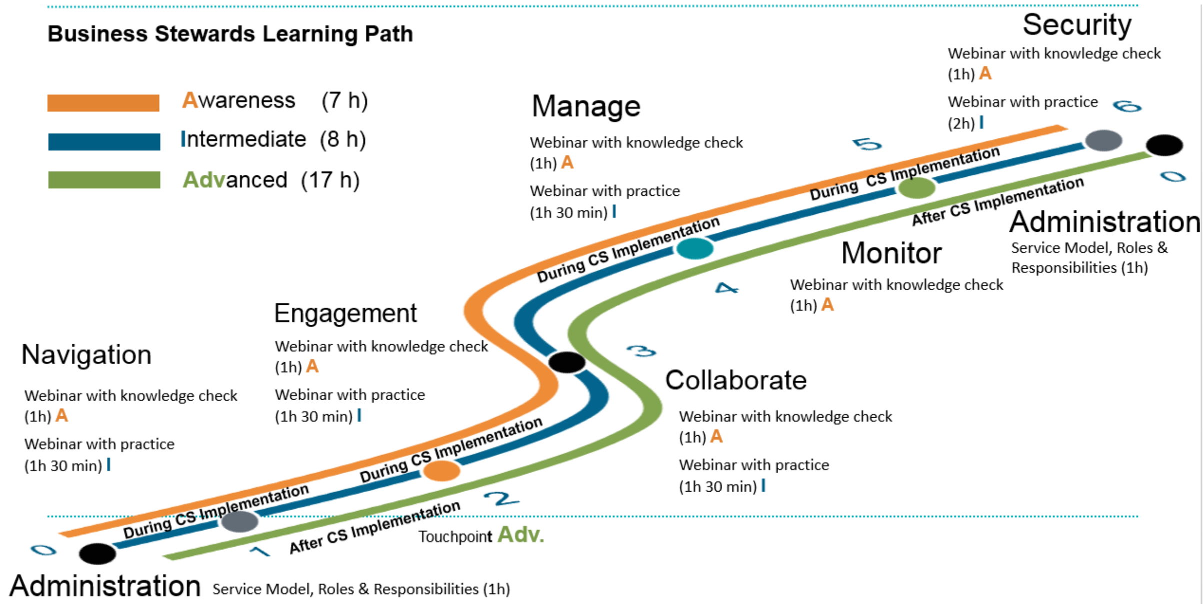


Figure 10: Business Stewards Learning Path

Upon completion of the modules (Administration, Navigation, Engagement, Collaborate, Manage, Monitor, Security), the Business Stewards received a Certificate of Achievement that highlight their enhanced capabilities in digital work.

4.3 Technology: Knowledge management approaches integrated in functionalities

The AHS information and knowledge management need was addressed by analyzing best practice organizations and implementing relevant knowledge management approaches that made sense in the context of the organization: demonstrated business value, increased people engagement and enhanced collaboration. A mapping was completed to connect the pain points identified by the stakeholders (need for more engagement, sharing, collaboration, management and monitoring tools) to *proven* (e.g., lessons learned, knowledge base, Communities of Practice, etc.) and *emerging* (e.g., Ask the expert, newsfeeds, analytics-dashboards) knowledge management approaches (see Figure 11). Technology features were aligned to develop the tools that covered these approaches. Twenty knowledge management approaches are embedded within CS (7 proven, 13 emerging). This ratio also indicated the need for a concerted effort for both education/training and change management.

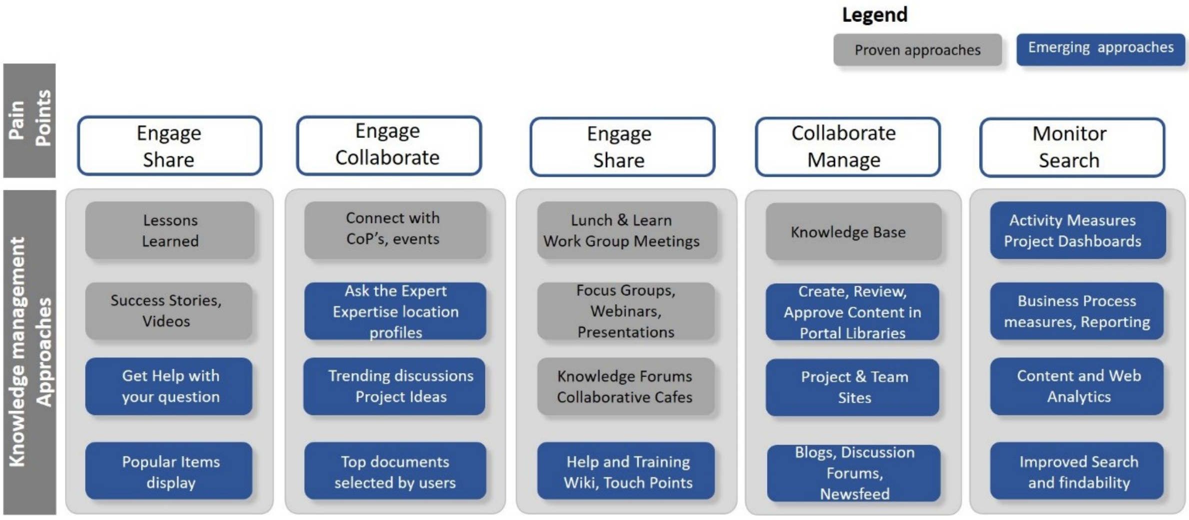


Figure 11: Proven and Emerging Knowledge Management Approaches Embedded within CS

5. Conclusions

Enhancing stakeholder engagement in digital transformation initiatives require robust process and people-focused foundations in order to be successful and sustainable. The strategies and blended solutions can include a wide range of permutations between the change management, knowledge management, and performance improvement domains. Organizations can achieve digital transformation while driving deeper engagement and better results for the business. Rebalancing mind and machine, platform and product, and core and crowd represent the future of the work and organizations. There are eight aspects that require continuous attention when leading these types of changes:

5.1 People

1. *End User adoption* – clearly explain the reason for the change and engage them through the entire change process and WIIFM (What's In It For Me) and business value.
2. *Dynamic stakeholder engagement* – stakeholders continue to be actively involved and responsive in the post- implementation phase, continuing to model adoption and business rules.
3. *Create new working relationships* – recognize the need to act and build competencies in users, as well as modeling the change with mentoring and coaching to make it work.
4. *Workers' role changes* – machine/technologies replace repetitive tasks in the flow; however, a set of skills remain the domain of people. Science, technology, engineering, and math are valuable for programming and decision making; Creativity - thinking outside the box to handle exceptions; Social skills – empathy, motivation, and interpersonal skills are crucial for managing information, decision making, and collaborative efforts. Physical dexterity – machines can dominate in the world of robots, but many jobs require dexterity that only human touch can achieve.
5. *Managers' role changes* – enable experimentation and data-driven decision making and help teams design good experiments and make fair and objective analyses that lead to the "best" answer; develop coach-like approaches for team members, developing them towards high performance and helping them build on their strengths and mitigate their weaknesses; set a context and vision for the team, and constantly work to align the workers to that vision.

5.2 Processes

1. *Enhanced support model* – be available to provide training; respond to questions; support learning at all levels (beginner, intermediate, advanced); make resources available to build and maintain trust and performance.
2. *Value of feedback to optimize* – be responsive to user feedback before, during and after implementation; demonstrate through follow-up updates and improvements that their input counts.
3. *Continuously evaluate* – evaluate what you do; capture gaps and opportunities.

Collaborative Sites were implemented in 23 departments, the corporate business area and few hospital administrations. This represents a limitation. If implemented organization-wide, more lessons learned could be drawn and the digital transformation strategy and roadmap adjusted accordingly. Collaborative Sites continue to evolve, driven by priorities in the organization, user identified needs, and progress in technology. This represents another limitation and challenge.

Next steps include analysis of the specific needs and development of a toolkit of templates that can be used across the CS users, automated workflows for repeated steps and Artificial Intelligence/Machine Learning to support users with their questions (chatbots, sentiment analysis). The challenges ahead relate to the constant rebalancing required to fine tune the digital transformation engine.

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'Good to know': An Exploration of the role and Influence of Professional Ethics in ICT Bodies of Knowledge (BoKs)

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Abstract: As our dependency on ever-more complex, opaque, and ubiquitous information and communication technologies (ICTs) increases, ethical concerns about the development of those technologies are also rising. One approach to mitigate these concerns is to improve the maturity of the ICT profession through codification of its knowledge base and professional ethics. In this paper, some key theoretical approaches to ethics with a long-established tradition within Philosophy are explored and how these approaches may manifest in the codification of knowledge within ICT Bodies of Knowledge (BoKs) is discussed. BoKs provide a common vocabulary and knowledge inventory to aid communication and encourage shared values and practices, particularly in emerging professional areas such as the ICT profession. Thus, identifying and understanding how ethics are codified in ICT BoKs is important for maturing ICT professional practice in general, and more specifically, for the resolution of ethical concerns. This paper 1) explores considerations and approaches to how ethics are incorporated within ICT BoKs, and 2) conducts content analysis on how ethics are codified within the content structure of ICT Boks. It is found that theoretical ethical approaches are rarely explicated cited in BoKS though, in the more mature BoKs, the discussion of ethics does include consideration of most of the major philosophical approaches. The implications of how knowledge about ethics is described and integrated into the wider knowledge infrastructure of the ICT profession including curriculum guidelines and accreditation processes is discussed. In a wider contribution to the Knowledge Management discipline, potential lessons to increase maturity for other emerging professions through the development of BoKs are also outlined.

Keywords: Bodies of Knowledge; knowledge codification; ethics; ICT profession; Knowledge Management; professional education

1. Introduction

Knowledge Management (KM) concerns knowledge, but what kind of knowledge is ethics? This is not only a question for individuals but also plays out in the workplace and wider society. How can we know what is 'good' and how can we get better at doing it? If we have better knowledge of what 'good' is and how to behave in ethical ways, does this make it more likely that people's behaviour will improve? The concept of professional ethics is familiar within our understanding of established professions, such as Medicine or Law. If professionals have expert knowledge and power over important parts of our lives, for example our health, we expect them to be responsible and ethical in how they operate. We also expect them to have knowledge of their own professional guidelines and to know how they might work in practice. In contrast, professional ethics are less defined or understood in newer or emerging professions such as the Information and Communications Technology (ICT) profession. The question of how the ethics of emerging ICT professions are codified and managed is becoming progressively more important in light of society's growing intertwinement and dependence on ICT, particularly given newer technologies such as AI and IoT (Lemonne, 2018). Many major safety critical infrastructure systems, for example, are increasingly dependent on ICT. As the complexity, iteration, and pervasiveness of ICT in all facets of life increases, and as significant risks of negative impacts of ICT emerge, public concern about potential ethical implications also increases. Simultaneously, as these technologies develop, new professions start to emerge around them. As these professions mature, their knowledge is codified, and processes are put in place to consolidate and share knowledge, as well as develop a shared sense of ethical professionalism. Over time, knowledge about ethics becomes more embedded within the profession. Professional ethics is distributed throughout all professionalism documentation, i.e. codes of ethics, certifications, accreditation, etc. Ethical issues or questions are addressed in a more integrated fashion and are seen to shape other areas of professional knowledge.

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As professions develop, they generally codify their expert knowledge in a structured document described as a Body of Knowledge (BoK). A BoK is a structured representation of the proposed and/or practised knowledge needed to function as a profession, as well as its scope or jurisdiction. In many cases, these BoKs are described as a reference guide to 'the Body of Knowledge'. Thus, they are often explicitly defined as a partial 'snapshot' of the full Body of Knowledge, which exists in multiple publications and the expertise of professionals. These are nearly always developed by a relevant professional body or organisation, though some can be developed through government policy initiatives. Importantly, these often explicitly cover some description of professional ethics within that domain as well as often implicitly reflecting an ethical posture in various ways. The inclusion and degree of ethical knowledge in BoKs (or indeed, its exclusion) is itself an ethical stance. The very existence of BoKs and their knowledge claims in identity forming and empowerment of groups has ethical implications. Similarly, a BoK's knowledge claims and their application in structuring or producing a 'legitimate' profession may have wider societal ethical implications (Greenfield, 2017). A BoK invariably reflects ethics, explicitly or implicitly, which will have intentional and unintended ethical implications. Thus, both knowledge and ethics are central to the concept of professionalism (Saks, 2012). BoKs do not operate in isolation but both represent and influence the education, training, and practice of the profession, through books, curricula, accreditation, etc.

Getting better at developing usable and relevant BoKs, as well as considering and incorporating ethics, is an important current policy and social issue for the ICT profession (EU Commission, 2018). Despite this increased policy focus on ethics and ICT related BoKs, they have received little corresponding academic attention. In light of this, this paper examines the current state of play regarding the integration of ethics within ICT professional BoKs. The following research questions guide this study:

RQ1 How is ethics codified within the content structure of ICT professional bodies of knowledge?
RQ2 How does the treatment of ethics in BoKs relate to the main ethical theoretical approaches?

To address these questions, we begin by (1) exploring existing literature at the intersection of ICT Professionalism, BoKs, and ethics. We then (2) conduct content analysis on prevalent high-level ICT BoKs that influence the ICT profession. Furthermore, (3) we select three BoKs that have the highest level of ethics integration and we analyse them further to gain deeper insights into their approach to ethics.

Finally, we carve the path to a research agenda connecting ethics and its relationship to professional knowledge. The nature of how ethics can be integrated into BoKs and how this may be linked to known ethical theoretical approaches is discussed. The possible implications for more effectively integrating ethics into other tools or aspects of professionalism are then outlined. Whilst we contribute to the understanding of knowledge about ethics within the ICT profession, insights gained may also be applicable to other professions, particularly those newly emerging.

The contribution of this study is threefold. It is the first analysis of how knowledge about ethics is codified in ICT BoKs and how this relates to wider ICT professionalism. Secondly, in the more detailed analysis of the high maturity BoKs, it develops an initial framework for how the three main ethical approaches relate to different approaches to discussing ethics in ICT professionalism tools and documentation. Thirdly, arising from these findings, it discusses the ways in which this may increase our understanding of the relationship between knowledge, ethics, and professionalism. This is an important contribution to KM both theoretically and practically, informing approaches to improving how knowledge about ethics is managed and developed within any professional sphere. Getting better at understanding the nature of professional knowledge and how it relates to professional ethics is only going to get more important as expert knowledge becomes increasingly specialised.

The paper is structured as follows. In section 2, we overview the core concepts of this paper: : ICT Professionalism; Bodies of Knowledge (BoKs); Curriculum Guidelines and Accreditation; Ethics; Professional Ethics. The relationship between Knowledge and Ethics is also discussed. In section 3, we outline our method for BoK selection and approach to analysis. Section 4 presents the results of analysis and introduces the framework of the key themes and ethical theoretical approaches. Section 5 is a discussion of the potential impact of how different approaches to the codification, description and integration of ethics within professional BoKs may influence how ethics is incorporated or not into professional identity and practice. Finally, section 6 draws some conclusions on the implications of this study for KM as a discipline and how insights from ICT BoKs may have possible lessons for other emerging professions. This concludes with some suggestions for future research on the topic of ethics and knowledge within the ICT profession.

2. Literature Review

In this section, we discuss the nature and scope of ICT as a profession, as well as significant developments in relation to research and policy linking the ICT profession with ethics. The major theoretical approaches to ethics are introduced with some discussion about how they manifest in the context of ICT. It also covers the focus of this paper, i.e. the nature of Bodies of Knowledge (BoKs), and associated professional documentation including curriculum guidelines and codes of ethics in more detail. This general overview provides context to the subsequent discussion as well as the wider research agenda of ethics, knowledge, and ICT professionalism proposed in the conclusion.

2.1 ICT professionalism

ICT is a hard topic to define clearly and professionalism is a disputed concept. Grasping these combined concepts is therefore rather complex. The 'European Centre for the Development of Vocational Training' (CEDEFOP) defines ICT professionals in terms of, 'conducting research, planning, designing, writing, testing, providing advice and improving information technology systems, hardware, software and related concepts for specific applications. They develop associated documentation and design, develop, control, maintain and support databases and other information systems to ensure optimal performance and data integrity and security' (CEDEFOP, 2016). This implies the scope of an ICT professional can be quite varied, in terms of research, practice, and ICT focus, with ethical considerations more explicitly evident concerning data integrity and security.

In relation to the exact nature and value of the professions, there is a long disputed historical debate on their role, as observed by Saks (2012), whilst Eraut (1994) discusses 'newer' professions such as education and their struggles to gain equivalent autonomy and status compared to more established professions. Within ICT, there have also been some robust debates on the relevance of professionalism to the field. In Australia, for example, one author argued 'that Computer Societies have been bewitched from the pursuit of their humanistic objectives by the lure of professional status' (Holmes, 1974, p.127). Here we see that professionalism, as well as incorporating ethics, may sometimes be perceived as a distraction from ethics. Despite these debates, authors generally agree on the importance of a profession's relationship to at least some expert knowledge, and that some ethical approach be adopted. As expert knowledge is key to professionalism, with ethics also important in this regard, we examine how they can be connected. Ethics in terms of professionalism is also distinct from general ethics as it explicitly applies only to those within the profession: the possession of expert knowledge bestows particular ethical obligations.

Connecting ICT professionalism with ethics is particularly salient in relation to high profile disasters and frauds caused or enabled by ICT, which can severely weaken public trust in ICT and those who develop and use these systems. In parallel, there is growing concern about ICT ethics and an emerging consensus that ICT ethics must be explicitly addressed (van der Linden et al., 2017) as part of the general drive towards professionalism. As the ICT profession is relatively immature compared to the well-established professions of Law and Medicine, and as society's dependence on ICT increases, it is imperative that standards improve. Furthermore, maturing the ICT profession can have associated economic and social benefits. For example, this could include a reduction of risks posed by ineffective development and use of ICT, due to poorly trained ICT labour with inadequate ethical awareness.

There has been some prior research and policy work on maturing the ICT profession within the European context (McLaughlin et al., 2012) which has developed a model of ICT professionalism based on literature analysis and data collection from stakeholders. The model consists of four building blocks: a) Competences; b)Bodies of Knowledge; c) Education and Training; and d) Professional Ethics. 'Competences' are primarily concerned with workplace skills, which can be practically demonstrated; 'Education and Training' are concerned with improving consistency and standards, in some cases through certification; 'Bodies of Knowledge' concern developing an agreed core structured knowledge reference; and 'Professional Ethics' is about improving the level of ethical knowledge, behaviour, oversight and responsibility within the ICT profession.

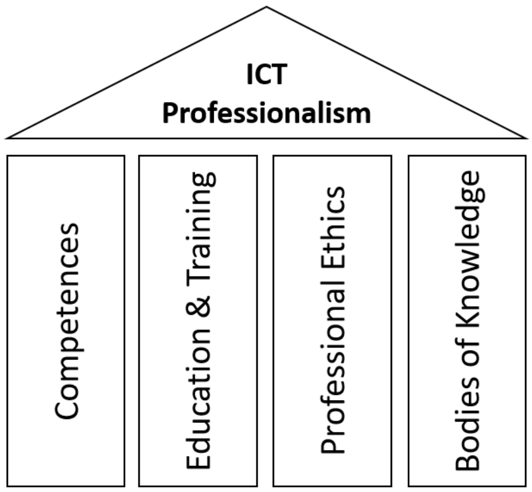

Figure 1: The Pillars of ICT Professionalism (adapted from McLaughlin et al., 2012)

The European Commission's policy drive for developing ICT professionalism, as part of the overall Digital Europe Strategy (The European Commission, 2019), aims at maturing these building blocks in an integrated way. The key question, however, is: how exactly can these building blocks be integrated both conceptually and in practice? It is not too difficult to integrate a competence framework into a training programme (Sanz et al., 2018), nor is it problematic to consider how to use a Body of Knowledge as part of developing competences. Ethics, however, does present a challenge in terms of integration, as it appears to have important differences from the other types of professional knowledge. The path is less clear than the other aspects of professionalism as people can disagree on ethical priorities and there are some cultural differences (Sherry, 2013). A recent review of ethics as part of ICT policy revealed both core agreements and differences within the EU, for example, former Eastern bloc countries held different perspectives than some Western European countries (Thornley et al., 2018).

Indeed, dilemmas and complexity are often highlighted as key parts of ethics and ICT (Runciman, 2019; Thornley et al., 2011). Some areas of ICT raise particular concerns in terms of transparency and accountability, such as Artificial Intelligence (Koene, Clifton and Hatada, 2019) and efforts have been made to map their internal workings to visible connections to known moral norms (Tubella et al., 2019) . Many ICT professional areas are cross-sectoral in that they directly affect and support a very wide range of sectors outside ICT. Cyber security, for example, is critical to many sectors and articulating cyber security ethics in all these varied areas is challenging (Yaghmaei et al., 2017) with many complex ethical trade-offs. The potential ethical implications of the increasing role and ubiquity of data is a broad concern and this is addressed as a business issue in the professional literature (Lynch et al., 2016) as well as in the more academic sphere (Floridi and Taddeo, 2016). Regulating the ethics of emerging professions can also be seen as a challenge to their independent professional status in some cases (Eraut, 1994) and can be a difficult balancing act.

2.2 Bodies of Knowledge

Part of KM is about enabling knowledge sharing through effective codification. Bodies of Knowledge (BoKs) are explicitly designed to model, codify, and share common core agreed knowledge, normally for specific professional groups. A BoK is knowledge codified to make it easier for professionals to complete their duties and tasks. BoKs are both normative (this is what a professional should know, in some cases with priority areas defined) and descriptive (this is some detail on the content of knowledge that professionals need). Their content structure generally contains a section explaining the purpose, scope and intended audience. The knowledge they describe/define is grouped into categories/areas KA and subdivided into further knowledge items (KI) or units (KU).

From our study of ICT BoKs, regarding the 'types' of knowledge they include, it can cover concepts, models, theories, and methods. These can vary in the degree of abstraction depending on the nature of the profession and how specific the particular BoK is. Some BoKs allocate different knowledge items into specific levels of professional knowledge depending on how advanced or specialised they are. More commonly, some Knowledge Areas or Units are mandated as essential for all professionals, whilst others are allocated to specific professional sub sectors. The question of how to include ethics within ICT BoKs has received more attention recently, and will be discussed more in the findings section, but there are acknowledged tensions between demonstrating that 'ethics' is everywhere for everyone and also including enough detailed ethics content to actually guide teaching and professional development. BoKs exist for many professions but are normally only discussed or critiqued when a nascent profession feels it needs one, e.g. recent work on requirements engineering (Penzenstadler et al., 2013), or when a major update is required, e.g. project management (Morris, 2001).

BoKs are explicit knowledge, according to Nonaka's (1994) distinction between explicit and implicit or tacit knowledge, as they are always written down or 'codified'. At the same time, they draw heavily on tacit knowledge as they are typically devised through consultation with experts. The method of their development generally involves a literature review of key sources to identify topics and new trends and then a consultative period (Sefton, Shea and Hines, 2011) to consolidate and attempt to reach consensus. While there is no single agreed method for development, this broad outline is used as a common approach (Morris, 2001; Morris et al., 2006) though different professions rarely acknowledge methodological input from other professional BoKs. So far in our literature review, we found no real input in BoK development from KM expertise on knowledge codification, such as expertise on improving elicitation methods (Gavrilova and Andreeva, 2012).

BoKs are not only a recent development but are discussed in an historical sense when studying books or artefacts that represent specialised ancient knowledge such as Shamanism (Rutz, 2013). They are often afforded a kind of reified status and are described as ontologies, 'representations of', and in some cases, have an almost totemic status (Durkheim, 1912) in symbolically externalising the shared identity of a profession. This is particularly notable in the rhetoric of BoKs in emerging professions, such as massage therapy (Sefton, Shea and Hines, 2011). They can be linked explicitly to the human body as part of a critique of the tendency to focus on learning and knowledge as purely cerebral rather than embodied (Peters, 2004; Claxton, Lucas and Webster, 2010). Indeed, the term 'Bodies of Knowledge' as opposed to, for example, 'Knowledge Reference Guide', does perhaps indicate that BoKs suggest an incorporation of knowledge into the physical practices of a group. In many cases, BoKs explicitly claim that they are merely a representative artefact of the actual Body of Knowledge, which only exists in the sum of all relevant literature and the expertise of professionals. Thus they can be both a codification and an acknowledgement of the limits of codification, with no sense of perceived contradiction. They are knowledge with a clear purpose and codification is seen as useful insofar as it furthers that purpose. A BoK, however, does not need to claim complete exhaustivity or exclusivity of all relevant knowledge.

BoKs concern issues of identity, developing or furthering professionalism and, in some cases, claiming and disseminating knowledge by formerly marginalised groups. A strong example of this is the women's movement in the 1970s. Up until that time, medical knowledge about women's bodies was owned and controlled by the predominantly male medical establishment. The seminal book 'Our Bodies Ourselves' (Hawley et al., 1971) was developed and published by women in an accessible form, which also incorporated the lived experience of women's embodied lives (Davis, 2007). Both the book and the associated discourse around its publication are fascinating examples of the role formalising knowledge can have in creating shared identity and empowerment. Thus, whether BoKs formally include ethics within their structure or not, they often have a value driven motivation in their formation, development, and dissemination. These developments are not without dissenting voices, such as recent discussion on the validity and usefulness of the SCRUM Body of Knowledge (Kim, 2020) and the ongoing debate on the validity and objectivity of the Psychiatry Profession's Classification Manual of Mental Disorders (Spiegel, 2005).

2.3 Curriculum guidelines and Accreditation

BoKs are part of a wider domain knowledge infrastructure, being increasingly allied to competence development through links with curriculum guidelines and competence frameworks (Morris et al., 2006) for their related professions. Curriculum guidelines are published by some ICT professional bodies and these provide more detailed specifications for the content, ordering, assessment, and delivery of courses. In some cases, the distinction between a BoK and curriculum guidelines is not completely clear cut. In any case, curriculum guidelines will refer to or include content from their associated BoK. If educational institutions then wish to have their courses accredited by the relevant professional body, they must include BoK content in their courses and structure it in line with the curriculum guidelines. In these cases, BoKs can have a particular influence as they flow directly into curriculum guidelines and are linked to curricula or course accreditation. This accreditation matters, as it demonstrates to potential employers that the course covers material deemed as essential and useful by the professional body. It can happen in different ways, sometimes quite directly as is carried out by the Australian Computing Society (ACS) and other times via another standards body as is done by the Association for Computing Machinery (ACM). The way ethics is included and integrated in the BOK and associated processes, if done well, should result in professionals entering the workplace with the required ethical knowledge and skills to apply it. Accreditation processes linking to a BoK that includes ethics will require the accredited institution include ethics tuition in its accredited ICT programme, often with quite directive guidance on how this must be done, e.g. integrated within modules and as a stand-alone module.

Competence or Skills Frameworks are used more in continuing professional development (CPD) and professional education. The inclusion of ethics in these furthers the integration of ethics into professional development and identity. This increases the potential role of ethics in BoKs, as there is a push from educators and employers to incorporate ethics in professional education. This is partly due to decreased public trust in professions *per se* and how high profile disasters (Gelles, 2019) and privacy leaks have decreased public trust in the ICT profession.

For example, the IEEE has recently completed extensive work on ethics for AI and autonomous systems (IEEE SA, 2020) in response to growing public disquiet. The IEEE's initiative incorporates educational guidance and is moving towards certification. The recently updated European e-Competence Framework (e-CF, 2019) now includes ethics as a Transversal Aspect designed to influence all competences. There is also currently a European project, Ethics4EU, on improving the teaching of ethics in computing curricula (Ethics4EU, 2021).

2.4 Ethics

Ethics generally concerns the study of what is right or wrong (or morals), why that might be so, and how humans engage with these concepts (Rachels and Rachels, 2019). This includes understanding systems of values, their application, and resulting implications. It has a long history of study within Philosophy and can be broadly grouped into three main approaches: virtue ethics; deontological ethics; utilitarianism/consequentialism. Virtue emphasises moral character and was initially developed by Aristotle (Aristotle, 350AD). Deontology emphasizes duties or rules and following those rules regardless of consequences. Finally utilitarianism (Mill, 1863) or consequentialism emphasizes the need to weigh up the positive and negative consequences of actions before deciding what is the right course of action to take (Hursthouse and Pettigrove, 2018).

Depending on which theoretical approach is taken, there are different perspectives on what knowledge about ethics might be. In virtue ethics, it is primarily implicit aspects of a person and their identity that guide behaviour, suggesting education and mentoring might be the best approach to impart knowledge/values and fully integrate it into a person's mindset and practice. In a rule-based approach, it suggests developing guidelines incorporating the correct ethical approach, and then ensuring everyone knows the rules and is compliant with them. This can include formulating and formalising code(s) of ethics. It may also include encouraging compliance by linking ethics codified in BoKs to graduate certification or even accreditation of the educational institute itself (i.e. curricula must be based on a BoK of which ethics is a part). The consequentialist approach requires the ability to weigh up the likely implications of actions, so it is in one sense knowledge or data driven. This is not straightforward, however, as the knowledge required to correctly assign ethical actions in different possible scenarios is different from gaining knowledge about what those scenarios may be. If taken at an individual level, it could also suggest a strong legal or compliance-based approach to ICT professional ethics, whereby ICT professionals would be obliged to behave in an ethical fashion due to fear of punitive legal sanctions if they do not. On a broad ICT level, this was part of the motivation for the heavy fines payable by organisations if they breach the guidelines of the European General Data Protection Regulation 2016/679.

Thus, we can see that one's view of 'what ethics is' affects the approach to improving ethical standards within a profession and how one might include ethics in a Body of Knowledge. It can also be dependent on one's view of the nature and role of a profession in relation to tackling ethics. The link between individual understanding and values, social or professional norms, and the connection between knowledge and practices are complex factors, which influence how knowledge about ethics plays out in a profession. There remains the concern that even if professionals are provided with very clear knowledge about ethics that they may still not necessarily apply them in professional practice. This is an issue with a long history, as Aristotle was concerned with the problem of 'weakness of will' which is the paradox, as he saw of it, of knowing what is right and still failing to take the right action.

2.5 Professional Ethics

Professional ethics is strongly related to the general use of the term ethics but is by its nature less universal. Professional ethics, as codified and articulated in various ways, are explicitly only applied to the profession in question, not the general population (Davies, 2004). Since part of what defines a profession is an organised group of people bound by defined specialist knowledge they use for a certain purpose, we argue that knowledge and its use have a more primary focus in professional ethics than in ethics in a general sense. Professional ethics incorporates a sense of duty or obligation towards the people who use and rely upon the professional's services who, by definition, do not share all of the professional knowledge or they would not need to consult them. There is often a power disparity between the professional and the client and the professional has an obligation to use their knowledge in the interests of the client and not to betray trust. This does not totally trump wider social ethical obligations, though it can conflict with them quite strongly, for example, a lawyer defending a murderer in court even if s/he is personally certain they are guilty. Within ICT professional ethics, there may be cases when the social good would be seen as more important than the request of the client, e.g. a company requesting illegal surveillance, or an HR algorithm which disadvantaged women or black people. In these cases often, though not always, it is a rushed , short-cut approach which can inadvertently cause the creation of biased systems or non-compliant use of technologies. Thus the desire of company to reduce costs and increase profits can be in conflict with professional ethics.

Recent discussions on improving professional codes of ethics suggest moving away from a rule-based approach to a more principles-based approach. The American Institute of Certified Public Accountants (AICPA), for example, has recently added a new conceptual framework to their professional ethics by suggesting that all its members regard every questionable situation, circumstance, transaction, or relationship by attempting to view it through the eyes of an imagined reasonable third party (Spalding and Lawrie, 2019). There is also some suggestion to more closely link the approach to professional ethics with the existing practices and ethos of the relevant profession. This is demonstrated in recent work on the use of pragmatic care and design principles to inform engineering ethics (Nair and Bulleit, 2020) and incorporating ethics into the software design process (Gordon et al., 2020). Furthermore, recent work has also examined means of 'ethical deliberation' as a remedy to the uncertainties of the software design process, whilst acknowledging availability and constraints of time and resources allocated to projects (Gogoll et al., 2021).

2.6 Professional Ethics Documentation

Ethics in most professions is not only implicit, but also explicitly codified in some way as a reference document. Similar to a BoK, this documentation is both aspirational and representational of the ethics that the profession espouses and enacts. In our study of ICT BoKs, we identified multiple methods of documenting ICT professional ethics, including codes, case studies, educational materials, and references to legal cases (ACM). Codes of Ethics usually include some general ethical principles then become more specific about how that might translate into actual conduct in practice. Some codes explicitly acknowledge that professionals may face situations where they perceive an ethical dilemma or a case where two ethical principles may be in conflict (e.g. privacy and public safety) and deciding on the 'right thing to do' is not a simple case of applying a certain ethical principle. Both the Association for Computing Machinery (ACM) and the Australian Computer Society (ACS) include case studies in their ethics material to allow education and discussion around ways to approach these dilemmas. The ACS in particular offer detailed guidance on how the case studies relate to particular parts of the codes of ethics.

The ACM discussion of the legal use of the ACM code is interesting. It has been used as a legal defence for professionals to refuse government requests for customer information, arguing that the right to privacy is a stronger ethical force that legal compliance if (and only if) that legal compliance is clearly anti-privacy. This demonstrates that professional codes of ethics, whilst not legally binding, are recognised within the legal profession as indicative of a profession's accepted practice and have a high standing. It is hard to envisage that if the ACM had failed to codify their ethics that a similar argument could be made just because 'the ACM generally thinks that privacy is very important'.

3. Method

3.1 Selection for review

The criteria for the inclusion of ICT BoKs in the review were authority, i.e. the BoK is from an established and known institution, and availability, i.e. it is possible to locate and access the BoK. A review of significant ICT BoKs involved initial selection through a literature search using the search terms 'BoK', 'Body of knowledge', or 'Bodies of Knowledge', combined with different ICT related terms, ranging from broader (ICT, IT, computer, software, etc.) to narrower terms (project, data, service, security, etc.) to ensure comprehensive coverage. This was extended through searching websites from authoritative bodies and sources in the field. These BoKs indicate what is considered relevant knowledge for their specified field. The selection of BoKs were verified through two stakeholder meetings with experts in the ICT professionalism field who were selected on the basis they had published on the topic or contributed as experts to previous EC ICT Professionalism projects. Thus, the list cannot claim to be exhaustive, but it is reasonably representative.

Twenty-three BoKs were analysed in total. Six BoKs addressed the generic level of ICT management and seventeen focused on more detailed specialist areas. ICT has many different specialisms thus there are more specialist BoKs than generic BoKs but the more general BoKs often have a broader influence. As BoKs are often part of a suite of resources for a profession (i.e. knowledge infrastructure) including other items such as competence frameworks, codes of ethics and certification programmes, we also noted if the BoK referred to ethics material in related resources.

After examining how the BoKs incorporated ethics, we selected three, based on how well and thoroughly ethics was integrated in both their structure and content, and how that was further integrated with other tools of professional maturity, namely codes of ethics, curriculum guidelines and accreditation. In these high scoring cases, we reviewed how ethics was considered in the relevant BoK in more detail, examining key themes and drawing connections between different theoretical ethical approaches.

3.2 Analysis methods

We used content analysis through a reading of the full text of the BoKs and a final check using the search function in Word for ethics and related terms. Our first step was to ascertain where ethics was overtly incorporated within the overall content structure, i.e. scope, introduction, KI/KU etc. We then further examined the ways in which ethics were explicitly present in the BoKs, i.e. in definitions and concepts, and links to the domain knowledge infrastructure. We reviewed whether ethics was included as core to the BoK, i.e. as a knowledge item or knowledge unit within the knowledge structure. Next we examined where ethics was mentioned in other parts of the BoK, for example the introduction or purpose section. If the BoK had a separate references or literature section, we reviewed this list for sources related to ethics. The final analysis looked at how the BoK linked ethics to the domain knowledge infrastructure, i.e. to other professional resources such as codes of ethics, curriculum guidance, or incorporation into a professional certification process.

4. Results

4.1 Summary Results from all BoKs

The results are analysed in two stages. First, we provide an overview of key findings with a summary table describing the main findings. Second, we explore how ethics is portrayed in three of the BoKs, selected due to their higher stage of professional maturity, in more detail.

Table 1 shows the results from the initial analysis and provides an overview of the BoKs surveyed, whether and how they included ethics, and if there were other ethics content sources available such as a code of ethics and/or guide to professional conduct. The main finding is that all but one of the BoKs we surveyed did include ethics in some way, the only exception being the ‘Enterprise Architecture Body of Knowledge’. Even in this case the BoK mentioned ethics as important, which would be developed in the future. We then carried out some detailed analysis of the BoKs that included ethics, to ascertain if they could be usefully further categorised. We examined them to see where and how exactly ethics was discussed in the BoK. The results show the following key findings:

4.1.1 Findings related to ethics within structure of BoK

- Ethics is most commonly a knowledge unit (18/23)
- Ethics in over half of BoKs is included as part of introduction/purpose/overview (12/23)
- Ethics is rarely the heading of a general knowledge area (4/23)

4.1.2 Findings related to ethics within definitions and concepts of the BoK

- Ethics is rarely explicitly linked to leadership (2/23)
- Ethics is sometimes included in definition of professionalism (5/23)

4.1.3 Findings related to link of ethics in BoK to other professional resources or processes

- Ethics included in the definition of professionalism tends to make it part of the certification process (3/5)
- The 2 that include professionalism but do not certify ethics have no certification process at all

Table 1: Overview of BoKs and ethics (*"n/a": item not applicable i.e. non-existent. **"?": no data could be found)

BoK Title	Ethics included in BoK?	Ethics as KA/KU/KI in BoK?	Ethics in other parts of BOK?	How is ethics included in other parts?	Ethics related sources in references	BoK linked to certification?	Ethics part of certification?	Separate code of ethics/ conduct?	Code of ethics mentioned in BoK?
GENERAL BOKs									
Core Body of Knowledge for ICT Professionals - ACS, 2015	✓	✓	✓	In definition ICT profession	n/a	✓	✓	✓	✓
Common BoK for Computing and ICT - CIPS, 2012	✓	✓	✓	In vision of BoK, in definition ICT professional	✓	✓	✓	✓	✓
Digital Practitioner BOKs - TOG, 2019	✓	✓	×	n/a	n/a	×	×	×	n/a
The European Foundational ICT BoK - EC, 2015	✓	✓	✓	In definition ICT professional	n/a	×	×	×	n/a
Domain description bachelor of ICT - HBO-I, 2019	✓	✓	×	n/a	n/a	×	×	×	n/a
Computer Science BoK - ACM/IEEE, 2013	✓	✓	✓	Work ethic critical; part of curriculum. Professional responsibilities	✓	✓	✓	✓	✓
SPECIALISED BOKs									
Business Analysis BoK v3 - IIBA, 2015	✓	×	✓	As behavioural characteristic in competences: short description	n/a	✓	×	✓	×
Business Process Management Common BoK 3.0 - ABPMP, 2013	✓	×	✓	Code of ethics: practical description of responsibilities	n/a	✓	?*	✓	✓
Cyber Security BoK 2.0 - NCSC, 2017	✓	✓	✓	ethical responsibilities', ethical hackers	✓	×	×	×	n/a
EDSF Data Science BoK v2 - IABAC, 2019	✓	✓	×	n/a	×	✓	✓	×	n/a
Enterprise Architecture BoK - EABOK Consortium, 2014	×	×	×	(Code of ethics important in future)	×	×	×	×	n/a
Enterprise Information Technology BoK - IEEE/ACM IT, 2017	✓	✓	×	n/a	×	×	×	×	n/a
IT Architecture BoK 2.0 - IASA, 2019	✓	✓	×	n/a	×	✓	?	✓	✓
IT Security Essential BoK - U.S. Dept.Homeland Security, 2007	✓	✓	×	n/a	n/a	×	×	×	n/a
Open Service Management Foundation BoK - OSM Alliance, 2017	✓	✓	×	n/a	n/a	×	×	×	n/a
Project Management Professional BoK 6 - PMI, 2017	✓	✓	✓	Term used in factors. Being ethical as quality of a leader.	✓	✓	✓	✓	✓
Quality BoK - ASQ, 2009	✓	✓	×	n/a	n/a	✓	?	✓	×
Scrum BoK 3.0 - SCRUM study, 2016	✓	✓	×	n/a	n/a	✓	?	×	n/a
Software Engineering BoK - IEEE, 2014	✓	✓	×	n/a	✓	✓	?	✓	✓
Systems Engineering BoK - IEEE, 2018	✓	✓	✓	Term mentioned in knowledge areas	✓	×	×	✓	✓

BoK Title	Ethics included in BoK?	Ethics as KA/KU/KI in BoK?	Ethics in other parts of BOK?	How is ethics included in other parts?	Ethics related sources in references	BoK linked to certification?	Ethics part of certification?	Separate code of ethics/ conduct?	Code of ethics mentioned in BoK?
The Information Management BoK - Blytheway, 2014	✓	×	✓	Ethical principles as part of case example	n/a	×	×	×	n/a
Usability BoK - UXPA, 2012	✓	×	✓	Terms 'ethical considerations' and 'ethical issues' used	n/a	✓	?	✓	×
Wireless Engineering BoK 2 - IEEE, 2012	✓	✓	×	n/a	×	×	×	✓	✓
Total (out of 23 BoKs)	22	18	11		5	11	4	11	8

We found two main approaches to including ethics in ICT BoKs, which are combined in some cases. The first approach includes ethics within the structure of the BoK as a general Knowledge Area (KA). Including ethics as a Knowledge Area brings it up a level of abstraction, strengthening its position and increasing visibility and coverage, though this approach is rare. More commonly, ethics is covered as a specific Knowledge Unit (KU) or Item (KI). This approach positions ethics as an essential piece of knowledge within the BoK, but it remains subordinate to the knowledge structure rather than being an overall or generally applicable concept. In most cases, where ethics was addressed within a KI or KU, the term is just mentioned without any further explanation or discussion. As a second option, ethics may be included as part of the introduction, mission, or purpose of the BoK. Here, ethics is presented as a general context but may not be intrinsically incorporated into the core of the BoK. Rarely, is ethics both discussed in the mission and identified as a core and common required knowledge area.

4.2 Analysis of selected BoKs

Three BoKs were selected for more detailed analysis. They were chosen because they had a high level of BoK maturity and linked closely to related ethical and professional documentation in their field such as certification and codes of ethics. All three were general ICT BoKs, rather than specialism-focused, so were more likely to offer broader insights for other professions. The three BoKs that were selected are as follows:

Core Body of Knowledge for ICT Professionals – Australian Computer Society (ACS), 2015
Common BoK for Computing and ICT – Canada's Association of Information Technology Professionals (CIPS), 2012
Computer Science BoK – Association for Computing Machinery (ACM)/Institute of Electrical and Electronics Engineers (IEEE), 2013

We were interested to see if the approach in these BoKs to describing or codifying knowledge about ethics could provide useful insights for BoKs and related professions that wish to improve ethical standards and develop professional maturity. In particular, we were seeking any evidence of the use of ethical theories in how ethics and knowledge about ethics were discussed in these BoKs. We present our findings under key themes or characteristics that emerged from these selected BoKs and review to find whether we can establish a connection between the BoKs and one or more theoretical ethical approaches.

Table 2: Overview of BoK ethical themes and theoretical approaches to ethics

	Virtue	Deontological	Consequential
ICT professionalism & societal aspiration	✓		
Ethical theories in teaching	✓		
Diversity and inclusion	✓	✓	✓
Limits of knowledge		✓	✓
Responsibility & consequence			✓

	Virtue	Deontological	Consequential
Power & inferred trust	✓		
Compliance		✓	

4.2.1 ICT professionalism and societal aspiration

The selected BoKs make strong aspirational claims about ICT and computing as a profession, its potential to dramatically affect society for good or ill, and the resultant responsibility of the ICT professional. This is stronger in the ACM/IEEE BoKs but the CIPS BOK makes explicit reference to the CIPS vision document 'CIPS in the 21st century'. This suggests an appeal to virtue ethics as it encourages intrinsic ethical values and a sense or personal ethical responsibility. It is also informative as it explains the enormous social and ethical implications of ICT and corrects immediately any view that ICT is merely a technical subject and profession. It is reasonable to conclude that in the more mature BoKs, the nature of the profession is explicitly extended beyond the technical and a conscious effort is made to instil a sense of responsibility and pride.

4.2.2 Ethical theories in teaching

The ACM/IEEE and the ACS discuss the nature of ethical theories and include them in guidance on what should be taught to students. The stated goals are to equip students with a deep understanding of ethics and to learn to apply theories and models in different situations. A key insight is that theories of ethics should be included but they must be integrated and related to specific problems or technologies and grounded in a discussion on what shared values will inform them. The ACS BoK states that this kind of ethical knowledge will take time for a professional to develop as they gain experience. Thus it is both abstract and grounded in practice. The CIPS BoK includes ethical theories in its 'Professionalism and Ethics in Computing and IT' Knowledge Area and states that professionals should be able to deal with and manage ethical dilemmas. This Knowledge Area is also labelled Knowledge Area A and is the first one described in the BoK, which may possibly indicate primacy though this is not stated. The CIPs BOK categorises its knowledge into three levels and ethics is required at the highest level of understanding (application). The CIPS BoK also has an extensive ethics section in their reference list. Not all of the ethics references link directly to ICT, suggesting that a broader theoretical understanding of ethics is encouraged. None of the selected BoKs explicitly favours one or other ethical approach, nor select one as most appropriate to ICT.

4.2.3 Diversity and inclusion

This is covered both in the sense that it is an ethical obligation to be aware of and respect diversity in race, gender, disability, etc. and also in acknowledging important cultural or national differences to professional ethics. Local adaptation of general values is generally seen as preferable to a full-scale acceptance of moral cultural relativism. Diversity of cultures and potential conflict is also covered, with guidance provided on approaching this through related professional documentation. Ethics is not just seen as an individual decision on particular work place issues but in most cases is linked to wider social and environmental concerns such as diversity, inclusion, and sustainability. The ethical approach taken in these sections of the BoKs is generally more pragmatic or consequentialist, with some appeal to virtue ethics. In many cases, of course, the equality and diversity issues are legally enforced so they are rule led or deontological but this has not been set by the ICT profession. Within ICT BoKs these values are portrayed as a given that one must respect and follow.

4.2.4 Limits of knowledge

A theme perhaps of most pertinence and interest to KM is that the very action of being clear on the content and boundaries of one's professional knowledge is identified in itself as a sign of ethical maturity. If ICT professionals are clear on their knowledge area and professional responsibility, they have an obligation not to act outside of this area and to honestly report if they are asked to operate outside of them. Professionalism is all about the limits of knowledge and the public acknowledgement of expertise held by the professional. The honest and explicit line between knowledge and ignorance is key. Failure to stay within one's areas of expertise can both be illegal and have terrible consequences, though this is not explicitly spelled out in its coverage within the BoKs. Concern for the limits of knowledge has strong philosophical foundations. The Socratic tradition emphasises very strongly the importance of humility and honest acknowledgement of ignorance (Plato, 399AD).

4.2.5 Responsibility and consequences

ICT is acknowledged in all the selected BoKs as having a major impact on society and that many safety critical systems and infrastructures depend upon it. In the CIPs BoK, there is a specific Knowledge Item on Safety Critical Systems, which includes Public Safety as a component. Risk and safety are addressed in all three selected BoKs.

The discussion around these encompasses all theoretical approaches to ethics. An ICT professional has an ethical responsibility (virtue ethics), the consequences of error are potentially catastrophic (consequentialism), and there are also legal implications and rules (deontological ethics) surrounding these high-risk areas.

4.2.6 Power and inferred trust

There is strong theme in the BoKs that power gained by expert knowledge must not be abused. This is perhaps particularly urgent in ICT as it is often invisible power that the public are not aware of. The technology is also beyond what most in the general population can understand. This is usually addressed in the introduction section to operate as reminder of why it is important to be clear on knowledge.

4.2.7 Compliance

Knowledge of the relevant codes of ethics, legal obligations, and organisational procedures that help enforce ethics, such as whistle blowing, are also part of the knowledge content of these BoKs. This is in one sense a deontological approach and also makes clear that professional ethics is not the activity of a 'lone hero' but should be enabled by good management practices and effective legal sanctions within wider society. Thus is it included a specific knowledge item and, naturally, its inclusion depends upon reasonable professional maturity in terms of the existence of a code of ethics.

5. Discussion

This research provides some analysis and discussion on the relationship between knowledge, ethics and professionalism through the study of ethics within ICT Bodies of Knowledge. It has shown how BoKs are both implicit and explicit in their approach to KM and that they have the capacity to integrate ethical aspiration, professional mission, and detailed technical knowledge. A particular area of current concern regarding ICT ethics is transparency in the growing field of Artificial Intelligence. This study provides a perspective that can help ground some of the current 'moral panic' regarding such ethical issues in the ICT domain. It demonstrates that one approach to tame this fear is to carefully articulate knowledge and directly relate it to professional identity and practice. The careful connection between the clarification of knowledge limits and ethics in these BoKs offers some insights into why there is so much public concern around AI, as with AI those limits are very difficult to define transparently.

It is clear from the analysis of the more mature BoKs that theoretical approaches to ethics are not explicitly called out as a justification for specific types of ethical knowledge but that all the major ethical theories are implicitly incorporated. The more mature BoKs require that ethical theories are part of the core knowledge of ICT professionals and this is generally explicitly linked to specific actual issues that will arise in practice. The stated aim is to equip ICT professionals with the theoretical tools and understanding so they can successfully identify assess and manage ethical issues in the workplace. This can be understood as a method to facilitate the integration of theoretical knowledge with personal values and professional practice.

This issue of integration and connection between theoretical knowledge and practice is echoed or reflected in the role that ethics appears to take in the maturity of the ICT profession. The highly developed BoKs we surveyed, which contained a well-considered and integrated discussion of ethics, also had the strongest connections to other various aspects of professional practice and knowledge such as accreditation. At the higher end of maturity, BoKS that include ethics in both their definition of professionalism and their certification and educational resources have more effective ways of sharing knowledge about ethics within their field. How a profession deals with knowledge and how it integrates this into its other structures is a sign of professional maturity.

6. Conclusions and future work

This section will examine two main conclusions of this work, firstly in terms of KM and secondly in terms of its implications for other professions apart from ICT. The first conclusion is what this work can mean for the development of KM as a discipline. As discussed in our literature review, we did not find any KM literature on the development or use of BoKs. BoKs are a fascinating combination of explicit knowledge that refers to implicit knowledge. They also have a complex purpose of sharing knowledge and linking to other knowledge processes such as education. Our work has shown how knowledge within BoKs contains ethical knowledge at both an abstract and more concrete level. BoKs are essentially a starting point for 'putting knowledge to action' and warrant further study as both a method and approach. Higher quality BoKs and a more widespread understanding of their role may help mitigate growing concerns about professional values and ethics in businesses and wider society.

Secondly, the insights that have been provided on the relationship between professional ethics and BoKs can also help inform other professions and new emerging ICT specialities. It demonstrates that ethics and expert knowledge cannot be seen as separate areas. The most benefit is gained when a profession carefully articulates the nature of ethics as knowledge and ensures coordination between different types of professional documentation and practices. It also shows that it is not surprising if the development of BoKs and professional ethics can cause conflict and disagreement. This will not be straightforward as professional knowledge is often disputed, and issues of power and identity will surface. As BoKs are often the first stage of professional maturity for new professions, it also shows that the considered inclusion of ethics into a BoK makes a solid ground for ethics in other professional processes such as education. Finally, the underlying assumption around most research and policy work on ICT professionalism is that it is playing 'catch up' with the more established professions such as Medicine and Law, which are highly regulated and have serious sanctions for professional misconduct. It might, however, be useful to critically engage with how these professions actually articulate knowledge about ethics in their BoKs and associated processes and see if the newer emerging profession of ICT may be able to inform or provide new insights into more established professions.

In terms of future work on the specific topic of ethics and professional knowledge within ICT, a more detailed analysis of how other professional documentation and resources consider ethics would be a useful next step. How exactly is ethics covered in ICT codes of ethics and other resources and processes such as accreditation guidance and curriculum development? In terms of the wider societal impact of ICT, a study of how ICT ethics is discussed in policy documents or relevant legal decisions would also increase our understanding of how knowledge about what is 'good' can actually be implemented in practice.

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A Review of Literature on Human Behaviour and Artificial Intelligence: Contributions Towards Knowledge Management

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Abstract: The main purpose of this research paper is to understand how artificial intelligence and machine learning applied to human behaviour has been treated, both theoretically and empirically, over the last twenty years, regarding predictive analytics and human organizational behaviour analysis. To achieve this goal, the authors performed a systematic literature review, as proposed by Tranfield, Denyer and Smart (2003), on selected databases and followed the PRISMA framework (Preferred Reporting Items for Systematic reviews and Meta-Analyses). The method is particularly suited for assessing emerging trends within multiple disciplines and therefore deemed the most suitable method for the purposes of this paper, which intends to survey and select papers according to their contribute towards theory building. By mapping what is known, this review will lay the groundwork, providing a timely insight into the current state of research on human organisational behaviour and its applications. A total of 17795 papers resulted from the application of the search equations. The papers' abstracts were screened according to the inclusion / exclusion criterions which resulted in 199 papers for analysis. The authors have analysed the papers through VOSviewer software and R programming statistical computing software. This review showed that 60% of the research undertaken in the field has been done in the last three and a half years and there is no prominent author or academic journal, showing the emergence and the novelty of this research. The other key finds of the research relate to the evolution of the concept, from data-driven (hard) towards emotions-driven (soft) organisations.

Keywords: Human Behaviour, Big Data, Artificial Intelligence, Knowledge Management and Creation

1. Introduction

Understanding human behaviour has been crucial for businesses, for as long as businesses exist. How to unveil people behaviour regarding motivation, engagement, and loyalty towards a company? How to gain deeper insights into your customers wants and desires? Creating useful knowledge for businesses to act upon and build strategies is no longer a mirage if you consider how much technology has helped us in the last twenty years.

To shed some light into this body of knowledge, the authors undertook a systematic literature review focusing published academic research, which addressed the understanding of human behaviour through artificial intelligence, machine learning and the application of neurosciences tools.

The first moment in history where machines were viewed as having intelligence was when in 1950, Turing[1] published his seminal article "Computing Machinery and Intelligence" where he described how to create intelligent machines, in particular, how to test their intelligence. This Turing Test is still considered today as a benchmark to identify intelligence of an artificial system (when a human interacts with another human and a machine and we are unable to distinguish the machine from the human). Today artificial neural networks and deep learning form the basis of most applications we know, they are the basis of image recognition algorithms used by Facebook, speech recognition algorithms that fuel smart speakers and self-driving cars (Haenlein & Kaplan, 2019).

We are surrounded by data, which is useless, unless it can be transformed into information, which then must be transformed into knowledge. Big data is in fact a big buzzword in recent years. Nevertheless, as described in a recent editorial from the Academy of Management Journal written by Simsek and colleagues (2019) there still is a great deal of ambiguity and even confusion on what Big Data is and what it means for organizational and management researchers.

Taming big data an artificial intelligence through machine learning can be the key to address many management issues, such as, how to identify real talent within and for your organization, knowing when your best employee is about to quit, predict consumer preferences and address unique consumer differences, amongst many others.

[1] Alan Turing, "Computing Machinery and Intelligence," Mind, LIX/236 (1950): 433-460

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According to Hoeschl and Barcellos (2006, p. 12) "the possibility of translating human intelligence to plastic artificial base has a clear limit: If intelligence can be generated from these elements, it must be necessarily different from human one, because results happen from different human elements." Also, to materialize knowledge (to safeguard it) one must find a way to manipulate, store and transmit it within the organisation. These authors name this as the biggest challenge of AI intelligent solutions over of the last decades.

In the original science fiction film *Blade Runner*, directed by Ridley Scott in 1982, and later in its sequel *Blade Runner 2049*, an interesting philosophical dilemma is put forwarded: are robots able to feel emotions? And if so, what makes us humans? The film set in a dystopian future, creates an interesting conundrum since humans develop machines that replicate humans but give them a date of expiration (they have a four-year life span) to enslave them to perform tasks humans do not want to do. The dilemma of "humanity" reaches its peak at the end monologue, performed by the character Roy Batty, entitled "tears on the rain"[2]. At this moment, the machine / human saves the life of its human prosecutor while sheds "invisible" tears on the rain, while his lifespan is ending. These replicants were created as adults but memories of growing up were implanted in their brains. These memories allowed them to feel empathy towards humans and develop emotions.

Where do we establish the limits? The knowledge that can be generated through AI and machine learning and the possibilities that it creates to generate more knowledge is a huge challenge for organisations and societies. Across different scientific areas researchers are on the verge of taming the challenges of the usage of AI for better performances. For businesses AI represents productivity, efficiency, but also new ways to do things to innovate and break barriers. Knowledge that creates knowledge in a Fibonacci spiral[3].

Inspired by these thoughts the authors raise the following questions: *how artificial intelligence, machine learning, big data and neurosciences, applied to human behaviour, have been treated, both theoretically and empirically, over the last twenty years, regarding creating knowledge through predictive analytics and human organizational behaviour*? How this field of research has been applied to create, retain, and develop knowledge within organisations?

2. Research Methodology

The aim of this research is to present the evolution of studies regarding human behaviour within organisations and highlight the relevance of new research intending to inspire research ideas by recognizing gaps or inconsistencies (Cronin, 2008) and/or creating theoretical frameworks (Coughlan, 2007). For this study, the authors followed the proposed methodology and process for conducting systematic literature reviews by Tranfield, Denyer, and Smart (2003). For verifying each step of the process the PRISMA guidelines were also adopted. This is a well-establish method aimed at systematizing knowledge in an orderly and consistent way, increasing its efficiency and effectiveness pro the generated output. PRISMA allows to systematize information verification practices, justifying all inputs and outputs, that is, papers included and excluded. This is a six steps method including, definition of research question and inclusion/exclusion criteria; collecting and selection of the studies; extracting and presenting the most relevant information and data; analysing and synthesizing information (Moher *et al*, 2009).

The database chosen for collecting data was B-On (the online knowledge library) since allows access to full texts from over 16,750 scientific international publications from 16 publishers, including the web of knowledge (Wok). To apply the search equations (combination between keywords), the following limitations within B-On were used: a) disciplines: economics; business and management, marketing; and sociology; b) restricted to access to full text; c) timespan: from 2000 until 2020 (current date); d) only peer reviewed journals.

The search equations were applied, and the researchers conducted an initial rigorous screening based on the article tittle, keywords and abstract. To be included on the database papers had to address human behaviour within organizations and to address how this behaviour was studied or understood through predictive analytics, neurosciences, big data, artificial intelligence, or machine learning.
Search equations, initial results and final selection numbers can be seen in the following table.

[2] Film's original monologue: *"I've seen things you people wouldn't believe. Attack ships on fire off the shoulder of Orion. I watched C-beams glitter in the dark near the Tannhäuser Gate. All those moments will be lost in time, like tears in rain. Time to die."*

[3] In mathematics, the Fibonacci numbers, commonly denoted F_n, form a sequence, called the Fibonacci sequence, such that each number is the sum of the two preceding ones, starting from 0 and 1. This is commonly known as the golden number.

Table 1: Search equations

Search Equation	***Results***	***Selection***
Artificial Intelligence *and* Machine Learning	2817	6
Artificial Intelligence *and* Human behavior	298	13
Artificial Intelligence *and* Human behaviour	361	9
Artificial Intelligence *and* Human profiling	2	2
Artificial Intelligence *and* Predictive Analytics	225	6
Artificial Intelligence *and* Big Data	394	5
Artificial Intelligence *and* Neurosciences	90	5
Artificial Intelligence *and* Knowledge Management	724	5
Artificial Intelligence *and* Knowledge Creation	46	5
Artificial Intelligence *and* Gaming	32	5
Machine Learning *and* Human behavior	298	6
Machine Learning *and* Human behaviour	339	3
Machine Learning *and* Human profiling	10	1
Machine Learning *and* Predictive Analytics	117	5
Machine Learning *and* Big Data	810	5
Machine Learning *and* Neurosciences	117	7
Machine Learning *and* Knowledge Management	821	5
Machine Learning *and* Knowledge Creation	42	3
Machine Learning *and* Gaming	28	5
Human behavior *and* Human profiling	132	5
Human behaviour *and* Human profiling	138	3
Human behavior *and* Predictive Analytics	23	3
Human behaviour *and* Predictive Analytics	23	3
Human behavior *and* Big Data	177	3
Human behaviour *and* Big Data	177	3
Human behavior *and* Neurosciences	673	2
Human behaviour *and* Neurosciences	673	3
Human behavior *and* Knowledge Management	1791	3
Human behaviour *and* Knowledge Management	1767	3
Human behavior *and* Knowledge Creation	115	3
Human behaviour *and* Knowledge Creation	114	3
Human behavior *and* Gaming	246	3
Human behaviour *and* Gaming	246	2
Human profiling *and* Predictive Analytics	0	0
Human profiling *and* Big Data	5	5
Human profiling *and* Neurosciences	6	4
Human profiling *and* Knowledge Management	15	5
Human profiling *and* Knowledge Creation	1	0
Human profiling *and* Gaming	1	1
Predictive Analytics *and* Big Data	180	5
Predictive Analytics *and* Neurosciences	2	2
Predictive Analytics *and* Knowledge Management	48	5
Predictive Analytics *and* Knowledge Creation	2	1
Predictive Analytics *and* Gaming	1	1
Big Data *and* Neurosciences	18	4

Search Equation	***Results***	***Selection***
Big Data *and* Knowledge Management	596	5
Big Data *and* Knowledge Creation	29	5
Big Data *and* Gaming	16	2
Neurosciences *and* Knowledge Management	84	4
Neurosciences *and* Knowledge Creation	5	2
Neurosciences *and* Gaming	41	3
Knowledge Management *and* Knowledge Creation	2858	4
Knowledge Creation *and* Gaming	21	3
Totals	17795	204

After elimination of duplicates a total of 199 articles were included in our analysis. The authors opted to keep the search equations quite open, since if they narrowed them down, for example: Neurosciences *and* Knowledge Creation *and* Machine Learning results would be zero. Instead, we have considered it useful to have broader search equations, such as: knowledge management *and* knowledge creation (n=2858) and then screening the abstracts for relevance. Also, the noun "behaviour" was spelled in the American and British forms to encompass all possible results.

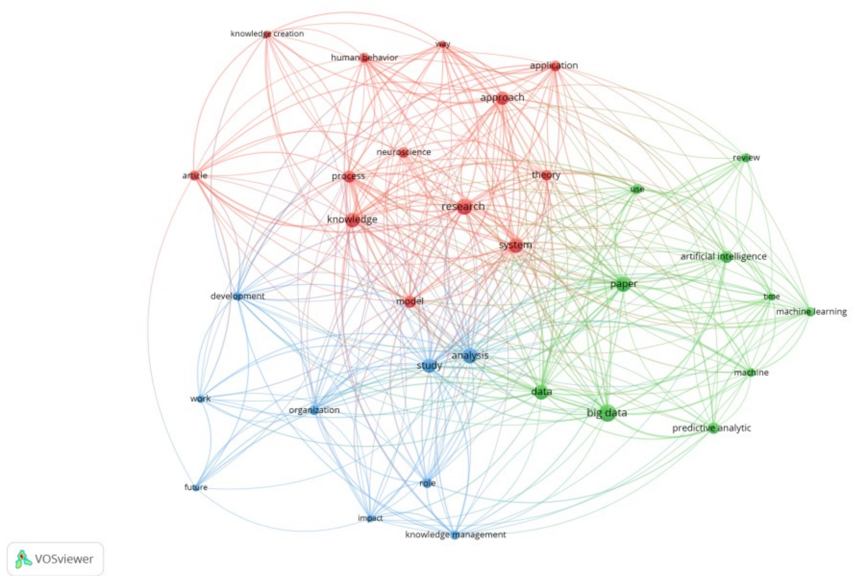
The next steps were to conduct descriptive statistics (using VOSviewer and R programming) and content analysis that will be described in the next section.

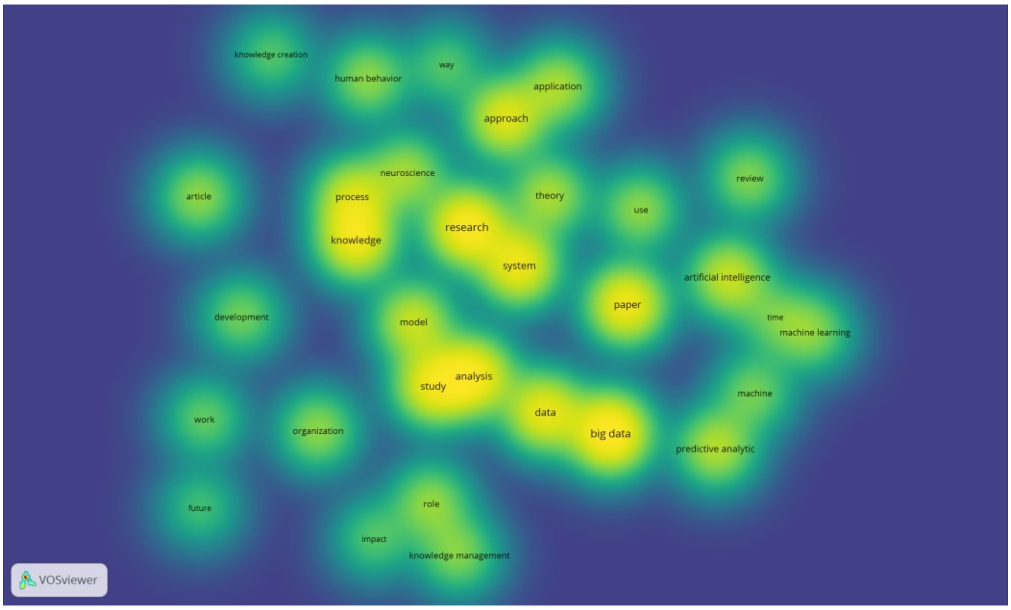
3. Research Findings

An analysis of the database showed that 60% of work published by researchers happened after 2016. Between the year 2000 and 2015 the average publication regarding these topics were 5,25 papers a year, while between 2017 and 2019 the average was 30 papers a year. This demonstrates an increasing interest on the topic, around 30 papers a year, nevertheless this amount still represents a very short number of articles on a specific subject.

3.1 Cluster Analysis using VOSviewer and R Programming

The VOSviewer software is a tool for constructing and visualizing bibliometric networks and R is a language and environment for statistical computing and graphics. The authors have analyzed the outputs from the filtered search equations (199 articles) and results are presented in the following figures (network and density graphs).





Figures 1 and 2: VOSviewer Network and Density Graph

To produce an analysis of the network graph, the authors did not considered words such as paper, article and research, which were mentioned several times due to the nature of the sources (and could not be eliminated from the software). Looking at the network graph, one can see the existence of 3 main clusters that can be identified by the intensity of relationships and size of the density (showed in yellow) characterized by the words analysis, knowledge, and big data. One might deduce that the Big Data cluster reflects the great scientific production around this theme, with direct relationships with artificial intelligence, machine learning and predictive analytics. In the *analysis cluster*, there is a strong relationship index with concepts such as, organization, role and knowledge management, driving the future. The *knowledge cluster* has a strong association with neurosciences studies, human behaviour and knowledge creation. The VOSviewer network graph also shows the opposite positioning of *knowledge creation* and *knowledge management*, where *knowledge management* is closely associated with big data and, on the other hand, *knowledge creation* is closely associated with *knowledge* and *human behavior*, positioned relatively far from the topic of *big data*.

An annual scientific production chart was also produced (using R programming).

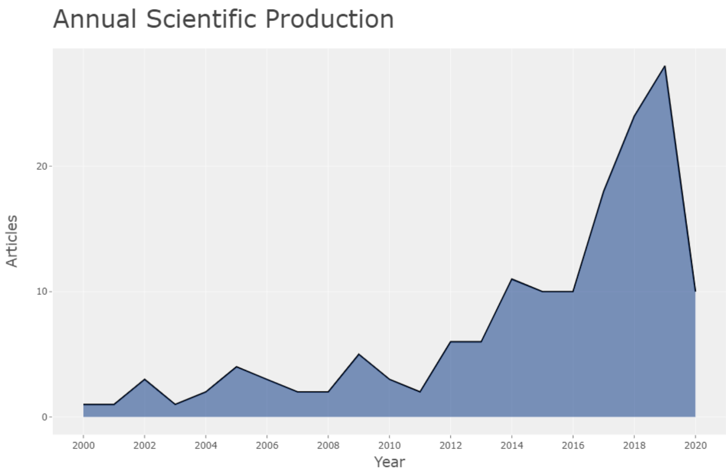


Figure 3: Annual Scientific Production Chart

According to the Annual Scientific Production Growth Chart, we can detect a steady but slow production rate until 2006, with an increment from 2016 that reaches its peak in the year 2019. The year 2020 is an enigma mainly due to the pandemic period, that started in the beginning of the year, which could cause delays in publications and that may not indicate a decrease interest on the topic.

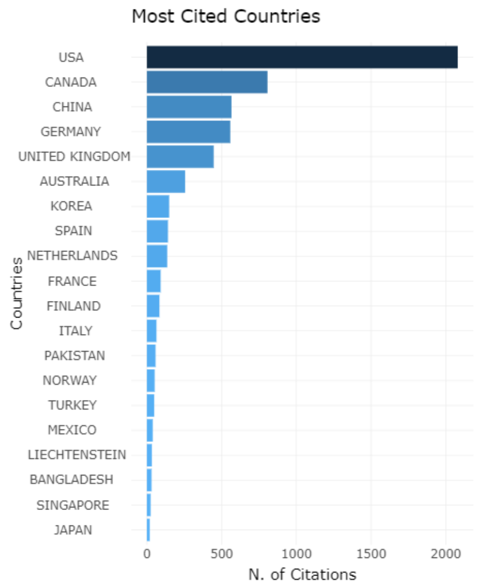


Figure 5: Most Cited Countries Chart

According to the most cited countries chart, USA is found to be the country with the largest scientific production, followed by Canada and China, whereas only two European countries appear in the top 6, Germany and the United Kingdom, respectively. To understand the differences between countries the authors analyzed the Delloite Report "Future in the balance? How countries are pursuing an AI advantage"[4] (2019). According to this report "for years, the United States has been a leader in public and private AI research. Consider the last several years of venture capital investment in the AI sector. In 2012, venture capitalists funded US$282 million in AI initiatives, and that number skyrocketed to US$5 billion by 2017. The following year, AI investments by VCs topped US$8 billion" (p. 15). Canada and China are also mentioned in this report, although Canada is appointed as having a cautious approach to the application of AI since "they confront a host of issues regarding ethical implications, enhanced cyber vulnerabilities, and questions of talent readiness" (p.10). Pertain to China its "government has declared its ambition to become the world's leading AI innovator by 2030" (p.11).

According to this survey "no matter where organizations are on their AI journeys, their approach to tackling these questions varies. Some are playing catch-up with their global rivals. Others are addressing their aims through focused projects, or by pursuing larger-scale initiatives. Some early adopters are much more focused on training and skills development than others" (p. 16). "There's clearly no one-size-fits-all approach to adopting and integrating AI. AI-fuelled transformation of businesses and industries appears to be coming rapidly, and the window for differentiation is shrinking. Much hangs in the balance—including the future competitiveness of companies and even whole countries" (p. 17).

[4] Delloite Insights Report consulted on 20th March in https://www2.deloitte.com/content/dam/Deloitte/lu/Documents/public-sector/lu-global-ai-survey.pdf

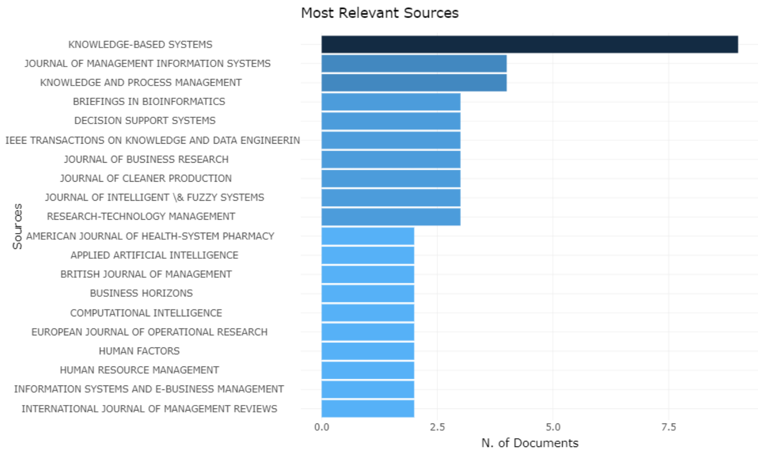


Figure 6: Most Relevant Sources Chart

According to the most relevant sources chart, we found that the Journal of Knowledge-Based Systems is the source that has the most relevant publications, with almost twice as many relevant publications as competitors, followed by the Journal of Management Information Systems and Knowledge and Process Management Journal.

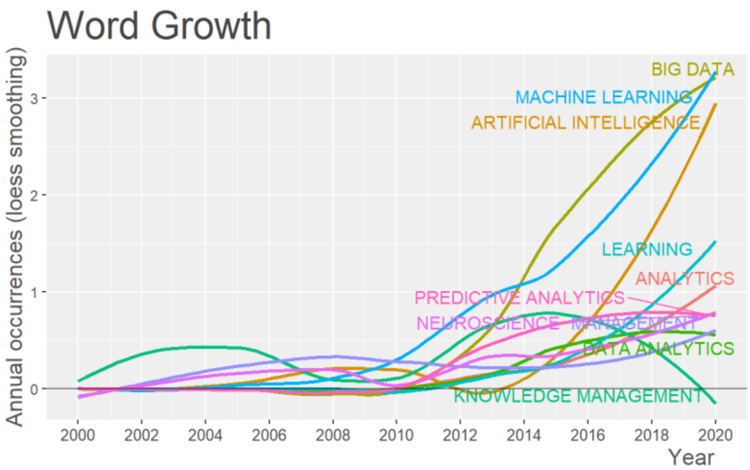


Figure 7: Word Graph

According to the graph, in the last 3 years the most searched words were Big Data, Machine Learning and Artificial Intelligence, evidencing a relevant growth since 2014. Until then all the research terms followed similar patterns. If we consider the interest AI has gained in the different countries that are adopting these techniques this could be considered quite logical. Also, “knowledge management” production rate tendency over the years did not follow the other subjects. It is interesting to observe the increase of the term “learning”. One may assume that knowledge has been replaced by the term learning.

3.2 Content Analysis

Content analysis was performed using a chronological review of the subject within specific timespans to conduct the content analysis.

3.2.1 From 2000 until 2004

Within this timespan articles focused on machine learning and artificial intelligence for fuzzy models for scheduling problems and decisions processes in manufacturing diminishing human error (Nematii, 2002; Akyol, 2004); predicting gaming behaviour (Hinnar *et al*, 2004); behavioural simulation for coaching purposes (Summers, 2004); the role of mind in human and organizational behaviour (Seni and Seni, 2000; Setterret, 2002; Wolozin, 2004); planned (Bamberg, 2003) and consumer (Morik, 2002) behaviour.

3.2.2 2005 – 2007

During this period articles focused on the emerging nature of knowledge management (Chua, 2005) and creating and sharing knowledge via the web using artificial intelligence (Cheung *et al*, 2005; Chen *et al*, 2005; Cracker and Coenen, 2006). Other papers found addressed using informatics and neurosciences to monitor behaviour (French *et al*, 2007; Monekosso and Remagnino, 2007).

3.2.3 2008 – 2010

In 2008, Michael Buttler concluded that knowledge has “plasticity”. By that he meant that different stakeholders, including scholars and practitioners, perceived differently the development and application of neuromarketing. Understanding this could be crucial for knowledge creation and diffusion.

Human decision-making process can be modelled and controlled (Moffat and Medhurst, 2009) and the future can be forecasted, as market behaviour, market dynamics, market analysis, organizational strategies for volatile new markets, and profiling products and services which do not currently exist, but which markets are ready to accept (Zenobia *et al*, 2009).

In 2010, Faber and Peters, present the idea that Knowledge can be identified as the driving force behind human behaviour and that this behaviour can be changed through, amongst others, information technology. Seni and Seni (2010) proposed that cognition, in the broad sense, was not exclusive to living organisms since, certain kinds of social organizations, such as businesses, possess elementary cognitive capabilities by virtue of their structure and their functions. Both authors propose the idea of “sociocognitivity” based on neuroscience and biopsychology applied to any organization: (1) The theory of intelligence and of intelligent systems; (2) The neurological theory of memory as distributed, hierarchical neuronal systems; (3) The theory of cognitive action in general and of learning in particular.

3.2.4 2011 – 2013

Lin and colleagues (2012) presented a study on the emotional expression and artificial intelligence in the interaction between computers and humans in order to understand users' emotions.

Giraldo *et al* (2013) showed how computer science and cognitive neuroscience could be merged to propose an effective profiling scheme by content personalization through the identification of an individual's learning behaviour. In 2013, Aztiria and colleagues studied intelligent environments (IE) where the technology adapts its behaviour to the users, even anticipating their needs, preferences, or habits. The environment learns how to react to the actions and needs of the users.

3.2.5 2014 – 2016

Buttler *et al* (2016), explore the potential links between human biology and management and organization studies. The authors defined, what they considered to be a new field as “organizational cognitive neuroscience” (OCN). In their paper they revealed three clusters of activity, covering the fields of economics, marketing and organizational behaviour (considered as an outlier), which contributed to a greater understanding of the biological mechanisms that mediate choice and decision-making.

Human behaviour understanding plays a fundamental role in several innovative application domains such as smart video surveillance, ambient intelligence and content-based video information retrieval (Acampora *et al*, 2015). These authors propose a hierarchical architecture, based on a tracking algorithm, time-delay neural networks and fuzzy inference systems, aimed at improving the performance of current human behaviour analysis systems in terms of scalability, robustness and effectiveness in behaviour detection.

Lavín *et al* (2015) studied cooperative behaviour aiming to understand the motives behind people's subscription to a specific organization and whether their motivations are consistent with traditional experimental evidence about cooperative decision-making. Their results revealed a conjunction between structural frames and individual ethical values to be critical for explaining human cooperation.

Yu-Ping *et al* (2015) combined machine-learning techniques with functional neuroimaging data to characterize the set of processes that give rise to associations between brands and personality. They have showed that brand personality traits could be captured by the weighted activity across a widely distributed set of brain regions previously implicated in reasoning, imagery, and affective processing, i.e., brand personality traits appear to exist *a priori* inside the minds of consumers.

Emotion is a cognitive process and is one of the important characteristics of human beings that makes them different from machines (Nahin *et al*, 2014). In their paper they have attempted to detect user emotions by analysing the keyboard typing patterns of the user and the type of texts (words, sentences) typed by them. To analyse data they've used several machine learning algorithms and manage to demonstrate above 80% accuracies in identifying emotions.

Smidts *et al* (2014) sketch the development of consumer neuroscience as a discipline and compare it to neuroeconomics. They also provide important insights into individual differences in decision-making and shed some light into the predicting decisions from brain activity and their reliability as measurements of consumer behaviour.

3.2.6 2017

Kraczla (2017) undertook a research on human profiling based on personality traits. The rationale assumed that personality factors constitute a fundamental indicator of development potential of a particular person, and as such, it was possible to depict his/her functioning style in a job position and hence predict professional suitability in performing a given professional role.

Michie *et al* (2017) present the Human Behaviour-Change Project (HBCP) using artificial intelligence and machine learning. The purpose of their work was to (i) develop and evaluate a 'Knowledge System' that automatically extracts, synthesizes, and interprets findings from evaluation reports to generate new insights about behaviour change and improve prediction of intervention effectiveness and (ii) allow users, such as practitioners, policy makers and researchers, to query the system easily and efficiently.

Shmueli (2017) coined the term Behavioural Big Data (BBD), meaning the very large and rich multidimensional datasets on human behaviours, actions, and interactions, which have become available to companies, governments, and researchers. In his work he describes the BBD landscape and examines opportunities and critical issues that arise when applying statistical and data mining approaches to BBD and its implications.

3.2.7 2018

According to Harteis *et al* (2018) preventing humans from committing errors is a crucial aspect of man-machine interaction and systems of computer assistance. In their work they use eye-tracking technology and automated face recognition to analyse / test persons' emotional reactions and cognitive load during a computer game and learning through trial and error. Results show a positive correlation between learning and emotions and that gaze behaviour and facial expressions inform about the errors that follow.

Chan *et al* (2018) use an approach to profiling brand image using functional magnetic resonance imaging. They compare consumers' brain responses during passive viewing of visual templates (photos depicting various social scenarios) and brain responses during active visualizing of a brand's image, and then they generate individual neural profiles of brand image that correlate with the participant's own self-report perception of those consumer brands. This neural profiling demonstrates the potential of using pattern analysis of neuroimaging data to study multisensory, nonverbal consumer knowledge and experience.

Fredriksson (2018) discuss big data in the theoretical light of organizational knowledge creation and decision-making in organizations. The findings suggest that creating new information and knowledge out of big data, and its use as support for decision-making in organizations, would enhance the quality and increase trustworthiness in decision-making. Goul (2018) addresses the importance of big data and predictive analytics on operations and manufacturing management and their utilization for capability building, and how this capability affects cost and operational performance.

Guha and Kumar (2018) study the digital footprints of consumers to understand and predict consumer behaviour (especially in the areas of cloud computing, internet of things and smart city, predictive manufacturing and 3-D printing and smart healthcare) and the associated challenges.

3.2.8 2019 - 2020

Bleidorn and Hopwood (2019) use machine learning in psychological science to predict human behaviour through personality traits. Machine learning approaches to personality assessment have focused on the associations between social media and other digital records with established personality measures. This research aims to expand the potential of machine learning approaches to personality assessment by embedding it in a more comprehensive construct validation framework.

Constantin *et al* (2019) build a model to train and validate an artificial neural network to forecast the following year's value of economic sentiment using values of several economic indicators. Research on predicting European Economic Sentiment Indicator (ESI) using artificial neural networks is a starting point, with work on this subject almost inexistent, the reason being mainly that ESI is a composite of five sectorial confidence indicators and is not thought to be an emotional response to the interaction of the entrepreneurial population with different economic indicators.

Canhoto and Clear (2020) point out that artificial intelligence (AI) and machine learning (ML) may save money and improve the efficiency of business processes, but these technologies can also destroy business value, sometimes with grave consequences. They propose a new framework by which to map the components of an AI solution and to identify and manage the value-destruction potential of AI and ML for businesses.

Knox *et al* (2020) examine visions of 'learning' across humans and machines in a near-future of intensive data analytics. Building upon the concept of 'learnification', practices of 'learning' in emerging big data-driven environments are discussed in two significant ways: the *training* of machines, and the *nudging* of human decisions through digital choice architectures.

Steinberg (2020) introduce the possibility that, in the future, firms will be able to use big-data analysis to discover and offer consumers their individual reservation price (i.e., the highest price each consumer would be willing to pay, given their preferences and available income). This can generate some interesting benefits, such as a better situation in terms of equality of both welfare and resources, as well as increased social welfare. However, these benefits are countered by considerations of relational equality. This article takes up the market-failures approach as its basis to demonstrate what is wrong with using big data to personalize prices.

4. Discussion and Further Studies

From the systematic literature review undertaken and the bibliometric analysis done using VOSviewer and R programming, four emergent research areas were identified, namely, the use of big data for business efficiency, artificial swarm intelligence (through knowledge management and decision-making), personalized engagement marketing (customer/people connection) and the feeling economy (communicating with and for people), that are linked with the key issues of this paper.

Going back to the VOSviewer graph if we apply and x axis (current state of research) and y axis (from past to future solutions) it seems that we are moving from an information era, regarding the usage of Big Data, AI and machine learning (hard issues) towards an era of the understanding of human behaviour and knowledge creation (soft issues).

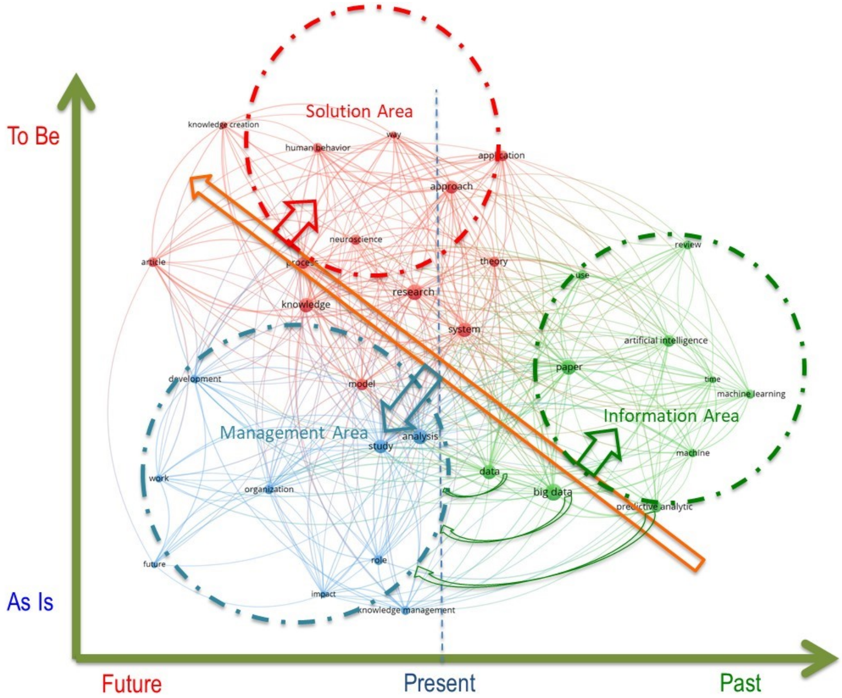


Figure 8: From Information to Management towards Knowledge Creation

Kumar, Yogesh and Dwivedib (2020) point out some interesting research questions addressing this field of research, amongst them, are some we consider relevant for understanding the challenges this field of research pose, namely:

- How can big data-driven research be used to explain digital service or technology adoption, usage, and impact behaviour?
- How can user engagement or disengagement can be measured and explained based on big data analytics?
- How can we develop typology of users or organizations based on user generated content in forums, social media and platforms?
- How can we explain relationships between organizations and other stakeholders (organizations, individuals, customers, suppliers, government, etc.) based on online content in platforms and e-markets and their impacts on engagement or disengagement?
- How can we model adverse impacts of disruptive technologies like artificial intelligence, blockchain, internet of things based on usage behaviour or user generated content?
- How can theories be developed to explain grand socio-political problems and challenges of like pandemic management, sustainable development goals, political harmony, etc.?

The journey over the past 20 years of research demonstrated that we have started on managing data, moving forward to having information that was transformed into intelligence. Intelligence can then be transformed into knowledge. But managing knowledge is no longer sufficient, since now we possess technologies that allow us to create knowledge from knowledge, so we are moving towards a fuzzier understanding of the human behaviour. In summary we are moving from data-driven organizations towards the feeling economy (from *hard* issues such as analytics towards *soft* issues such as people).

4.1 Organizational Efficiency (data-driven)

Artificial intelligence helps the predictive ability of organizations (Davenport *et al,* 2020). AI has recently become popular because it provides a cheap way to make predictions about complex problems based on examples in historical data that a company might already have. This is possible through machine learning (ML). ML is a key issue of this paper, as is defined as “a set of methods that can automatically detect patterns in data, and then use the uncovered patterns to predict future data, or to perform other kinds of decision making under uncertainty” (Murphy, 2012).

4.2 Artificial Swarm Intelligence (ASI)

Schools of fish, flocks of birds and ants' colonies demonstrate collective intelligence, since they are capable of making decisions that go beyond the knowledge of individuals in the group (Sulis, 1997). According to Sulis, individuals within the group base their decisions on self-organized local interactions with group members. Mimicking nature for understanding organizations is not new. The emergent decision-making process found in honeybee swarms provides a powerful analogue for how human brains make complex decisions and allowed ASI to enable groups of networked humans to function as a unified intelligence (Rosenberg, L., 2016). This field of research can be found at the top quadrant of Figure 8. "ASI draws from the methods of achieving collective intelligence found in biological swarms to enable human groups to form a single emergent intelligence" (Metcalf *et al*, 2019, pp. 85).

4.3 Personalized Engagement Marketing

Personalization is often presented and studied alongside customization, as they are related concepts, although differing in application (Kumar, *et al*; 2019). Personalization derives from the business strategy (based on data collection from individual preferences) whereas customization originates from the customers preferences (for example you can customize a car, choosing the colour and specific features). According to Kumar and colleagues (2019, p. 151) "firms are able to leverage individual customer information and AI technology to provide curated products and services. The AI technology can facilitate real-time learning and help managers improve customer value proposition over time. Such a strategy of curated products that provide increasing value to customers will form the basis of customer retention and sustainable competitive advantage". The step forward will be using the knowledge gained through AI to trace profiles of human behaviour and predicting more precise preferences.

4.4 The Feeling (Emotions) Economy

"The Feeling Economy is an economy in which the total employment and wages attributable to feeling tasks exceed the total employment and wages attributable to thinking or mechanical tasks" (Huang *et al,* 2019, pp. 44-45). According to these authors in the emerging of the *Feeling Economy*, the interpersonal, empathetic, feeling tasks of a job, such as communicating with people inside and outside the organization, establishing and maintaining interpersonal relationships, and selling to or influencing others, tend to be more important than thinking tasks and mechanical tasks, for both employees and consumers. Huang and colleagues add that this Feeling Economy will fully overtake the Thinking Economy (jobs that require analysing data and making decisions) by the year 2036.

Main challenges derived from this are: (1) understanding the nature of future jobs and the required skills, (2) considering that humans and machines must collaborate as a "team", (3) anywhere-anytime interaction with internal and external consumers addressing their emotional needs.

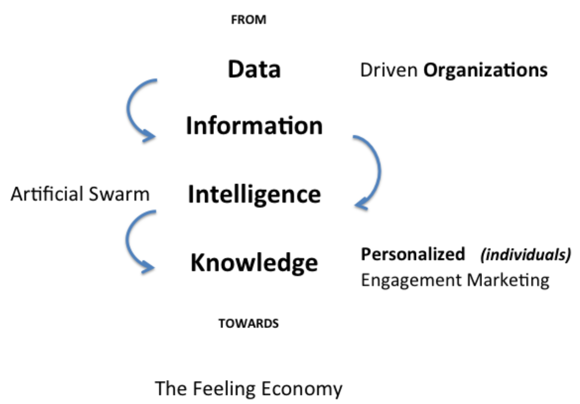


Figure 1: The Journey from Data to People

There are many challenges for researchers in this field. Deep Learning, a key technique used by most AI systems, and the study of the human brain (emotion versus reason) are inherently black boxes, making it very complicated to fully comprehend. Also, there is a fear, that, in a similar manner as the automation of manufacturing processes has resulted in the loss of blue-collar jobs, the rising use of AI will result in less need for white-collar employees and even high-qualified professional jobs, resulting in a resistance for adopting ASI. Nevertheless, researchers have demonstrated that ASI addresses the limitations associated with group decision-making, amplifying the intelligence of human groups, and facilitating better business decisions. Also, the use of AI, machine learning and neurosciences, pose unique ethical, legal, and philosophical challenges that will need to be addressed.

5. Conclusions

The research conducted by the authors included a systematic and bibliometric literature review, of the past 20 years on the study of knowledge management related to artificial intelligence, machine learning and the understanding of human behaviour through neurosciences approaches. The research showed the past, present and future of this field of research and the linkages between the different terms that were reviewed.

The paper achieved the proposed goal by mapping what is known about the key issues and "understanding how artificial intelligence and machine learning applied to human behaviour has been treated regarding predictive analytics and human organizational behaviour analysis".

The main limitation of the study lies in the information sources considered. Papers were selected from B-On and WoS databases, and as such, grey literature was not included, thus many interesting studies may be omitted.

The main conclusions of the study were that we are moving from business efficiency (data-driven organisations) towards business efficacy by using knowledge to create knowledge. Knowledge that occurs from managing information (hard issues) towards knowledge that evolves from the understanding the collective (swarm) and individual intelligence, through the application of neurosciences tools, towards knowledge creation within the feeling economy.

The human being is quite complex and makes decisions that are not always rational, often influenced by emotional or situational factors. Assuming that AI and Machine Learning are based on rational models, are these methods the best tools for predicting human behaviour? Also based on AI and ML's ability to analyse and sort a lot of information, namely in the digital relationship between people and organisations, are these the best tools to anticipate, manage and generate organizational knowledge?

Further studies should be developed in this field of research addressing the questions posed along this research article, especially empirical works focussing the journey from data to people.

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New Collaboration through Artefact-Mediated Interaction with a Joint Knowledge Base

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Abstract: Collaboration is changing and increasingly emerging as what we call "New Collaboration", a knowledge-based and community-oriented way of working together (especially digital, online collaboration). Unfortunately, organisations use only a small percentage of the potential of New Collaboration. One main reason for this is that they do not understand that New Collaboration is based on knowledge sharing and requires the individual knowledge of the collaborators to be integrated into a shared knowledge structure, a so-called Joint Knowledge Base (JKB). This concept of a Joint Knowledge Base as the tacit knowledge structure which is constructed, shared and maintained during collaboration, emerged during the course of our previous work and became more and more prominent as a key to collaboration. When a group interacts, the JKB functions as an interaction bridge, and this is why it is a key to collaboration. In this paper, we will revise and elaborate in more detail our concept of a JKB and explain its role in artefact-mediated interaction. First, we will explain the main characteristics of New Collaboration and summarise them based on a concise definition. Secondly, we will introduce the concept of a Joint Knowledge Base, explore the role of social negotiation in constructing it, define the JKB as a distributed knowledge structure, discuss the problem of obstacles which hinder its development and suggest how to solve it by means of gaining deeper insight into the complexity of the involved processes (communication, interaction). And next we will further develop this solution by introducing the concept of boundary artefacts and describing their implementation as tools for artefact-mediated interaction by means of a systematic approach. Finally, we will explain this systematic approach and show how boundary artefacts and artefact-mediated interaction work in practice during meetings performed on a commercially available collaboration platform where they contribute to the construction of a JKB.

Keywords: new collaboration, knowledge sharing, joint knowledge base, boundary objects, artefact-mediated interaction

1. Introduction

The business world in which we are living today is a world of volatility, uncertainty, complexity and ambiguity (VUCA). It is a new world which changes faster than we can learn and where business outputs "*depend on a wider and wider range of knowledge, skills, values, technologies and competences*" (Obeng 1997, pp.3-9). In order to be successful in this new world, collaboration must adapt and change. In previous work, we proposed a knowledge-based and community-oriented understanding of collaboration which we called New Collaboration and described based on three models: a system model (Bettoni et al., 2016), a presence model (Bettoni et al., 2018) and a hierarchical process model (Bettoni and Obeng, 2020) called the "Pyramid of New Collaboration". This pyramid model of collaboration requires the individual knowledge of the collaborators to be integrated into a shared knowledge structure, a so-called "Joint Knowledge Base" (JKB). For doing this it is essential to understand how the JKB enables collaboration and specifically how the JKB is constructed and maintained. This is our main research question here. A better understanding of this aspect of knowledge sharing will contribute to raising awareness of the fact that a JKB plays an essential role in collaboration and to taking this seriously.

Secondly, it will help to understand how the interwoven process between knowledge sharing and collaboration works. Last but not least, it can help to understand group learning (and group work in general) not only as a form of knowledge acquisition (cognitive process) and participation in a social community (social process) but also as collaborative knowledge creation (Paavola et al., 2004). Therefore, the aim of this article is to revise and elaborate our concept of a JKB in more detail. Our results define the main characteristics of New Collaboration, specify the role of social negotiation in constructing the Joint Knowledge Base, define it as a distributed knowledge structure, identify obstacles which hinder its development and suggest how to solve this problem by means of communication and interaction. We furthermore introduce the concept of "boundary artefacts", describe their implementation as tools for artefact-mediated interaction and show how this has been implemented on a commercially available collaboration platform. The article ends with a discussion and conclusions, including limitations and implications for further research.

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2. Literature Review

Our research is highly innovative, in fact the aforementioned main topics, i.e. "process model of collaboration", "shared knowledge structure" and "knowledge-based collaboration" are missing in the academic and business literature on collaboration and knowledge sharing. This can easily be checked by doing an internet search as well as by analysing literature review articles. A systematic literature review of state-of-the-art functionalities in knowledge sharing mechanisms provides a representative example (Navimipour & Charband, 2016). The research topics identified in this review have not changed since the beginning of knowledge sharing research in the 1990s: motivation for sharing knowledge, impact of good practice and job satisfaction, cultural influences, strength of social ties, explicit knowledge vs. tacit knowledge, trust, empowerment, leadership style, leadership behaviour, impact of IT (platforms, etc.), exchange relationships with co-workers, social interaction, sociocultural factors (like trust, shared goals, shared language and collaboration). Thus, the literature focuses mostly either on outcomes or on "external" aspects as conditions for successful outcomes. As a result, we can conclude that there is practically no literature about how knowledge sharing actually proceeds or the steps of its process. Notice moreover that collaboration is considered only to be a factor influencing knowledge sharing and never as a factor affected by it, like in the seminal work by Roschelle and Teasley (1995) which started the investigation into the role of knowledge sharing in collaborative problem solving in a fundamentally new way, which has never been followed up by other researchers.

Recent surveys show that, in order to cope successfully in the VUCA world, organisations should develop collaborative cultures, embrace collaborative practices (IDC, 2016, p.42) and invest in collaborative business models (Dufft, 2017, p.11). Unfortunately, the business and education world seem to largely ignore the fact that collaboration, in the wake of the spread of knowledge-intensive work (Smith, 2002; Bettoni, 2000), has also changed and is increasingly emerging as a new way of working and learning together which we call "New Collaboration". Surveys about the application of digital collaboration in business show that e-mail (which promotes divergent interaction) is still considered to be the most important collaboration tool (Roten et al., 2016, pp.3-4). But New Collaboration requires a completely different type of interaction: convergent interaction. Hence, considering and applying e-mail as the main collaboration tool clearly indicates that New Collaboration is still going unnoticed or at least is not well understood and not sufficiently put into practice.

Stoller-Schai, a pioneer of e-collaboration research, recently defined collaboration as "*the direct and mutually influential active confrontation of two or more people, oriented towards common goals, to solve or master a task or problem*" (Stoller-Schai, 2021). While this is very good as a generic definition, let us look more deeply at the aforementioned "task or problem". In the VUCA world, more and more groups are facing knowledge-intensive tasks which are judgmental rather than intellective (have a demonstrably correct solution), complementary (require abilities, skills, knowledge of different people) rather than conjunctive and unitary (cannot meaningfully or efficiently be divided into subtasks and assigned to different group members) rather than divisible (for these categories see: Laughlin, 2011). And for these tasks they need New Collaboration.

3. Methodology

To answer our main research question (how is the JKB constructed and maintained, see above), we take a Systems Thinking approach, a way of thinking which enables to better understand and design complex issues. Systems Thinking requires (Haberfellner, 2002; Vester, 2007):

1. the systemic definition of concepts. We define four new concepts in this way: a) new collaboration, b) joint knowledge base, c) artefact-mediated interaction, d) boundary artefact;
2. the use of these concepts in the context of a holistic view;
3. the use of systemic models. We describe two such models: a) distributed knowledge structure, b) bicyclic knowledge conversion;
4. the use of holistic, interconnected thinking. We have applied this in two cases: a) system of boundary artefacts, b) QUBE New Collaboration.

4. Results

After defining the main characteristics of New Collaboration, we specify the role of social negotiation in constructing the Joint Knowledge Base. We then model the JKB as a distributed knowledge structure, thus clarifying the issue of its existence; we identify obstacles which hinder its development and suggest how to solve this problem by means of a model which combines communication and interaction. We further introduce the concept of "boundary artefacts", describe their implementation as interaction tools and demonstrate how our theory works in practice by showing its implementation on a commercially available collaboration platform.

4.1 New Collaboration: Concept, Definition, Process

If we want to fully exploit New Collaboration, we need first of all to become aware of its emergence and secondly to better understand its structural and dynamical complexity. This requires a clarification of our concept of New Collaboration, a description of its essential elements (structure) and a model of how New Collaboration unfolds (method, process).

Successful groups are increasingly collaborating in this new way: they work together on a knowledge-intensive, judgmental and complementary task without splitting it. And because the task (the unit of work) is not split, the related knowledge needed during the performance of the task must also form a unit and be maintained as a unit. For this reason, New Collaboration requires the individual knowledge of the collaborators to be integrated into a shared knowledge structure. This essential "Rule of Unitary Group-Knowledge" can be concisely stated as:

IF the group-task is unitary, THEN group-knowledge should be unitary.

In this sense, we say that New Collaboration is knowledge-based. Moreover, the practice of constructing and maintaining this task-related knowledge as a shared knowledge structure requires that the group's members accept fair terms of collaboration, like reciprocity or mutuality (Rawls, 1971; 2001). Against this background, group collaboration has three relevant dimensions: (1) the mutual engagement of the group in a conscious, continuous effort to pursue (2) a joint enterprise (shared tasks) which, over time, leads to the development of (3) a shared repertoire (symbols, words, concepts, stories, ways of doing things, routines). Since these are the three dimensions of practice in Wenger's community of practice model (Wenger, 1998, pp.72ff), it is in this sense that we say that New Collaboration is community-oriented. The aforementioned characteristics of the concept of New Collaboration are summarised in the following definition (adapted from Bettoni et. al., 2016; Bettoni, 2017):

New Collaboration is a way of working together at a complementary and unitary task without splitting it, thereby concurrently practicing fair terms of collaboration and being mutually engaged as a community for constructing and maintaining a Joint Knowledge Base as a basis for accomplishing that task.

This definition has its roots in the seminal work by Roschelle and Teasley (1995) which investigated collaborative problem solving almost 25 years ago. In our process model "Pyramid of New Collaboration", we have modelled this type of collaboration by means of a breakdown structure similar to the "Work Breakdown Structure" (WBS) of project management; it is a hierarchical decomposition with seven layers, where each layer specifies the means that enable the process in the upper layer, and all the layers together implement the whole collaboration process. With this approach, collaboration (the highest level) is based on knowledge sharing (the 6^{th} level) as the essential means which enables collaboration. This aspect, new collaboration being knowledge-based, is perhaps the main difference from traditional collaboration and requires us to elaborate our concept of a JKB in more detail.

4.2 Joint Knowledge Base

The term Joint Knowledge Base (JKB) indicates the shared knowledge structure which is constructed and maintained during collaboration on a unitary task (new collaboration). According to Roschelle and Teasley (1995, p.76), collaborators interact through language (conversation), physical action and combinations of words and action. During these collective activities, each collaborator contributes their unique knowledge (Fig.1) to the group work and from this interactive process, shared knowledge elements emerge, the building bricks of the JKB.

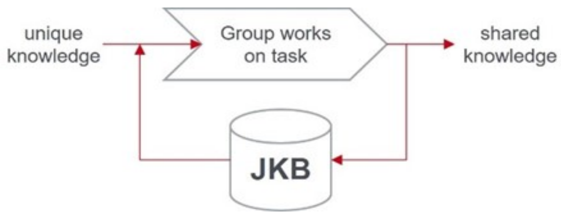

Figure 1. Group working on a *unitary* task – the JKB as an interaction bridge

The JKB collects and organises these knowledge elements into a system. Thanks to this, it can function as a basis for accomplishing the shared task on which the group is working and can also be seen as a control unit regulating the interaction, a bridge between shared and unique knowledge (interaction bridge), an essential condition for the possibility of successful collaboration. In our Pyramid Model of New Collaboration (Bettoni and Obeng, 2020), Knowledge Sharing is placed immediately below it, at level six, as the fundamental activity which enables New Collaboration (the highest level). It is here where collaborators construct and maintain the Joint Knowledge Base. In order to do this and organise the knowledge elements into a system they must interact in new ways described at the underlying levels five and four, called "Negotiation of Meaning" and "Co-Construction of Knowledge" (Bettoni and Obeng, 2020, p.167).

4.2.1 From IKB to JKB: Negotiation of Meaning

Before entering the JKB, any knowledge element must have been previously constructed by an individual group member (collaborators) and be part of their Individual Knowledge Base (IKB). The IKB is not merely storage for knowledge elements; in line with Immanuel Kant's definition of knowledge ("*A system of compared and connected mental constructs*", Kant, 1781/1787, A97, own translation), we conceive it as a knowledge system which plays a role in basic cognitive functions such as assimilation and accommodation (Piaget, 1936). Thus, an IKB is much more than simply a repository and contributes a greater functionality to cognition than just a memory system. It is hence important to understand how a knowledge element of an IKB can become part of the JKB so that it can be considered as "shared". In order to be accepted as constitutive parts of the JKB, knowledge elements must be evaluated as meaningful by the group. The meaning that they must have is not simply a specific relationship between a sign and a reference (lexical meaning) or a grand principle of reason or ethics (philosophical meaning). They must make sense to the group in practical ways, especially in relation to the professional experience of each group member. This is why the knowledge elements can enter the JKB only if they successfully pass through a "sensemaking" process called a negotiation of meaning*:* an interactive process which comprises two highly interlinked activities, participation and reification (Wenger, 1998), and which is the first of the two main components of cognitive presence (Bettoni et al., 2018). In short: any element of an IKB of any group member must go through a process of group cognition and can enter the JKB only as a socially negotiated result of this process.

Participation must be about something, some content, ideas, proposals; and reification also must be of something. So, what we need here in first place is to produce relevant content, hence to be creative and skilled in constructing (producing or modifying) knowledge elements. Thus, the core process underlying and enabling the negotiation of meaning is the co-construction of knowledge, the second main component of cognitive presence. It comprises skills like: (a) shared language, (b) shared content / storage, (c) co-planning, (d) co-solving, (e) cowriting (Bettoni et al. 2018, p.1137).

4.2.2 The JKB as a Distributed Knowledge Structure

During the course of the co-construction of knowledge, each collaborator builds and maintains in their mind their own individual knowledge base so that, within a group, we have as many IKBs involved as there are collaborators. But the overall shared goal of working with the other collaborators on the same shared task leads to the emergence of areas within the individual knowledge bases which mutually converge (and resonate). When the negotiation of meaning succeeds, this leads to the emergence of knowledge areas in each individual which converge and resonate among the group members: the elements of these areas can then be considered as "shared" knowledge elements. Thus, the Joint Knowledge Base does not exist in a single place and is not constructed outside the minds of the collaborators. There is no single, integrated knowledge base that grows outside of them; instead, a JKB is a distributed knowledge structure made of the converging parts found within the individually constructed knowledge bases (Fig. 2).

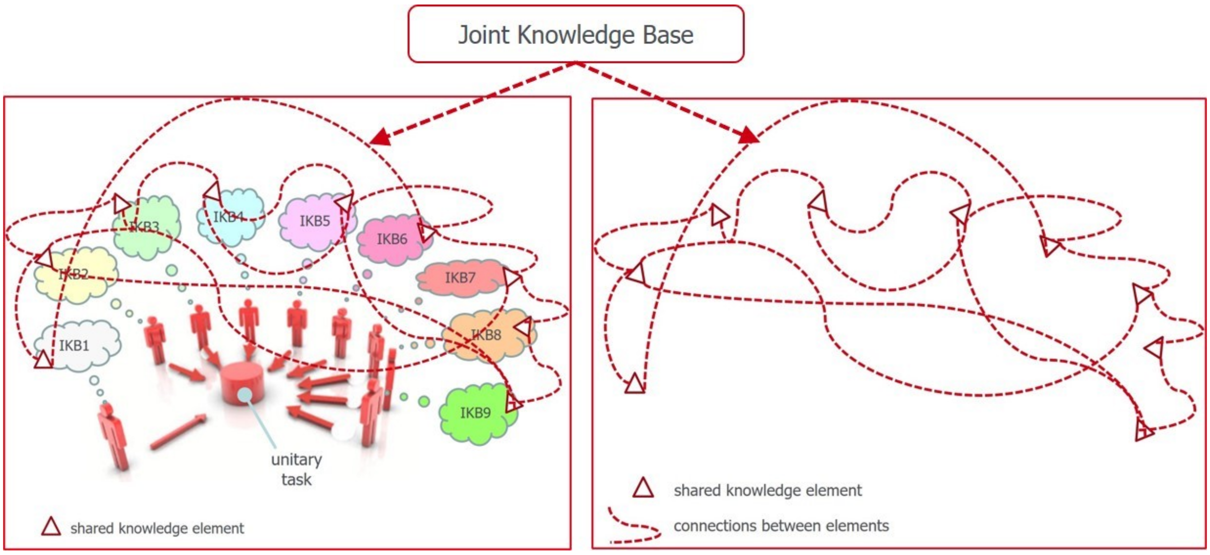

Figure 2: Joint Knowledge Base as a distributed structure (one shared element, all group members).

It is in this sense that we speak of a "joint" knowledge base: the JKB is the distributed system connecting and comparing all those individual knowledge elements whose meanings converge and fit across group activities. Thanks to this, the JKB enables meaningful conversation, action and interaction in relation to the purposes which emerge, step by step, during collaboration on a shared task. Any JKB is bound to the specific group of individuals who interact: when one individual is missing or a new one arrives, then the JKB changes. The fact that two or more individual knowledge elements are seen as converging does not necessarily imply that they precisely overlap or match in all their parts and across all the individual knowledge bases of the group members. It is sufficient if they are fit for the purposes in hand. In this sense, we should speak more precisely of taken-as-shared rather than shared knowledge elements (Cobb, 2000, p.166).

4.2.3 Knowledge Sharing Obstacles

When collaborating in this way, the JKB can grow and step by step become more and more representative of the group's knowledge. But due to the complexity of communication and interaction, co-constructing such a representative JKB is not easy to achieve! When people engage in conversations and debates for contributing knowledge elements and negotiating their meaning, they will encounter many obstacles. Two of the main obstacles (also called "semantic boundary", Carlyle, 2002) are:

1. the meaning of messages cannot be just transferred by communication;
2. interpretations of messages are often different.

The first obstacle exists because meaning does not travel; it must be (and always is) actively constructed. Heinz von Förster called it The Hermeneutic Principle: "*The hearer, not the speaker, determines the meaning of an utterance*" (Förster and Glasersfeld, 1999, p.13). The second obstacle exists because differences in experience and background among participants have created different experiential worlds (Glasersfeld, 1991, 2007) and these lead to different conceptualisations and interpretations which, on one hand, may be a source of creativity but on the other, can create social dilemmas and conflicts (Du Chatenier et al., 2009).

These intrinsic obstacles allow us to recognise something very important for collaboration: that plain conversation is an intrinsically limited resource when it comes to constructing a JKB. We know this very well from conventional meetings: they are very often not only unproductive and a waste of time (Kello, 2015) but also last too long, mostly because the collaboration and knowledge sharing are not working as they could and should when the meeting only uses plain conversation and debate (Bettoni and Obeng, 2020). Thus, as a next step, we need to solve this problem with the intrinsic limits of conversation.

4.2.4 Bicyclic Knowledge Conversion

Conversation is a complex process, but since language is learned without effort (in childhood), that process unfolds hidden behind a "veil of simplicity" (in analogy to the "veil of ignorance", Rawls, 2001), that we put on step by step during the course of our language skills development, until we reach the highest level, that of unconscious competence (Flower, 1999). By looking behind this veil, we can see how, during conversation, a knowledge base is built and maintained by several *element-related* activities which are performed on the knowledge elements during a circular, recursive process.

The four main activities are:

1. introducing new elements (through assimilation or accommodation);
2. modifying existing elements when divergence arises during collaboration;
3. detecting divergence across collaborators by monitoring ongoing interpretations of knowledge elements and comparing them with the intended interpretations to determine whether these fit;
4. last but not least, rectifying intended interpretations when there are conflicts (meanings do not fit).

If we want to solve the aforementioned problem of the intrinsic limits of conversation, then the complexity of communication and interaction involved in such knowledge sharing activities should be taken seriously. To this aim, we have developed a model of *bicyclic knowledge conversion* between a subjective self and another person, indicated by "Self" and "Other" (Fischer and Herr, 2019). The model is called "bicyclic" because it combines two main ways of *recursive*, *coordinated* interacting (Fig. 3): a communication (lower half of the diagram, based on Glanville, 2007) and a co-action (upper half of the diagram).

Since we focus on knowledge conversion in our model, in constructing it we used the SECI model of knowledge conversion (Nonaka and Takeuchi, 1995) and the IECS basic knowledge sharing model (Kharabsheh et al., 2016) as sources of inspiration. But differing from the SECI model, in our model the interaction process begins by explicitly considering two individuals, each with their own individual knowledge base (explicit and tacit knowledge) and looks at how knowledge conversions proceed first within each single person and then between them. More precisely, typical bicyclic knowledge conversion starts within the individual and proceeds as follows (Fig. 3, left side):

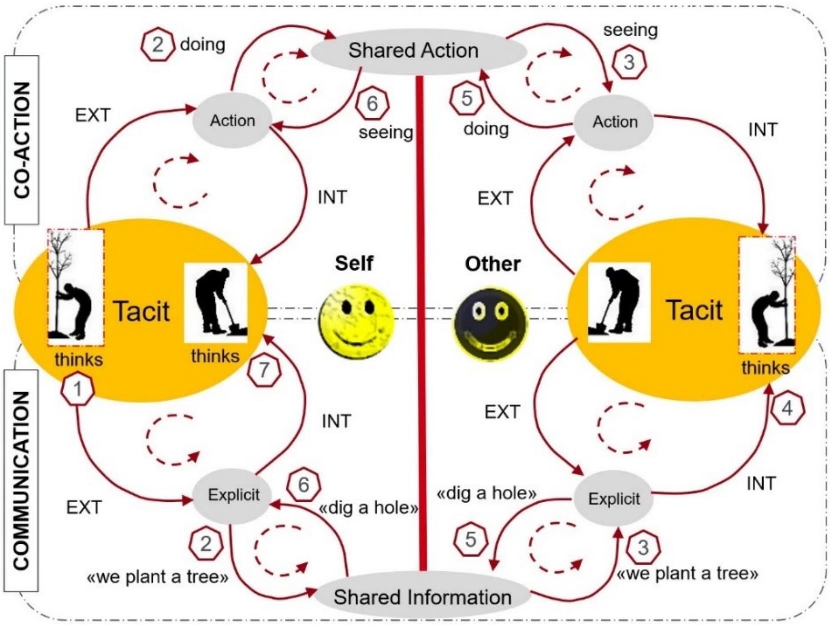

Figure 3: Bicyclic knowledge conversion between the Self and Other.

1. First, the model considers two knowledge conversions by the Self, from tacit to explicit (acronym EXT) and from explicit to tacit (acronym INT). EXT means "knowledge externalisation" (to document, to express) whereas INT means "internalisation" (to learn, to understand).
2. These two knowledge conversions form a loop internal to both individuals, indicated in the diagram with a circular arrow (dashed line). This loop can eventually lead to some thoughts related, for example, to planting a tree, indicated in the diagram - within the tacit knowledge base - by the silhouette of a person holding a young tree.
3. In a third step, the model looks at the knowledge conversion from explicit to explicit called "combination", which in our case is seen as an exchange of information in the sense of a *conversation* between two individuals.

4. At the same time, we also look at knowledge conversion from tacit to action, depicted in the upper part of the diagram.
5. An interactive knowledge conversion between Self and Other begins with the conversation depicted in the lower part of the diagram but is interlinked with the process of co-action.
   - Step 1: Mrs Self thinks of planting a tree.
   - Step 2: She says “we plant a tree” and, at the same time, the action of catching, moving and holding the tree begins.
   - Step 3: Mr Other hears “we plant a tree”; this is the only information transferred. Meaning is not transferred, so what does this sequence of words mean? If there were no action, interpretation could be difficult and lead to misunderstandings. But Mr Other sees what Mrs Self is doing.
   - Step 4: He understands correctly what Mrs Self said and contributes a complementary idea, for example by thinking that the tree needs a hole.
   - Step 5: He says "dig a hole” and begins to do it.
   - Step 6: Mrs Self hears "dig a hole". Again, if there were no action, interpretation could be difficult. But Mrs Self also sees what Mr Other is doing.
   - Step 7: She understands correctly what Mr Other said and contributes a complementary idea, for example by thinking of a combination of her holding the tree and Mr Other digging a hole: they fit and so the collaboration is successful.

We see here that, thanks to co-action, interpretations on both sides were correct and conversation has been successful; moreover, thanks to this intertwining of conversation and co-action, a fourth step of knowledge conversion called “socialisation” has also been successfully performed; this is the step in which tacit knowledge is shared between the two individuals by means of integrating the two types of interaction, conversation and physical action. This suggests that the problem with the intrinsic limits of conversation can be solved if the group collaborates (and constructs the JKB) in a way so as to intentionally make use of both conversation and co-action.

4.3 Artefact-Mediated Interaction with Boundary Objects

Given the previously presented model of a JKB, our next task now consists in suggesting collaborative patterns for group work and business meetings which promote this way of collaborating. Facilitation techniques already answered this question in part a long time ago by adding a specific type of physical action in space to conversation. This approach increases the complexity *of* leading the interaction, but we know from the practice of facilitation (Wagenaar and Hulsebosch, 2008; Kaner, 2014) that there are lot of tools and techniques (which can be easily learned) which help skilled facilitators in coping with this complexity of leading. Complex interaction methods, if appropriately facilitated, best fit with the complexity of the co-construction process, thus enabling the group to interact in a much more efficient and much more effective way.

A knowledge café, which requires dialogue rules, a specific venue with tables (each for 4 or 5 people), a facilitator with the skills to chair the session, a powerful question, a relevant introduction, small group conversations, etc. is a good example of such a complex interaction method (Sharp, 2019; Gurteen, 2021). Physical action is implemented mainly by means of the session’s assembly changes (from plenary to small groups, from group to group 3 times then back to plenary) but can also include notes taken by all participants on large shared sheets at the tables.

Another example is storytelling: in this method, the physical action comes with the chain and flow of events which make up the story; we find it in the central conflict of the story as well as in its resolution. What we have here is merely a described and imagined physical action but it is there as a new dimension which increases the opportunities for activating the imagination, stimulating further thinking, creating tacit knowledge, helping to rediscover meaningfulness and orientation, awakening emotions, creating cohesion and strengthening memories. Among other types of stories, fairy-tales are particularly suited to fostering collaboration because they bring and hold together individuals and their (tacit) experiences through references, metaphors and analogies which can easily be assimilated (Bittel and Bettoni, 2014).

4.3.1 Artefact-Mediated Interaction

When conversation and physical action on an object (in space) are combined into one single group activity, we obtain a new type of interaction, which we call object-mediated interaction (combinations of words and actions on a shared object), where the physical action is performed on real objects which can be created, moved, modified and transformed in various ways in space. The new dimension which physical action adds to conversation and the object which is produced step by step over the course of the interaction largely increase the number of choices and hence the opportunities for knowledge co-creation.

When the object is an artefact produced by the group (like, for instance, a list of ideas, a mind map of concepts or a flowchart of a process) and this artefact is made easily visible and accessible for everybody by means of a poster, a whiteboard, a panel or a table, then we speak of artefact-mediated interaction. In artefact-mediated interaction, the physical action performed by the collaborators consists of moving within a shared 3D space, sitting in small groups at tables, gathering in-front of a panel or poster, writing on large sheets or on small cards, fixing them on a panel or wall and then organising them according to a given problem-solving method etc. In doing so, they not only use existing artefacts; they also change or produce one or more of them as a result of their interaction. Such a product could be a set of marketing ideas organised in subgroups, a form for systematically organising information about project progress or a plan of action for training new clients.

When studying collaborative, heterogeneous problem-solving by scientists from different disciplines, Star (1989) recognised the importance of such collaboratively-produced artefacts. In fact, she observed that those scientists, despite their differences, were nonetheless able to successfully collaborate and attributed this to what she called “boundary objects”: objects produced during the interaction that enabled those scientists to establish shared context (Star, 1989, p.47) like, for instance, documents, terms, standardised forms and methods, models, maps and other forms of reification (Wenger, 1998, p.105). In order to underline the fact that these objects are produced during the interaction, we will call them “boundary artefacts”. They can link communities together by allowing different groups to collaborate on a common task (Wenger, 1998, pp.105ff) but they can also link individuals together by allowing a group to collaborate on a unitary task.

4.3.2 A System of Boundary Artefacts

Although traditional facilitation methods and tools (Kaner, 2014) use boundary artefacts, this alone is not enough to cope with the complexity of the co-construction process and to produce a representative JKB. We need a more systematic approach, which identifies a set of relevant dimensions (like space, time, culture, tools, methods and behaviours, see section 5) and where the whole interaction process is designed around boundary artefacts. Implementation of such a systematic approach exists in the QUBE system, a 3D collaborative virtual environment (3D CVE) of the “virtual world” type (Pentacle, 2015).

On QUBE, a boundary artefact is called *PET* (abbreviation for Performance Enhancing Tool). A QUBE PET implements a set of knowledge elements on a pinboard, structured in a specific way (see Fig. 4 and 5): this given structure functions as catalyser for the interaction, thus guiding the construction of shared knowledge elements along clearly defined pathways and making the negotiation of meaning more efficient and effective. Four of the most successful QUBE PETs are Hopes&Fears™, 5Ps™, StickySteps™ and RAPID™:

- The PET called *Hopes&Fears™* (Fig. 4) has a pinboard divided in three fields: on the right, a box for the fears, on the left a box for the hopes and below, a box for ways for overcoming the fears. This is a great way to initiate any new activity with stakeholders, especially if there is lots of uncertainty in the goals or methods. Working with this PET helps with the first steps of inclusion in teambuilding; it contributes to emotionally engaging team members from the start, helping them to define shared goals, agreeing early on what does and does not fall within the scope, agreeing on what are hard and what are soft success criteria, identifying risks and creating the basis for a common project culture.
- The PET called *5Ps™* (Fig. 4) provides a way of formulating the essential aspects of a message, task or action. The pinboard is divided in two fields. The box on the left is for the unstructured, spontaneous description of an idea, message or task. The box on the right is structured into 5 fields: Purpose, Principles, People, Process and Performance. Working with this PET helps to avoid misunderstandings and communicate clearly about complex issues, like the core elements of a project, problem or solution. It should be used at milestones when the group needs to reflect on the project, task or action and gain a clearer view of its essential aspects as well as every time a team member or stakeholder receives instructions to act independently.

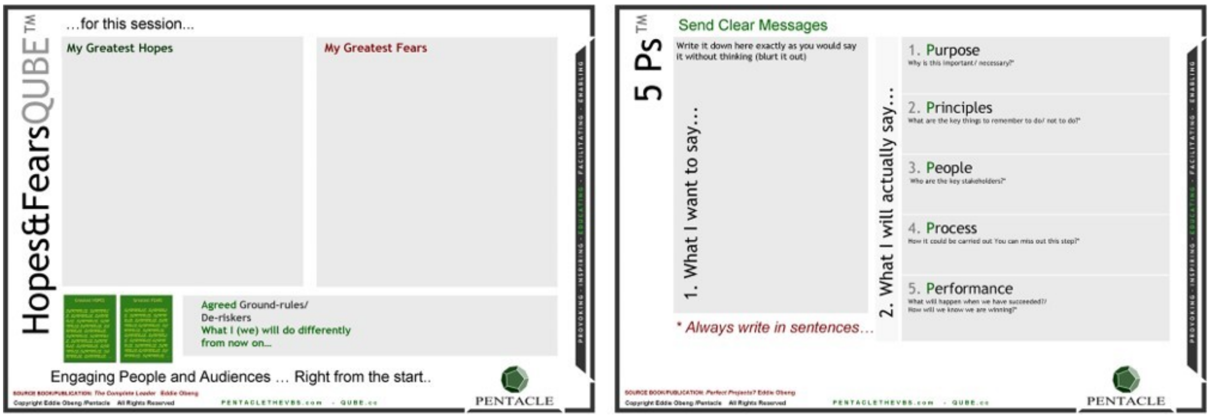

Figure 4: Boundary objects Hopes&Fears^{TM} and 5Ps^{TM} (www.pentacle.co.uk).

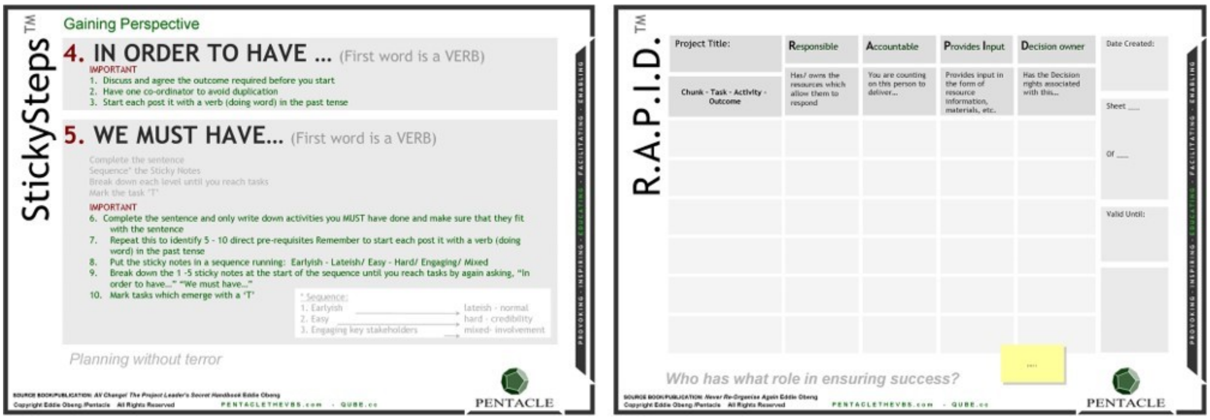

Figure 5: Boundary objects StickySteps^{TM} and RAPID^{TM} (www.pentacle.co.uk).

- The PET called *StickySteps^{TM}* (Fig. 5) displays a simple pinboard with just two areas; a row on the top for expressing the overall goal and a large area below this row for breaking down the overall goal of the action into the means required to achieve it. If one or more actions in this lower area are still too large, the team repeats this step by adding a lower breakdown level; the breakdown continues until you reach tiny little steps (tasks). This PET provides a quick and effective way to plan a project or action whenever they are almost too large to contemplate. This kind of breakdown (goal to action) allows interdependencies between parts of the project, action or task to be dealt with appropriately.
- The PET called *RAPID^{TM}* (Fig. 5) is simply a table of tasks (rows) with columns for the different roles (responsible, accountable, contributing and deciding) needed for accomplishing a task; when roles for tasks are assigned to group members, then the facilitator enters their names in the related cells, thus making sure that everyone knows exactly what it is they have to contribute, and in what way. This PET is also very useful for ensuring the interdependence of the activities and people involved on them in a systematic way: this helps to reduce bottlenecks which tend to slow down the pace of execution of a project. It should be used at the end of any team meeting and in general every time the group agrees on tasks for a piece of work in which the group members are involved.

4.4 QUBE New Collaboration

On QUBE, the previously mentioned systematic approach to online collaboration is obtained by designing a meeting around six relevant dimensions, which can also be seen as six relevant components: Physical Space, Time, New Culture, New Tools, New Methods, New Behaviours. Strictly speaking, artefacts-mediated interaction is implemented by means of the 5th component (New Methods) but all the other dimensions also contribute and are necessary for the QUBE New Collaboration:

1. Physical Space on QUBE is supported by a *3D* environment (3D CVE) which simulates a business campus with buildings, various types of rooms and other places and provides avatars with which each participant can move around in the rooms, meet other people, sit with them and chat at tables, visit panels, point to items on the walls of the room, walk to other rooms, work at an individual desk, etc.

2. Regarding Time, on QUBE a meeting continuously uses boundary artefacts, in each phase, from begin to end.
3. An example of "New Culture" is the principle of "Write first, talk second" which requires that, for any given topic of discussion, participants must first write their contributions on a panel and then conversation will start based on and referencing those written contributions.
4. An online "New Tool" is, for example, the sticky note facility and the panel on a wall: each participant can create as many sticky notes as they wish, write a text on each and place the sticky note on a panel visible to all the other participants.
5. A "New Method" is, for instance, the so-called "Hopes & Fears" method for collaboratively planning a session.
6. Last but not least, an example of a "New Behaviour" is being fully attentive to what is going on instead of reading e-mails or surfing the internet during the meeting.

Thus, in general, on QUBE, collaboration and the construction of a JKB proceed as a group activity where cognitive, social and leading presence come together at the intersection of these different dimensions and produce boundary artefacts.

4.4.1 A QUBE Session

A typical session on QUBE, for instance a kick-off meeting, begins with session facilitators welcoming the participants as they arrive in the space. Each person in QUBE is represented by an individual avatar, a simple box figure (like LEGO mini figures but gender-neutral) which provides enough of a human form to foster the required level of identification.

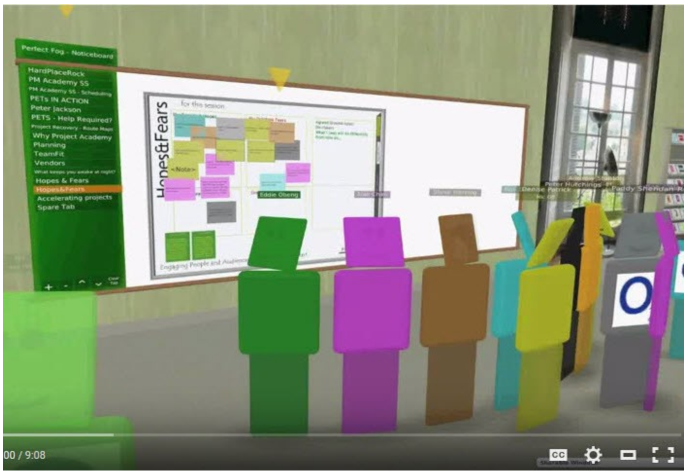

Figure 6: Group at whiteboard with Hopes & Fears PET by Pentacle (http://www.pentacle.co.uk/)

Using your avatar, you are able to communicate with other people just as you would in the real world. You can move around in the rooms of a building, physically interact and work shoulder to shoulder, literally brainstorming with many other people by means of whiteboards and sticky notes.

The facilitators welcome each one individually and make sure that they are ready to begin. Then the avatars can visit the virtual collaboration space until the meeting starts. The room has been carefully prepared in advance. The whiteboards, panels, tables and chairs needed during the meeting are available on the walls and on the floor. Some whiteboards display poster tools called PETs (Performance Enhancing Tools), guidelines or procedures about how to accomplish a task described on a poster. PETs can easily be replicated on a whiteboard or wall when needed; each PET is linked with a specific documentation which describes "what is it?", "why do I need it?", "when do I use it?" and "how do I use it?" In this sense, a QUBE PET is a collaboration method and corresponds to what is often called a collaboration pattern in literature (Eppler and Schmeil, 2010). What is special about a QUBE PET is that the collaboration involved is always an artefact-mediated interaction.

4.4.2 Problem-Solving Meetings

Regularly scheduled problem-solving and decision-making meetings with a project team are the most important requirement for effective and efficient collaboration (Gordon, 1977). On QUBE, these meetings, called "drumbeats", eventually receive the high level of consideration which they deserve. Within such a drumbeat, we see exemplified how QUBE implements artefacts-mediated interaction: conversation and physical action are combined during a meeting on QUBE to form a mediated interaction in which collaborators produce the aforementioned boundary artefacts (see 4.3.1). A drumbeat starts with a previously appointed coordinator welcoming the team members as they arrive in the project space on QUBE and gather at the central meeting place, called the "home" (leadership presence, social presence). When the group is complete, they walk together to a panel which displays the PET "Hopes & Fears" where the coordinator asks: "*what are your expectations and what are you afraid of in relation to this meeting?*". Each participant writes their contributions on cards and places them in the hopes or fears area of the panel (Fig. 4, left). Collaboration enabled by this boundary artefact starts within the individual, with the two knowledge conversions of "internalisation" (INT) - when a participant reads the cards that other participants place on the board – and "externalisation" (EXT) – when a participant writes their own contributions on cards and places them on the board, among the others. A team member will then organise the cards in clusters and clarify their meaning with the help of the group, thus beginning the knowledge conversion of "combination". Together the team then needs to discuss what could remove the Fears (social presence) before creating a meeting agenda of steps for making the Hopes a reality (cognitive presence): this will require writing some new cards and placing them on the board as well as putting existing cards in a proper temporal sequence. The knowledge conversion of "socialisation" happens in these card-related actions: pointing to a card when talking about its content, moving cards to put them in a better order, creating clusters or sequences of cards, changing the size of a card, formatting its words, etc.

When the meeting agenda is ready, then the team starts working on the tasks defined in it. PETs like "5 Ps" and "STICKY STEPS" help to clarify the problem and plan some quick wins in the beginning. During the interactions, some specific questions will arise and provide opportunities for starting work in smaller groups. Small groups can move to an area in the same room equipped with chairs and round tables and sit down here when they want to discuss something, for example how to proceed when dealing with the specific question they have selected to work on (cognitive presence, leading presence). Once they have decided this, they can move to another area of the space and gather in front of a huge whiteboard with sections separated by panels. At tables and in front of panels, the group members will only hear each other talking, without noise from other groups (a feature which is quite impossible in a real room). At the end of the meeting, a PET called RAPID will help the whole team to define the next steps and related tasks and plan when and who will accomplish them after the meeting (leading presence, social presence). After that, the team usually gathers in a circle in the middle of the room. Here the group performs a so-called "spincasting" (social presence): each team member in turn has the opportunity to give brief feedback about the work carried out in the small groups (insight, remarks, questions, learning, etc.).

This structure of a drumbeat meeting in three steps (start in plenary with a teambuilding PET, work in small groups with problem solving and planning PETs, closing the meeting with a planning PET and a plenary feedback) can also be applied during any phase of project work.

5. Discussion

In the VUCA world, the trend is clearly moving towards increasingly knowledge-based work in a fast-changing environment. In order to successfully cope with this evolution, organisations should develop collaborative cultures and embrace collaborative practices. New Collaboration can support this but in order to fully exploit its potential, we need to better understand an essential aspect of knowledge sharing, the Joint Knowledge Base.

To this aim, we have first provided a definition of New Collaboration as a knowledge-based and community-oriented activity where collaborators are mutually engaged in constructing and maintaining a JKB as a basis for accomplishing their unitary task without splitting it. At first sight, this concept of collaboration may seem excessively resource-intensive; imagine, for instance, a research department; what could it mean here, "*working together on a unitary task without splitting it*"? Of course, researchers should not work all together on every research project and on every work package in a project. There are tasks which were, are and will also in future be better assigned to one individual. But the trend is clearly moving towards increasingly *knowledge-based work* units (Jacobs, 2019) and because knowledge evolves so rapidly and remains mostly tacit (less time for documenting) due to the high rate of innovation, these tasks tend to be complementary (require the contribution of more than one individual). When problem-solving requires interaction with other people, what you have is often a consulting situation. Sometimes just a phone call or e-mail to one colleague may be enough;

but in many cases, you need more time and to involve more than one person. You may need a prolonged, problem-solving interaction with a group and this can seldom be done one-to-one on the phone; it requires a meeting. So, with increasingly knowledge-based, complementary and unitary tasks, the number of (problem-solving) meetings is also increasing. These meetings are critical for any organisation, but most people hate them (so-called "paradox of meetings"). Fortunately, New Collaboration also applies to problem-solving meetings and has recently been proposed as a solution to the paradox of meetings (Bettoni and Obeng, 2020).

The knowledge elements of a JKB are all initially constructed by individual group members and must then go through a process of group cognition (a negotiation of meaning): they can enter the JKB only as a socially negotiated result of this process. This approach implies that the group must pay great attention to the two components of the negotiation process, participation and reification.

By arguing that participation and reification are both based on and enabled by the co-construction of knowledge, we have in a certain sense shifted the focus to the intrinsic limits of plain conversation as a method for building a JKB, like for instance in conventional meetings. Our model of bicyclic knowledge conversion has enabled us to look behind the veil of simplicity: there we were able to see not only the obstacles which hinder and the activities which contribute to the construction of a representative JKB but also to understand the essential role that physical action can play in overcoming the problem of the intrinsic limits of plain conversation. Based on this, we have proposed artefact-mediated interaction as a solution to this problem and argued for the need of a systematic approach*,* where the whole interaction process in all its relevant dimensions (like space, time, culture, tools, methods and behaviours) is designed around boundary artefacts. Finally, we were able to show that this way of collaborating is not just theory but already daily practice: the commercially available collaboration platform called QUBE and the tools and culture which it promotes constitute a real-world system which successfully implements artefacts-mediated interaction by means of boundary artefacts (PETs), thus enabling the Joint Knowledge Base to be representative of the group's knowledge and the full potential of New Collaboration to be exploited.

6. Conclusion

Our paper deals with the fundamental issue of a Joint Knowledge Base, which so far was missing in the research literature. Our model of a JKB adds a missing piece to the description and generation of collaborative group interaction patterns (Eppler and Schmeil, 2010). We believe our model to contribute an important aspect to the effort of formalizing collaboration both in virtual and in physical environments, a task that is crucial especially in order to advance the application of digital collaboration. Our research contributes further to a better development of collaboration patterns as "*recommendations for how (or how not) to interact*" (Wasson and Mørch, 2000), which is essential for promoting innovative, valuable new forms of working together (New Collaboration). Nevertheless, being this the first attempt to address fundamental issues like *how* a JKB enables collaboration and specifically *how* a JKB is constructed and maintained, the current version of this attempt has some limitations, which will need to be well investigated in the evaluation of this research and addressed by future work.

First of all, our model of a Joint Knowledge Base is only a rough sketch; further research will be required for investigating: 1) how knowledge areas, which mutually converge and resonate, emerge within many individual knowledge bases; 2) to what degree the meanings need to be consensual and build convergent areas in order to enter the JKB; 3) what indicates the convergence of meanings and how does resonance manifest itself in these convergent areas when meanings do not overlap or match across all the individual knowledge bases of the group members. Secondly, in mediated interaction, further investigations will have to deal with our interpretation and use of the boundary artefact and clarify how cognitive, social and leading presence come together and contribute to its production. In particular, regarding physical action, we need to develop a model: 1) of what this type of action adds to the interaction when it is performed on cards which can be placed and grouped on a whiteboard; 2) of how physical action influences the motivations, roles and relationships of the participants. Last but not least, the way in which the intertwining of communication and co-action contributes to the knowledge conversion called "socialisation" will require further clarification in future work. This will be important to make it easier to share tacit knowledge in a variety of collaborative situations.

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Making Knowledge Management Research more Scientific, Relevant, and Engaged: A Comparative Study of Academic ECKM Papers

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Abstract: The purpose is to analyse and compare all the academic papers in the proceedings of the European Conference on Knowledge Management (ECKM) in 2017 (Barcelona), 2018 (Padua), 2019 (Lisbon), and the digital conference in 2020 (Coventry). The methodology is to code and classify 440 papers and use five contemporary science frameworks to describe and analyse the papers. The theoretical implication of contemporary KM is a research field without common paradigms, domains, and perspectives without accumulating knowledge. The KM researchers do not understand the nature of knowledge management as a field where the research cannot be replicated, synthesized, or theorized. Knowledge management needs to move along from the empirical research paradigm to a clarified subjectivity and action-basedresearch. The criticism implying acceptable/unacceptable solutions and constructed adequate/inadequate solutions for corporations and societies have strengthened their place, offering new paradigms and perspectives. The way to do this is to let in controversial, greener, and sustainable studies, whatever objectivity or subjectivity the studies have. We need more actual problem focused and less knowledge and instrument focused studies. KM will have a higher responsibility for sustainability and greener corporations and the possibility of accumulating knowledge into replication and synthesizing for general knowledge. The rate of tested and replicated studies is for the four conferences zero. The tested part, but not replicated, is 80%. The rate of untheorized untheorizable concepts is zero, the rate of theorized but not synthesized studies is zero, while the number of synthesized, theorized, and conceptual studies is around 20%. To become a discipline or research domain KM needs to replicate both empirical and conceptual studies. The only way to accumulate knowledge is through replication giving paradigms for verification and falsification. To move ahead for better quality in the research, we must break free from the empirical and materialistic paradigms and move into the clarified subjectivity and action paradigm. Paradigmatic ecumenism will tend to a fiercer but idea-generating debate. This pluralistic approach will give more engaged practical research representing more sustainable societies and businesses. ECKM is on the road to include more pluralistic perspectives upon sustainability, value creation, gender issues, and the design of future knowledge work. There is a critical openness toward these issues making ECKM 2020 a more relevant conference than the ECKM conferences in 2017, 2018, and 2019. The 2020 conference more open up for reflections, dialogues, and criticism upon existing problems and knowledge asking about what is the adequate actual KM solutions.

Keywords: Knowledge paradigms, Knowledge concepts, Knowledge management, Knowledge creation, Knowledge accumulation, Knowledge sharing

1. Introduction

Two essential points of departure for this paper's discussion are the discussion of significant trends in contemporary philosophy of science and the relevance for knowledge management research. Second, the conceptual broadening of knowledge management research. The line between relevance and rigor in knowledge management research is discussed versus different degrees of complexity. The discussion about if it is at all possible to establish objective criteria is central in the paper**.** The nature of the knowledge management concept is also considered. Verification and falsification require replication of studies, but the knowledge management concept might be a concept without the possibility for replication, theorizing, and synthesizing. The concept will be subjective of nature, and the only possible interpretations will be a form of clarified subjectivity.

There are many reflections and even speculations about the quality and relevance of knowledge management research. Nonaka (1985) created the importance of knowledge management in his book "The knowledge creating company," describing knowledge as the essential resource in any corporation. Nonaka (1985) reflects upon knowledge management but does not make any empirical tests of the proposed theories. However, many similar fields like information management, information resources management, information systems management, information technology management, and intellectual capital management are still around in their societies and journals. We have different areas of knowledge and different types of knowledge which we are sharing, managing, and organizing. We have different levels of personal knowledge. As knowledge workers,

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we specialists in a small area, while we have a working familiarity in a larger area and a nodding familiarity in a broader knowledge area. A part of our knowledge is explicit, and a more significant part tacit. We are further all the time learning and de-learning our knowing according to personal needs, societal needs, and corporate needs. ECKM arranges an annual conference for research papers covering all these aspects. The research papers are published in the annual conference proceedings. Analyzing all these papers will then give us an overview of all the aspects covered by knowledge management and state-of-the-art research quality of the field knowledge management. The research papers give a unique empirical possibility to evaluate the actual scientific situation to compare several conferences. The methodology for the study has been to evaluate all the research papers for 2017, 2018, 2019, and 2020 and compare the results. The classification of papers is based upon the abstract, introduction, methodology, literature review, findings, analyses, and conclusion. Classification is compared and coded to the five contemporary frameworks of the philosophy of science to answer the research questions.

Our research questions for the study are as follows:

1. What is the KM philosophy of science framework characteristics of academic research papers in contemporary KM presented at the ECKM conferences?
2. What is the philosophy of science requirements to make KM research more creative, engaged, and relevant?
3. How can we make KM research more creative, engaged, and relevant?
4. How can we make KM research contribute to more sustainable and greener businesses?
5. What are the future characteristics of KM research?
6. What is the rate of tested and replicated, tested but not replicated, and untested KM research?
7. What is the rate of untheorized untheorizable concepts, theorized, but not synthesized and theorized and synthesized KM?

The main conclusion is that KM does not replicate investigations and focuses on the instruments and the existing knowledge and not upon actual problems. The knowledge used is what we already know and not what we do not know that we know. Criticism and especially constructions are less used. What is adequate and not adequate and what is acceptable and not acceptable are seldom asked. The methodology is concentrated upon qualitative and quantitative survey research interpreted as objective results. The results are presented as definitive and more seldom as sensitizing presenting directions along which to look. The deduction is chosen much more than induction to look scientific. The paradigms are empirical and materialistic and more seldom subjective and action-based. There are no agreed-upon paradigms or research domains or perspectives, or schools. KM research is not repeated, theorized, or synthesized, and there is no knowledge accumulation. We define the state-of-art as a pre-scientific situation.

Where any result may be as enjoyable as another result, KM has to accept that results may not be replicable, testable, or synthesized-able. KM must develop inductive clarified subjectivity and action-based studies constructing and testing the consequences of sustainable and greener businesses and societies. Trust-based, value-based, and transparency-based leadership should be an essential part of the KM concept. KM will then foster creativity, engagement, and relevance.

The paper is organized as follows:

The study is, in many respects, what we look upon as a clean-cut study. The introduction introduces what we are looking into, how we look into what we are looking into, and the main results. The study continues with the literature review and the methodology. The literature review might have been a theory of everything within KM but is kept to the philosophy of science frameworks. We continue with the five philosophy of science frameworks and a presenting and discussion of findings. We answer the six research questions in our section and continue with the conclusions, the framework for future research, and limitations. A research paper like this is about cutting corners to get everything together. We believe that we have positively cut corners, creating the foundation for learning and reflection upon the future state of KM.

2. A literature review of contemporary philosophy of science compared to KM foundations

"There are trivial truths and great truths. The opposite of a trivial truth is false; the opposite of a great truth is also true" (Bohr 1948:120). Bohr's position is that subjective speculations are needed to advance any science, even physics. Bohr argued that any discipline needs a basis from science and physics philosophy and should keep this in mind to get alternative proposals and solutions. Feyerabend's position (1979) was that we must break the methodological rules and procedures to advance science and the social sciences. Our argumentation has anyhow to be logical and convincing. Popper (1968) noted that we are standing on quicksand where pure falsification and verification will not advance any science in itself. Data do not prove anything at all. It is our logical interpretation of the data that might make a verification or falsification. If a falsification or verification is possible (Lakatos 1978) or if every result is relative dependent upon the cultural context (Toulmin 2003).

Kant (1787) found that universities had two tasks. The primary mission was to educate professions, and the second job was to develop the sciences as sciences. Kant included the humanities (mainly philosophy and theology) among the sciences. The two tasks demanded different knowledge, experiences, and attitudes. Wilson (1979, 1984) identified this as two kinds of powers and cognitive authorities. The procedures and rules have to be different for these powers. However, both forces had to work with relevant problems for their context to survive and not degenerate as useless powers. Both Wilson (1984) and Toulmin (2003) noted that all knowledge is contextual and relative. All knowledge is subjective and might be interpreted differently according to the context of the knowledge. Berger and Luckmann (1968) concluded that all activities, including the sciences, are social constructions, and the question is how to make adequate constructions acceptable. The construction of reality is subjective, and the glasses we are using to define reality will form what reality we are seeing.

Knowledge management research is a new discipline that we might date back to Nonaka (1985) and a discipline without agreed-upon paradigms, perspectives, or schools. Kuhn (1970) identifies disciplines like knowledge management research as a pre-scientific situation where any discipline might remain until the discipline dies or advances a new paradigm. Lakatos (1970) argues that a movement from small science to big science in the number of involved researchers and grants does not improve a discipline's knowledge. There might be a degeneration both in more minor and more extensive research programs, according to Lakatos. Creativity, imagination, and relevance do not have to do with the size of the programs or schools. The most available research to industrialize is quantitative survey research, where easily collectible data are often collected and presented as the emperor's new clothes through fanciful instruments. Kuhn (1970) and Lakatos (1978) defined this as a pre-scientific situation without scientific progress. Feyerabend establishes the nature of leadership and management research as better or worse stories replacing each other not as truths but as socially constructed stories. Feyerabend (1979) described social science survey research as often quantitative and qualitative fact-based case storytelling in constant need of new cases and stories. Feyerabend is proposing the state-of-the-art in KM. Feyerabend notes that storytelling is not replicable, and the usefulness is not a theory or a synthesis but a piece of situation-based information depending upon the actual audience.

Feyerabend (1974) concluded that this was the management literature situation where one case description follows the other case report without knowledge accumulation. According to Feyerabend, this is a storytelling tradition where the marketplace gives new stories all the time. The faster the marketplace develops, the more the researchers will be in dissonance with the market. According to Feyerabend (1987), they will produce more and more "hard science" stories without basis in reality, but with basics in business schools further and further from the firm itself. The businesses themselves will find the highest-rated research less and less relevant (Van-de-Ven 2012, Olaisen and Revang 2017 and 2018). The ruling group in business schools is its exclusive audience and often behaves like a mob against revolutionary thoughts. The group might be dogmatic, authoritarian, and narrow-minded. They represent groupthink. The mind is, in other words, temporarily closed. The highest aim is to control the field and the rules for the accepted puzzle-solving activity. The rules of the puzzle-solving activity become the most crucial issue. There is a Matthew effect in work – those who do it the most accepted way shall get more, and those who do not do it the accepted way shall not be published or getting tenure (Merton 1968). Most researchers in knowledge research are trained in Ph. D. programs with an emphasis on empirical studies. They know that to get papers accepted, they have to follow the "correct" researchers, have a representative sample, and use a proper statistical package to prove their results and end up with decent results or a proposal for another knowledge framework. Marketing and management research is repetitive studies adding no progress or creativity, or hope (Lawrence 1992).

Feyerabend (1974,1987) represents this anarchistic, irrational, and artistic view of science and social science. Feyerabend's reasoning can be summarized as follows. Epistemologists claim that scientists and social scientists follow specific "rational" rules in carrying out their research and that as a result of this, there is "progress."

However, scientists follow "irrational" rules in any science, and there is progress. Therefore it is not needed rules and a research strategy supporting this (Minzberg 1979).

Consequently, we will have to define this discipline as a subjective multidiscipline, and we will have to explore, innovate, simulate an experiment to a much higher degree. We need more subjectivity conflicts and minor harmony and objectivity in our research. Leadership and organizational methodology movement towards phenomenon research take research out of the iron jacket into a flexible and soft jacket opening up for alternative realities (Doh 2015, Schwartz and Stensaker 2014, von Krogh et al. 2012). The movement is towards action-based and clarified subjective paradigms representing instrument-itis, problem-it is, and knowledge-itis criticism and construction to grasp sustainability, gender equality, and new professional working forms.

The business reality is today complex and global. We need to understand both wholisms and atomisms in a good research strategy (Minzberg 1979) and actionable puzzle solving (Morgan 1980). We require imagination and intuition for this process (Bunge 1967, Alvesson and Skjoldberg 2009).

Furustien (1999) describes management research as a form of gurus where gurus from consulting companies and academia define what works, which gives management research studies building more on believing-based than evidence-based knowledge. Furustien describes KM as a discipline-based upon the capital owner's interest and not upon the human resources and the society's need for KM. Locke and Spender (2011) confront that the business elite does not need critical knowledge management research, but only acceptable as-is results defending a conservative business practice. Alvesson and Skjoldberg (2009) ask for bullshit knowledge management research to tell us that we need to differentiate between bullshit and meaning for the employees and organization. Many researchers are redefying KM as studies that uncritical accept the realties as-is and serve the large global owners, while a small part of the academic establishment regard KM as bullshit research (i.e., a form of social science without criticism and innovative inductive constructions). Olaisen and Revang (2018) concluded that more than 30 years of research upon the role of tacit knowledge in KM had given no progress without any possibility to replicate results or synthesize accumulated results. The process of transferring tacit to explicit knowledge remains as unknown in 2021 as in 1959 when Polyani launched the concept. The concept of tacit knowledge might not be testable or possible to replicate or synthesize. As knowledge processes are unknown, knowledge will be difficult to define and even more challenging to manage.

Tornebohm (1983) conceives social science as a sequence of partly cumulative and partly non-cumulative transformations of knowledge (K), problems (P), and instruments(I). Tornebohm (1983) argued that if the sciences and social sciences are going to progress, there must be a balance between K, P, and I. An overemphasis on any of them will hinder a free scientific discourse and, by that, the development of any scientific field. For instance, a central notion from the compound (K1, P1, I 1) to (K2, P1, I2) occurs when the problems P1 are solved to increase the stock of knowledge from K1 to K2. In the problem-solving process, new instruments may be developed or borrowed from other disciplines, at this moment changing I1 to I2. If one of the three aspects is allowed to dominate the other two, the discipline becomes less relevant. Overemphasis on knowledge ("knowledge-itis") may result in empirically empty structures irrelevant to the problems. Empty content structures are the case for business school research in general (VendeVen 2007, Olaisen and Revang 2017), where business schools are producing more and "better" research than ever. However, the practical business world finds the study results less relevant than ever. Preoccupation with problems ("problem-itis") may mean shallow pragmatism and conceptual malnutrition. Finally, too much attention to instruments ("instrument-itis") may erode the substantive core. The focus of the studies is how to practice the research methodology in itself. The researchers end up testing themselves if they can master the instruments and not the theories. Tornebohm (1983) identifies these imbalances in the researcher's orientation as lacking commonly agreed-upon perspectives and defines management research as something less than social science and more than fiction. Kuhn identifies management research as a pre-scientific situation where any discipline might remain until the discipline dies or advances a new paradigm.

The initial KPI maps the aspect of interest (in this case, feature of knowledge structures or processes). The KPI compound in this process filters through what is called the "researchers orientation and worldview" or perspectives in Tornebohm's words (1983) or paradigms in Kuhn's words (1970) or research domains in Olaisen's words (1985). These authors are all referring to the fact that there are alternative ways of approaching the social sciences and, by that, also knowledge management research. The aspects studied are not given once and for all. New knowledge widens the boundaries, as might happen after the broadening of knowledge management research. Thornebohm's idea is that pluralism is needed in any discipline to get an accumulation of knowledge. If this pluralism lacks time, any discipline will erode and be a mechanistic puzzle-solving of more and more irrelevant problems. The relevance will be found in other disciplines replacing a discipline over time. Kuhn (1970) labeled this as normal science activities where the scientists agree upon good science reproducing noticeable results in quasi-scientific ways to gain respect within a smaller and smaller circle.

Galtung's (1972) idea was to identify four ways of approaching the social sciences in a triangle of theory, data, and values:

1. Empiricism – is what we are presenting true or false (if true consonance if false dissonance)
2. Criticism – is what we are presenting acceptable or not acceptable (if acceptable consonance if not acceptable dissonance)
3. Constructivism – is what we are presenting adequate or inadequate (if adequate consonance if not adequate dissonance)
4. Pluralism – a triangulation of empiricism, criticism, and constructivism (if congruence consonance if not congruence dissonance)

Galtung (1972) assumes that a common goal of all social sciences is to establish what are called sentences dichotomizing their "world space" by including some defining the empirical world by including some "world points" and excluding others. Hence, data sentences explain the empirical world by including what they observe and eliminate what they do not see or imagine. Theory sentences (hypotheses or propositions), on the other hand, define the foreseen world, including aspects that are predicted by the underlying theory. Finally, value sentences refer to the preferred world, including what is accepted and excluding what is rejected. Galtung's idea was that all the social sciences could be analyzed according to this framework. Our research paper is the first time Galtung's and Tornebohm's approaches evaluate academic papers.

Blumer (1969) argued that research concepts in any social sciences might be divided into definitive concepts and sensitizing concepts. The concepts have an essential role in any scientific inquiry. They are usually the anchor point in the interpretation of findings.

The purpose of the definitive concept is to:
Describe-Explain-Predict and Control and Rule (A definitive and objective process). Bunge (1967) named this process "the process of all serious systematic research." Popper (1968) looked upon the definitive concept as the instrumental requirement for verification and falsification.

The sensitizing concepts have another purpose:
Describe-Explore-Reflect-Participate and Change (A subjective and relative process). Glaser and Strauss (1967) named this process “Grounded-theory-research," and Olaisen (1985) named it “dig-where-you-are” research.

Olaisen (1985) divided any kind of knowledge into four types of knowledge:

1. What we know defining
2. What we do not know implying
3. What we do not know that we know as a part of
4. What we do not know that we do not know

According to Olaisen, to get a scientific, intuitive, and creative movement between these four types of knowledge represents the essence of representable and non-representable knowing modes in any science and social science.

Olaisen (1985) divided the social sciences into four paradigms in a quadrate of harmony versus conflict and objectivity versus subjectivity:

1. The empirical paradigm
2. The materialistic political paradigm
3. The clarified subjective paradigm
4. The action paradigm

According to Olaisen, any social science paper could be placed within these four paradigms.
These are the five scientific philosophy frameworks used as analytical tools for analyzing academic papers.

We have in the literature section presented contemporary views of the philosophy of science that will be used as a theoretical framework for our empirical investigations. We have not presented a review of KM as a discipline, but the increasing criticism of the discipline KM regarding the discipline not as an objective discipline, but much as a storytelling discipline dressed up as an objective, testable quantitative discipline. The concept of knowledge is contextual and relative, and studies of knowledge cannot be tested and replicated, or synthesized into general theories. Knowledge is managed and organized, but as knowledge is situational, the management and organizing remain a clarification of different subjective practices. The practices might be described and analyzed, but there will not be any general theory or model since replication is not possible.

3. Methodology and rationale for the study

This paper aims to analyze and compare all the papers in the proceedings of ECKM in 2017, 2018, 2019, and 2020. A total of 440 double-blind reviewed academic papers within a framework of 5000 words for each paper. The approach uses five philosophy of science frameworks and compares the frameworks to the content of the research papers.

Common sense is simply one's primary supply of notions of what the world is like – what kind of things there are, how one can learn about them. As the anthropologist Geertz (1983) says, common sense is a theory of the world – a thin theory but a theory: It can be questioned, disputed, affirmed, developed, formalized, contemplated, and even taught … It is, in short, a cultural system, a discipline … and it rests on the same basis that any other system rests: the conviction by those whose possessions it is of its value, validity, and reliability" (Geertz 1983:76). Common sense is our theory of how the world is organized and of what gives characteristics meaning. Common sense represents our conceptual approach and rationale for choosing our research rationale. The authors of this paper have combined more than 60 years of experience as professors in KM. Our experience gives us a cognitive and affective authority for evaluating KM papers. We represent what Geertz calls "a professional common sense within a disciplined building upon knowledge, experiences, and attitudes" (Geertz 1983:103). We use our professional common sense in coding, evaluating, and classifying each research paper for the five philosophy of science frameworks.

We have used five philosophy of science frameworks to analyze all the papers:

1. Tornebohm's knowledge, problem, and instrument description (1983)
2. Galtung's scientific perspective triangle (1972)
3. Olaisen's four kinds of knowledge identification (1985)
4. Blumer's two kinds of scientific concepts (1969)
5. Olaisen's four kinds of paradigms identification (1985)

This paper has combined (4) and (5) a pluralistic proposal for future progress for knowledge management research.

Each paper has been classified according to:

1. Problem
2. Methodology
3. Theoretical foundation
4. Propositions or hypotheses
5. Presentations of results and analyze
6. Discussion of results
7. Conclusions
8. Theoretical and practical implications
9. Suggestions for further research expanding the KPIs

For each academic paper, a decision has been made for each of the five frameworks according to which format the paper fits within. The decision is based upon the reading of the paper. For two-thirds of the papers, the decision of placing them into a category was clear. For one-third of the papers, we had to make a subjective decision for which category we placed them within. The decision is based upon our notes from each paper, and if in doubt, we have reread the paper. All 430 research papers are finally coded, classified, and categorized for each of the five philosophies of science frameworks. The validity of findings is high in this process. At the same time, the reliability is lower owing to the lack of exactness in definitions and concepts and a high degree of similarity between the papers. The frameworks from the philosophy of science are used as analytical tools which give a better validity and reliability for the discussion of findings.

Schultz's (1970) understanding of "the theory of common sense" together with his criticism of scientific theorizing is the methodological rationality for how we will describe explorative interpretations and theories in our paper. Our knowledge in everyday life is not without concepts, inductions, and predictions, but they have all the approximate and typical characteristics for the situation. The ideal of everyday life is not a certainty or probability in a mathematical sense, but just likelihood for our interpretations. Anticipation for future states of affairs are conjectures about what can be reasonably expected. When afterward the anticipated state-of-art takes some form in actuality and interpretations, we do not say that our predictions have come true or proved false or that our hypotheses have passed the rest and are replicable, but that our questions and anticipations were well funded or not at all well-funded. The consistency of this system is not that of natural laws but that of typical sequences, relations, and understandings. As a process, we believe, theories render pretty well the reality of social interaction in everyday life. Their function will not be a prediction but usefulness through a better understanding of knowledge management. This anticipation will, in our opinion, be as far as we can reach concerning theories of knowledge management. We agree with Glaser and Strauss (1967) that our job is not to provide a perfect description and analysis of an area or discipline but to develop a description, analysis, and framework that accounts for as much as possible of how societies and corporations can be facilitated by creative, relevant and engaged knowledge management or destructed by a trivial and irrelevant knowledge management research.

Our research rationale can be helped by appropriate and theoretical apparatus that, like lenses or spectacles, extend the range of perception and improve its acuity and actuality; it can also be hindered by distorting lenses. We have the rationale that the ECKM research papers and the philosophy of science frameworks are the best apparatus ever given to study the empirical state-of-art for knowledge management. We have avoided distorting lenses by the inclusion and coding of all 440 papers placed into a few frameworks(5). The interpretations by that into the few variables of each framework giving a simplicity needed to hinder distorting and increasing the range of perception. We hope our methodological reflections and apparatus represent a new kind of thinking in knowledge management as a kind of clarified subjectivity raising questions suitable for reflections, new perspectives, and new understandings.

4. The context of the papers

More than 80% of the papers are surveys and case studies with a description of the case, including questionnaires and interviews with similar references. Two-thirds (65%) of the cases are from private businesses and one-third from public organizations (32%), with a small portion (3%) from non-profit organizations. The primary way of collecting data is through emailed surveys (35%), a combination of interviews and questionnaires (40%), or in-depth interviews (16%), while the remaining part (9%) are conceptual, theoretical studies. More than 80% of the surveys are using statistical packages and advanced statistics. The studies are using quantitative results to prove or disprove hypotheses. The average response rate in the surveys is 32% in 2017, 29% in 2018, 31% in 2019, and 37% in 2019. The low response rate is only discussed in 25% of the studies, while the remaining do not present this as a statistical problem. Only 16% in combine qualitative and quantitative data studies. More than 50% of the studies have propositions or hypotheses derived from the theoretical foundation. The overall picture is standardized statistical survey studies based upon email questionnaires with a relatively low response rate. More than two-thirds of the papers have the exact paper disposal and the same main headings. There is a clear standardization of the disposition of papers and in the presentation of quantitative results. Almost none of the studies are longitude studies. The studies are typical here-and-now studies made for the conference proceedings and later journal publication. Accurate delivery is an industrialized paper processing. About 11% of the studies are innovation studies, 67% are knowledge management studies, and 22% are general global leadership and management studies.

63% of the papers are coming from business schools, while the remaining part is coming from universities (15%), private businesses (15%), and public organizations (7%). 91% of the papers are co-authored, 75% co-authors from the same institution, while 25% have co-authors from different institutions. 78% of the authors are men, while 22% are women. The number of co-authorship and women are increasing from 2016 to 2020. The identity is a European conference dominated by European researchers. 83% of the authors come from Europe, while 10% are Asian authors, 5% are North American (the USA and Canada), and 2% are Oceania authors. The number of Asian authors is increasing. The dominating European countries are the UK, Germany, Holland, and Scandinavia (Norway, Sweden, and Denmark). The number of papers from France, Spain, Russia, and Eastern Europe is increasing. The most usual author is a male in his 40's from a European business school holding a Ph.D. from his home country. The trend is more female participants, more co-authored studies, more studies from the cooperation between businesses and business schools, a more triangulated methodology, and more qualitative studies. The trend is, however, slowly changing as might be expected. However, 2020 might be a trendsetter for faster changes.

5. Knowledge-itis, instrument-itis and problem-itis

The papers are suffering from "instrument-itis" and to some extent from "knowledge-itis," but they are indeed not suffering from "problem-itis." Problem-oriented research is demanding and requires systematic and logical argumentation (Lawrence 1992). Problem-orientated research might be a weakness for knowledge management researchers. The researchers do the statistical tests well, and the researchers present the data in "nice" total packages as a form of scholarly truth. However, very few results conflict with existing results or anything. 2 of 3 hypotheses are correct, and 1 of 3 hypotheses is incorrect. There are many similar hypotheses/propositions (54%) in papers dealing with knowledge sharing and knowledge management, while 61% reach the same result and 39% reach a different result for similar propositions and hypotheses. The Popperian falsification process (1973) is used for both explicit and tacit knowledge processes even if 82% in 2017, 84% in 2018, 83% in 2019, and 68% of the papers in 2020 do not distinguish between tacit and explicit knowledge processes. The inability to distinguish between tacit and explicit knowledge might represent a lack of theoretical sophistication (Polanyi 1964). Two-thirds of the papers lack a definition of knowledge, information, management, leadership, or the situations these concepts are used within. The lack of definitions presents a kind of storytelling where a story exemplified with statistics is told. The scholarly and scientific storytelling is what Kuhn (1970) labeled a pre-scientific situation where anything might be equal in importance or what Popper (1968) described as the situation for psychology as a field. Kuhn (1970) called this "something less than research." The lack of problem-itis makes it challenging to make progress and accumulate knowledge; as Olaisen and Revang (2018) noted, there was no progress in understanding and performance of tacit knowledge.

More than 60% of the papers write about the need for new knowledge leadership, knowledge management, and knowledge organizing. The papers, however, are centered around traditional leadership, management, and organization issues. The paper's label and marketing are proposing new ways of leadership, management, and organizing. However, they neither define the situation today than the situation tomorrow nor how we will take us tomorrow. The papers are promising the "promised land," but in the end, tomorrow's management is the same as today's management. The papers' problems are centered around solvable matters and very seldom if anytime, related to unsolvable problems. We define such "instrument-itis" and "knowledge-itis" in knowledge management research as a misdirecting striving for respectability. Forty of 430 papers (9.3%) discuss our ecological systems' problems and what we need to do to solve the climate crisis through sustainable businesses. These green ecological papers ask several questions they cannot answer and are thus speculative and are all conceptual papers without any empirical basis. The 2020 conference doubled the number of green papers and increased the conference's relevance for our current business situation.

We introduced Tornebohm in the literature review, and we have integrated all the papers into his framework as an analytical tool to pinpoint critical findings. The papers are mainøy dominated by being instrument-it in their format to try to achieve scientific quality through advanced quantitative statistics instead of testing the author's qualifications rather than adding new knowledge. The papers build upon already known knowledge and by that are knowledge-it is. Few papers, less than 10%, end up with conceptual, theoretical papers or papers raising new social and business problems and are not dominated by problem-it.

6. The aspects of the world studied

We are making a distinction between four areas of knowledge in management research: "What we know" (1), "What we know that we don't know" (2) and "What we don't know that we know (3) and What we don't know that we don't know" (4). Area (1) will define the area (2), while there will be a misinterpretation and bias towards the area (3) and area (4).

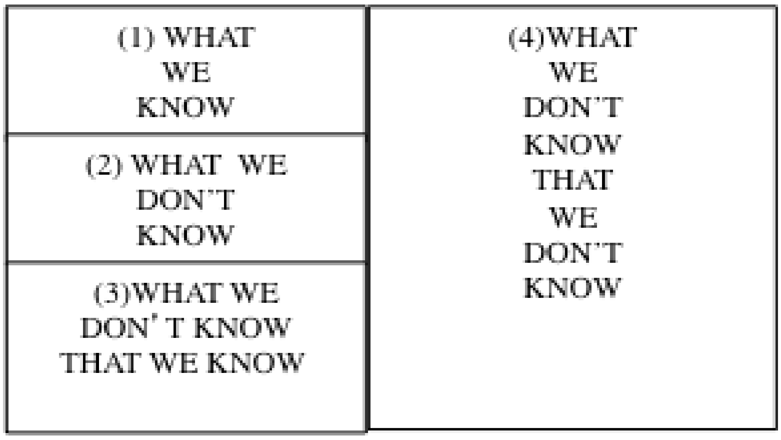

Figure 1 Knowledge representations (Olaisen 1985)

For areas (3) and areas (4), will imagination and intuition be necessary for the creativity needed to make a scientific movement in knowledge management in zone 3 and 4? If we expand only into area two, it will be somewhat limited knowledge research emphasizing instruments and knowledge while the problems will be defined by what we know.

If we want to move between areas one and two, logical, empirical studies ("secure and clean studies") will be ideal. However, the source of bias and misinterpretations start as soon as we move into what we do not know anything experienced. We will here begin to involve imagination and intuition. Experience-based intuition is the start point of any essential research effort. At the same time, the movement from area one to area two is only instrumental puzzle-solving, most often without any knowledge accumulation (Minzberg 1979, Morgan 1980). The way to improve our technique is not to attempt to analyze things into their elements, reduce them to measure and determine functional relations, and educate and train our intuitive powers (Knight 1936). Suppose our role is only to produce some publishable or travelable research. In that case, we are reduced to mechanic puzzle-solving, demonstrating that we can master the techniques we were learning in our Ph. D's. Between 70 and 80% of the research papers represent mechanic puzzle solving (Morgan 1980). We are sending out a questionnaire to a large sample getting a 5-20% response rate. Applying statistics and classifying research results in nice tables, diagrams, and figures, getting more of the same trivial already known knowledge. The 2020 papers are slightly more based upon qualitative in-depth interviews, constructed datasets from several studies, and theoretical foundations. Several papers in 2020 open up for discussing what we do not know that we know as the papers discuss how we will be coping with COVID-19 pandemia and the climate situation in the years to come. The papers take a more considerable risk upon concentrating upon the problems instead of the knowledge and the instruments.

Olaisen's figure and theory add mainly to one crucial area. More and more research is taking up or concluding with "What we do not know that we know." It appears that green papers and papers presenting sustainable problems and solutions are dealing with what we do not know the consequences of. Most studies are working within what we know and pretend to offer new solutions without offering them.

7. Scientific orientations

Galtung (1972) assumes that a common goal of all social sciences is to establish what are called sentences dichotomizing their "world space" by including some defining the empirical world by including some "world points" and excluding others. Hence, data sentences explain the empirical world by including what is observed and excluding what is non-observed. Theory sentences (hypotheses or propositions), on the other hand, define the foreseen world, including aspects that are predicted by the underlying theory. Finally, value sentences refer to the preferred world, including what is accepted and excluding what is rejected. Most of the papers (65%) in 2017, 63% in 2018, 61% in 2019, and 51% in 2020 do not develop hypotheses but only describe the theory's findings without concluding them into hypotheses for testing (Bunge 1967). However, the research compares data sentences with theory sentences without using Popper's falsification principle (Popper 1972). Dissonance does not produce new theory sentences, while a consonance occurs in noting that the research results align with mainstream knowledge management research. Criticism is the type of scientific activity where data sentences are confronted with value sentences. By the tenets of this orientation, consonance is created by producing new data sentences by changing reality into an acceptable condition. Criticism is not a large part of the ECKM 2017, 2018, 2019, and 2020 papers (15% versus 16% versus 18% versus 24%). The trend is towards more criticism-based papers. Criticism is needed through values, speculations, and ad hoc methods to advance a field even if the validity and reliability are low.

Constructivism implies comparing theory sentences with value sentences to see to what extent the foreseen world is also the preferred world. Consonance refers to what is adequate, and dissonance to what is inadequate. In dissonance, theory and value sentences are about equal priority, and both might be changed in knowledge management research. Constructivism represents 20% of the papers, increasing from 15% in 2017 to 25% in 2020. The business reality is today complex and global. Combining the understanding of both wholisms and atomisms is needed in a good research strategy (Minzberg 1979) and actionable puzzle solving (Morgan 1980). Imagination and intuition are required for this process (Bunge 1967, Alvesson and Skjoldberg 2009). The intuitive powers seem to be less trained among the ECKM researchers.

Intuition, imagination, and creativity are needed to handle a high degree of complexity like scenarios for the business future or the green environmental future. Such complex scenarios are only handled in 43 of the papers (10%). Both criticism and constructivism are handled simultaneously to develop what is acceptable and unacceptable for society going on with what is further adequate and inadequate for the businesses. The distinction between what is acceptable and what is adequate might, as a result, give us a greener, more innovative, and safer world where businesses and societies walk hand-in-hand. The paradigmatic perspective change results in more subjective and actionable research for a better future missed in the ECKM 2017,2018 and 2019 papers while increasing 2020 papers. Also missed is what kind of leadership will take us into a more responsible, sustainable world. The knowledge management papers represent the status quo and the existing business elite. We have to ask the question of what is acceptable and what is not acceptable. We have to construct our data for this purpose since data in itself does not prove anything. It is only our argumentation that can prove anything. We need constructivism, where we ask what is adequate and what is inadequate for a sustainable future.

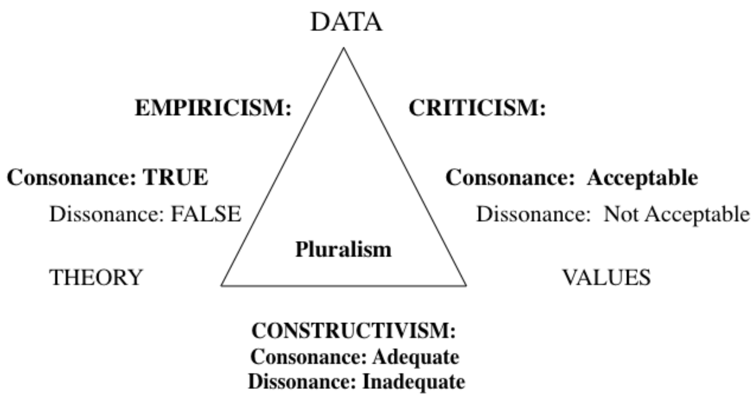

Figure 2: Empiricism, criticism and constructivism

Galtung's framework was well integrated into the results, especially the lack of constructed studies asking about what is adequate and inadequate missed out and are intensely needed to construct the data for greener and more sustainable businesses. There is an increasing number of studies based upon criticism asking about what is acceptable and not acceptable. The critical studies and the constructive studies are representing relevant and engaged research. The majority of studies in the four conferences are empirical studies representing yesterday's practice and theory. Galtung’s model from taken from a working paper in 1972 proved to be very useful and excellent to integrate.

8. The rise and fall of paradigms

The essence of Kuhn's position (1970) is that paradigms serve a normative and conserving function. When a standard prevails in a discipline, "normal" science practice evolves as a puzzle-solving activity. During normal science, the scientific community works under the assumption that "it knows what the world is like," and is prepared to defend this assumption "at any cost." (Kuhn 1970: 5). Very often, normal science suppresses "major novelties, conceptual or phenomenal" (Kuhn 1970:36). According to the traditional viewpoint or preconception, scientists are mainly preoccupied with solving problems/puzzles according to accepted specific rules. With such anomalies built up and scientists losing faith, the field enters the crisis stage.

Kuhn writes that "there can be a sort of scientific research without paradigms, schools, perspectives"… (1970:11), in such research "… though the field's practitioners were scientists, the new findings of their activity were something less than science or social science" (1970:13). He further notes that "… every individual researcher starts over again from the beginning" (1970: 13), that some competing schools are directing their publications where they may be published. A continued discussion over the same fundamentals and no scientific progress is made at all" (1970: 159).

We may sum up Kuhn (1970) in this way:

1. Only readily available facts are collected.
2. At this stage, all facts seem equally relevant.
3. The instruments are overemphasized and often presented in “quasi-fanciful” ways to get “false” respect.

If we look at knowledge management research at ECKM, we conclude that this is the situation for more than 80% of the papers. The 2020 papers were more scientific than the 2017, 2018, and 2019 papers – 71% versus 83%. There is in 2020 progress in making knowledge management more scientific and robust. We found that Kuhn's description fit the situation in knowledge management research well. It looks like every researcher starts over again from the beginning with was easily collected survey, and case data are assembled and presented in fancy scientific ways. The papers in 2020 (24%) upon sustainable businesses, greener businesses and societies, and the future of knowledge work represent a positive change. Kuhn's description of the state-of-art in a pre-paradigmatic stage fits completely with state-of-the-art knowledge management. Facts are collected where the researchers can get them most often in extensive emails surveys with low response rates. An enormous number of facts seem equally essential, and everything is presented in state-of-the-art advanced statistics. We will conclude that this is a form of science with low creativity, relevance, and engagedness. We get a ben-over-here-it. Comes-again feeling, but this descriptive research might have a high recognition rate for established practices.

The papers in 2020 on sustainability, gender equality, and new professional working forms 2020 opened up perhaps for a new generation of critical business and societal researchers at ECKM. We found for the first time as much as one-third in this group, and then we might get a critical mass of renewers for the subsequent ECKM conferences. The papers might concentrate on new knowledge management paradigms for sustainability, green corporations, and gender issues. The ECKM conference needs common paradigms and shared perspectives.

9. Alternative concepts

The concepts have an essential role in any scientific inquiry. They are usually the anchor point in the interpretation of findings (Blumer 1969 and Baugh 1990). The concepts are the glasses we have used since we got our Ph.D.'s. We discuss two different worlds of ideas. The definitive concept is based on empirical data or "evidence" and often searches for causal relationships.

The more definitive concepts are linked to "what we know and "what we know that we do not know, while the more sensitizing concepts will be related to "what do not know that we know and "what we do not know that we do not know." Sensitizing concepts will advise where to look and will set up and compare alternative views. They will indicate more relationships, and they will be dependent on inductive research methods and precise descriptions. Definitive concepts represent deductive quantitative research methods. For induction, the sample of 0 (imagined sample) or one might be good enough, while deduction requires large samples. Induction is closeness, while deduction is distance. Induction is participation and involvement, while we do not interfere at any price. Induction might be exploring, and actionable while deduction might be explaining without action.

In knowledge management studies, the definitive concepts are taking over the ground of the sensitizing concepts. Taking all the papers and dividing them into one of these ideas, around 65% of the studies rely on definitive deductive theories while 35% rely on inductive sensitizing concepts. In the ECKM 2020, about 55% rely upon definitive concepts, while 45% rely upon inductive sensitizing concepts. The induction process described as “directions along which to look and use intuition and curiosity” instead of facts or data is less used. Intellectual curiosity might be the path to choose for creative scholars. The papers are becoming more inductive and sensitizing in the 2020 conference than the 2017, 2018, and 2019 conferences.

The distinction between definitive and sensitizing concepts worked well as an analytical tool with a simple and usable distinction.

10. Alternative research paradigms

It is here proposed to analyze knowledge management research from four main perspectives. These alternative realities are different meta-theoretical assumptions about the nature of social science. The empirical paradigm where its explanatory power consists of establishing causal variables between variables. The knowledge systems and the knowledge technology relations have a concrete, actual existence and systematic character producing quantitative and qualitative findings according to the need for the societies and businesses. The business world is considered primarily conflict-free and harmonious at a higher level of aggregation. 50% of the studies in 2018 versus 45% of the 2019 papers belong here compared to 38% in 2020. The trend is towards fewer empirical papers.

The materialistic political paradigm where physical events and behavior are the surface manifestations of underlying mechanisms. The materialistic paradigm relies on the assumption of predictable uniformities in the knowledge systems. The world of knowledge systems exchanges is defined by concrete, measurable, ontologically fundamental structures and the interdependencies in knowledge systems. 20 % of the studies in 2018 are here versus 21% in the 2019 conference and 16% in 2020.

The clarified subjectivity paradigm holds that social reality does not exist in any concrete sense but is the product of individuals and organizations' subjective and inter-subjective experiences. According to this paradigm, knowledge behavior must be understood from the employee and organization's viewpoint rather than from the outside observer. We can only get such understanding by direct, give-and-take interaction with the employees and organizations. We can, of course, get in surveys as questionnaires, but then we are defining the questions and the business situation. 25% of the studies in 2018 are here versus 27% of the 2019 studies and 32% of the 2020 studies. The action paradigm (5% of the studies in 2018 and 7% of the studies in 2019 compared to 16% in the 2020 studies) also assumes that what passes for reality is socially determined. The move towards clarified subjective paradigms and action-based paradigms in 2020 is significant. A more sensitizing knowledge concept along subjectively chosen directions demands another kind of research paradigm. The role of knowledge research is to identify the stakeholders in the systems, their goals, interests, and power bases to describe the conflicts and contradictions of the knowledge systems and show how to emancipation, for instance, working smarter or greener. Knowledge management researchers inspired by the action paradigm are concerned with discovering how individuals can link thought and action as a means of transcending their alienation. The papers often analyze the situation where the author is a consultant, owner, or employee. The relationship to the investigated firm is close. The results are own experiences, knowledge, and attitudes from the actual situation resulting in practical and theoretical recommendations.

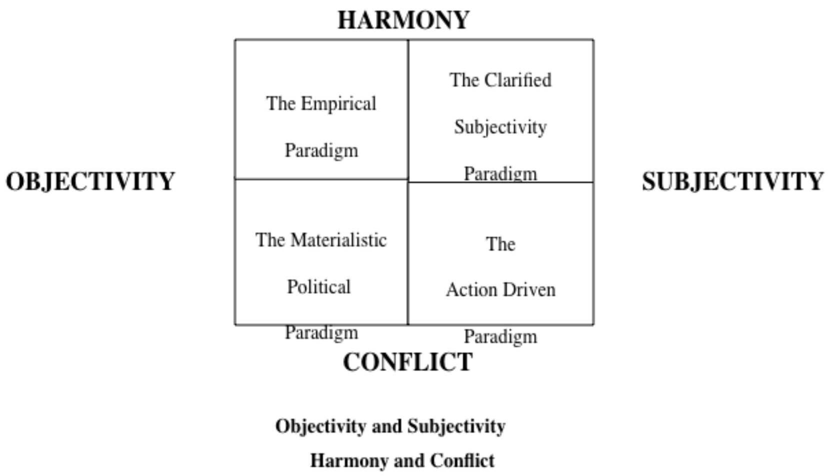

Figure 3: Research paradigms (Olaisen 1984)

The division of papers into four paradigms integrated well with the nature of the papers, and the four conferences moved on from the empirical paradigm to the clarified subjectivity paradigm and further to the action-based paradigm while the materialistic paradigm including a green society. The four paradigms will be well suited to analyze any ECKM conference for many years to come.

11. Alternative action-based cases in 2020

The three papers from Berkeley and Barcelona investigated two restaurants using organic food and wine within 50 km from the restaurant and only employing local staff members. Using only local resources might be a future for many businesses. The three papers action-based research proposed a radical change in how the companies of the future organize. The articles tell a subjective story about the need for change, but they raise actual problems bringing together several social and natural science references. In Barcelona, the tale of Brutal Bar illustrated how the first wine bar with only natural wines started and survived and thrived by only selling natural wines. The taste of wine is evident, a habit that can be changed; the three papers are examples of needed engaged research involving design, innovation, and knowledge. Chez-Panisse in Berkeley has thrived for more than thirty years under the same manager and has always been global in tastes and quality, serving both the affluent and not so affluent on two levels. Chez Panisse is demonstrating that locally produces works to the complete satisfaction of their customers.

We will soon be finding bars for natural wines and restaurants with short-traveled organic food worldwide. The innovation and design of sustainable businesses should be a cornerstone of all research, and there should be more of that kind of research among the proposals rejected. The survival of a large ECKM conference might be based upon such cases.

12. Knowledge management as a part of an open and critical society

The action-driven and the clarified subjectivity paradigms represent a different degree of complexity and subjectivity. They represent both harmony and conflict. Various levels of complexity require different research paradigms; Pluralism is demanded to catch different aspects of reality. Subjectivism is necessary to capture complexity.

Consequently, we will have to define this discipline as a subjective multidiscipline, and we will have to innovate and simulate an experiment to a much higher degree. We will have to accept ad-hoc hypotheses and ad-hoc methodological solutions and the clarified subjectivity. We need to cooperate with businesses and society to research sustainable societies and businesses supporting greener, more thoughtful, and safer solutions. A more engaged knowledge management research field is needed to be a part of the sustainable, global, and digital businesses replacing traditional businesses.

Intuition, imagination, and creativity are needed to handle a high degree of complexity like scenarios for the business future or the green environmental future. We process such complex scenarios in 40 of the papers (9%) where both criticism and constructivism are handled simultaneously to develop what is acceptable and not acceptable for the society going on with what is further adequate and what is inadequate for the businesses. This significance might, as a result, give us a greener, brighter, and safer world where the corporations and societies walk hand-in-hand. We miss subjective and actionable research for a better future in the papers. Also lost is what kind of leadership will take us into a more responsible, sustainable world. The articles represent the status quo and the existing business elite. We have to ask the question of what is acceptable and what is not acceptable. We have to construct our data for this purpose since data in itself does not prove anything. It is only our argumentation that can prove anything. We need constructivism, where we ask what is adequate and what is inadequate for a sustainable future. We have to apply our values for asking the Weberian question (Weber 1938) for a functional business and society or the Popperian problem (Popper 1973) of an open society. The meeting between a constructed reality and an actual reality gives scenarios of adequate and not adequate scenarios.

Consequently, we will have to define these disciplines as a subjective multidiscipline, and we will have to innovate, simulate, and experiment to a much higher degree. We will have to accept ad-hoc hypotheses and ad-hoc methodological solutions and the clarified subjectivity. We need to cooperate with businesses and society to research sustainable firms and organizations supporting greener, more innovative, and safer solutions. A more engaged design, innovation, and knowledge research field must be a part of the sustainable, global, and digital businesses replacing traditional businesses. To keep an open, liberal society, we need a critical discussion about what kind of research will contribute to a greener, brighter, and safer community. Popper (1973), the advocate of the logic of science, was also the advocate of an open society. Popper (1973) explicitly wrote that and free community is a fundament for pluralistic and critical research. Design, innovation, and knowledge are cornerstones built upon a liberal open society. There will not be any progress in these disciplines without a free community. Lakatos's (1970 and 1978) position as a critical rationalist built upon Hegel's theses and antitheses tested and failed through critical discussions between researchers. The synthesis, according to Lakatos, will be subjective as a proposal of as-good-as-it gets at the time being. Knowledge management research is built upon as-is descriptions never falsified or verified, often not exploring and explaining new solutions.

Lakatos's position is, however, built upon a society allowing experimentation, creativity, and discussions. He was a firm believer in Stalin's centralistic Marxism-Leninism. Still, as a professor in logic at Cambridge in the1950's he concluded that only an open society with a balance between the humanities, social sciences, and natural sciences would allow for the antitheses in pluralistic programs and schools. Toulmin's book "The Uses of Argument" (2003) strongly advocates that any truth is relative depending upon the cultural and historical context. Only an open society can provide this context. Toulmin (2003) and Popper (1973) are close to Wittgenstein, proposing that the language as a critical and complex system requires that pluralistic and different views of reality are presented. The question is, why does not such a highly ranked conference open up for a critical discussion of today's procedures and rules for today's outdated way of doing business. Why do so few professors ask the questions about what kind of sustainable business we need tomorrow and what actions take us to tomorrow's sustainable business? The industrialization of the professor's role as an ordinary knowledge worker serving the system as an industrial worker serving the industry might be why. The road from little business science to big business science might give fewer critical research voices. The future of knowledge management is an open critical society that advocates academic freedom to come up with independent critical solutions advocating new green and sustainable paradigms.

13. Synthesis and conclusion

Figure 4 presents a form of synthesis of our reflections. One of the axes represents the degree of complexity, and the other the level of subjectivity. The definitive concepts represent a small degree of subjectivity (i.e., the high degree of objectivity, if possible), while the sensitizing concepts express a high degree of subjectivity. The four paradigms might be subjective or objective. Objectivity does not exist any longer. The problematic question is: if we choose one model, will it then be possible to move on from a low degree of complexity to a higher level of complexity (i.e., can we generalize from a tiny part of reality to a more substantial portion of the fact). Are the models interchangeable? It might be impossible or difficult to move up the line from origo to a higher degree of complexity and from the top to Origo (Alvesson and Skjolberg 2009, Bunge 1967). The knowledge research reality in both sustainability and climate conflicts offers global complexity. To understand this, we must apply subjective paradigms combined with empirical investigations for theory building (Eisenhardt and Grabner, 2007). We have to use sensitizing concepts coupled with actionable definitive ideas. We have a field like knowledge research to understand whether applying it is subjective, but knowledge research should still be systematic and logically rigid.

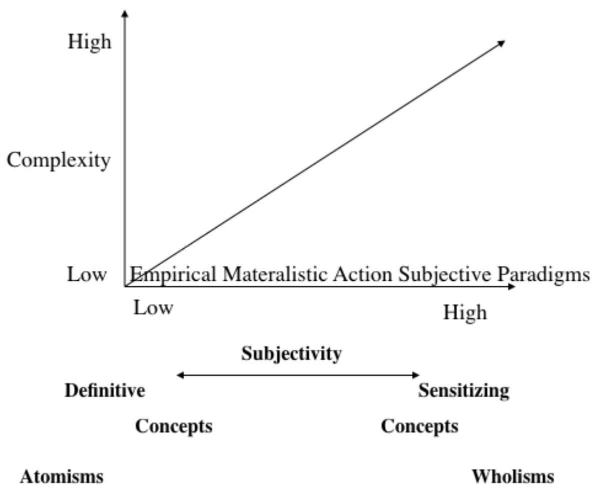

Figure 4: Complexity and subjectivity versus paradigms and concepts

The high complexity world in business is represented by unorder, complexity, chaos, innovation, open rules and procedures, induction, exploring, and exploiting fast facts. Most forward-running businesses are looking for what they do not know that they know. They are operating in many cultures with a high degree of complexity where they are retraining all employees from the university. Digitalization, working greener and more intelligent, robotics, and globalization demand a high degree of complexity and a high degree of subjectivity while globally delivering goods and services, requiring a lower degree of complexity and definitive procedures. The combination of efficiency and effectiveness is the essence of all businesses today and should also focus on future knowledge research. We need researchers saying that this is bullshit in a greener world and researchers saying this is the way to success meeting at future ECKM conferences.

14. The practical implications

The practical implications of the study might be many. Engaged research is problem-focused research looking into the actual problems of our businesses and societies, asking about new solutions and how we can contribute towards more sustainable and greener enterprises and communities, and even dare to ask questions about equality and the distribution of wealth. Imagination and intuition might be more needed than readily available facts to be measured. Creativity is required to formulate the problems and discuss solutions. Pluralism requires combining the empirical paradigm with the action paradigm, and theoretical and conceptual papers need to address how to make progress in information and knowledge management. This progress will come from engaged in practical research. We, however, the practical realities have to be challenged with problems about what is adequate and what is not appropriate for businesses and societies for tomorrow's sustainable reality towards more thoughtful and greener businesses.

We need more relevant knowledge management research to take responsibility for becoming more connected and more applicable. Any organization will have people, organizational structures, organizational processes, technology, tools, and a context. How do we design, innovate, and knowledge leadership working smarter, greener, and safer towards business and societal sustainability? We have to get research that describes, explores, reflects upon, participate, and changes corporations and societies.

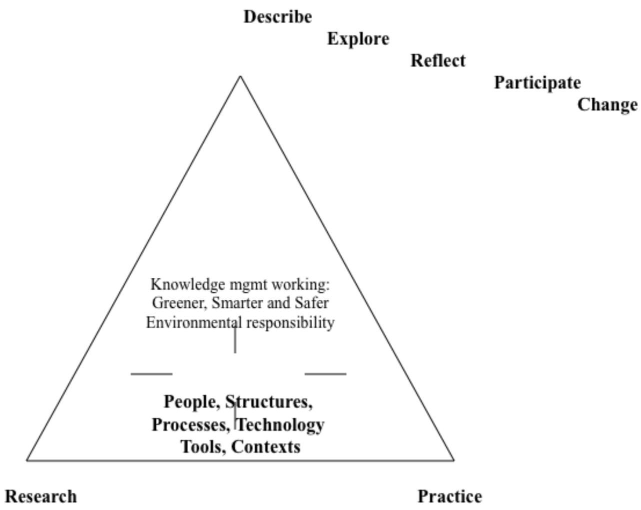

Figure 5: A responsible research agenda

15. The theoretical implications

Our answers to our research questions will also form the theoretical contribution of the study:

1. What is the KM philosophy of science framework characteristics of academic research papers in contemporary KM presented at the ECKM conferences?
   The theoretical implication of contemporary KM is a research field without common paradigms, domains, and perspectives without accumulating knowledge. The KM researchers do not understand the nature of knowledge management as a field where the research cannot be replicated, synthesized, or theorized. Knowledge management needs to move along from the empirical research paradigm to a clarified subjectivity and action-based research. The criticism implying acceptable/unacceptable

solutions and constructed adequate/inadequate solutions for corporations and societies have strengthened their place, offering new paradigms and perspectives.

2. What is the philosophy of science requirements to make KM research more creative, engaged, and relevant?
   There need to be an acceptance that nature and model for KM do not fit the natural sciences and objectivity requirements but need to deliver 50% of the research as part of action-based and clarified subjectivity paradigms.
3. How can we make KM research more creative, engaged, and relevant?
   The only way to do this is to let in controversial, greener, and sustainable studies, whatever objectivity or objectivity the studies have.
4. How can we make KM research contribute to more sustainable and greener businesses?
   The only way is to have a strategy and prioritize these studies on behalf of the objective empirical studies.
5. What are the future characteristics of KM research?
   KM will have a higher responsibility for sustainability and greener corporations and the possibility of accumulating knowledge into replication and synthesizing for general knowledge.
6. What is the rate of tested and replicated, tested but not replicated, and untested KM research?
   The rate of tested and replicated studies is for the four conferences zero. The tested part, but not replicated, is 80-90%. The rate of untested cases is 10-20%.
7. What is the rate of untheorized untheorizable concepts, theorized, but not synthesized and theorized and synthesized KM?
   The rate of untheorized untheorizable concepts is zero, the rate of theorized but not synthesized studies is zero, while the number of synthesized, theorized, and conceptual studies is around 20%. The results only tell about the nature of the concept of knowledge combined with management that is very difficult to theoretician, synthesize and replicate in tests.

16. Limitations and further research

The first limitation to the study is if the ECKM conference is representative of knowledge management research. The second limitation is if the contemporary philosophy of science framework is representative and applicable for the study.
The third limitation is if the coding and classifications are too subjective and work like getting shit in and shit out.
The fourth limitation is a literature review concentrating upon the epistemology of knowledge. The philosophy of knowledge does the KM right compared to a literature review only concentrating upon KM itself.

Further research should identify the most cited KM and use the same contemporary philosophy of science frameworks comparing the results.

Further research should also be done to find acceptable KM research where studies are replicated and compare the results to unreplicated studies.

Further research should also be done identifying theorizing and synthesizing KM studies to evaluate the theorizing and synthesizing towards ordinary KM studies discussing what makes synthesizing and theorizing possible,

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Editorial for the Special Issue of EJKM 2021

For close to 60 years, knowledge management has been emerging, evolving and adapting as a discipline and an area of practice. Over the decades, the field has drawn from many and diverse fields, including economics, education, computer science, business administration, communication, information science, and sociology.

Throughout these years, the heart of the knowledge management domain has been knowledge and people. However, as digital transformation efforts have gradually become both a priority and a critical management issue for businesses of all types, the digital workspace increasingly supports key knowledge management functions such as team collaboration, improved workflows and the sharing and reuse of knowledge assets.

On the 11 March 2020, the World Health Organization declared the COVID-19 outbreak as a pandemic. Our work environment shifted dramatically, and remote work meant that productivity, collaboration and culture were dramatically affected. At that point, those trends that were emerging prior to 2020 accelerated to define our new world. The initial concern of surviving the pandemic turned into unprecedented levels of collaborations and exchange of knowledge between organisations across the globe as they sought to innovate. New knowledge was created to understand and fight the virus. Organisational learning allowed for engineering companies and even universities to design and manufacture personal protective equipment to support the health sector. Knowledge was shared across sectors, as transport manufacturers and companies that normally produced medical devices collaborated for the production of ventilators to treat COVID-19 patients. Throughout this process, knowledge management gained importance as an enabler of our work, performance and innovation.

For organisations that chose –or were forced, to work remotely, knowledge management provided improved mechanisms to collaborate and share resources, capture the knowledge from experts who retired or change jobs as a result of the pandemic, and even establish new connections and a culture of learning. Today, knowledge management programs have become enterprise-wide and cross-corporate initiatives, increasingly central to any forward-looking business strategy.

Whilst still in the midst of a worldwide pandemic when this special issue was moving to publication, the debate in many organisations has shifted to the feasibility of the full return to the office and the extent to which technology-enabled remote and hybrid work will become the norm. This scenario would require a new level of maturity for knowledge management strategies and tools, so that the discipline continues to enable long-term performance as we transition from an industrial to a knowledge economy.

To achieve this, knowledge management scholars and practitioners will need to remain focused on challenges that pre-dated the pandemic, such as the development and improvement of knowledge management programs, as well as metrics that allow for quantification of their business value. A better understanding of its impact on the bottom line will help increase participation, engagement and support for knowledge management. The ways traditional in-person experiences are transferred to a virtual environment to enable knowledge flows in a work environment heavily dominated by technologies will also require further attention. While significant progress has been made since the start of 2020, the impact of remote and hybrid work on the effectiveness of knowledge management is only now beginning to be understood. There is a need to study how this new context enables, for example, collaboration across organisational boundaries. Monitoring and surveillance of employees working remotely have also increased, which may have a negative effect of knowledge sharing and adoption.

However, our constantly changing environment has also highlighted the need for the knowledge management discipline –enabled by the right technology, to expand its support to most business priorities. Take Artificial Intelligence (AI) as an example. While its principles are being widely adopted, many organisations have found themselves unable to make AI work for them. In theory, AI can help with automation of processes such as knowledge capture and harvesting, supporting knowledge search and discovery strategies, and ultimately driving better financial and operational performance. However, in order for AI –and technologies in general, to deliver on their promises, a solid knowledge management foundation is required. For example, contents that would drive decisions should be accurate and up to date; competencies that would drive collaborations should be accurately described and quantified; different repositories should be aligned in their content classification strategies.

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Knowledge management is also key to the digital resilience of the business. For example, in responding to the cyberattack that affected Norsk Hydro –one of the world's largest aluminium producers in 2019, the company had to overcome operational, threat-related, and technological knowledge barriers. A key theme throughout its response was that the company was able to effectively identify, capture and use necessary knowledge both within and outside of its boundaries. Examples of this ranged from its ability to regain otherwise lost know-how (from retirees and ex-employees), to the effective involvement of law enforcement and industry partners as sources of technical and procedural know-how.

In addition to increased productivity and the sustainable digital transformation of the enterprise, knowledge management can have a positive impact on strategic and operational areas including the quality of products and services; the organisation's ability to innovate; customer and employee experience; continuous learning at individual and organisational levels in the digital workspace; and even diversity and inclusion in the workplace. However, its success in achieving this impact requires the knowledge management discipline to continue to integrate both with information technologies and with the strategic goals of the organisation through key management functions such as risk management and value management.

This special issue was developed to bring together the experience of knowledge management scholars and practitioners on the challenges and opportunities of the discipline in the current socio-economic context. These articles cover subjects ranging from communities of practice to digital transformation, ethics and human behaviour, all of which determine the way the knowledge management discipline can rise to the stature of other business functions and operations. It is hoped that the issue will contribute to the current debate on how knowledge management can align with, and support the way the organisation works today and in the future.

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