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HARNESSING THE INNOVATIVE POTENTIAL OF KNOWLEDGE IN THE DIGITAL ENTERPRISE

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Abstract

The open, flexible affordances of pervasive digital technologies have fundamentally altered the nature of organisational innovation. In the extreme, these technologies become platforms for digitally enacted organisational innovation. At its core, innovation is a process of creating and using new ideas and concepts. In the digital realm innovation becomes a process of enacted knowledge creation. This research contributes to a growing discourse on the relationship between innovation and knowledge creation by building and testing a hybrid model of organisational knowledge creation and innovation. Its findings illustrate the utility of using knowledge-based perspectives to investigate organisational innovation and have significant implications for fostering digital innovation in the firm.

1   Introduction

Accelerated by rapid growth in digital technologies, the emergence of the knowledge economy was first observed forty years ago (Heffner and Sharif, 2008). Today, the importance of knowledge for organisational success is well recognised (Lubit, 2001). It is the key resource of individual firms (Gao *et al.,* 2008) as well as the core driver of business performance (Schiuma *et al.*, 2012) and competitive advantage (Taminiau *et al.,* 2009). As digital technologies have become increasingly interactive, immersive and pervasive (Yoo *et al.,* 2012), the discourse about knowledge in organisations has also evolved. In particular, the information-processing paradigm of old has given way to new ideas about the relationship between knowledge and innovation (O Riordan, 2011; Lam, 2006; Kogut and Zander, 1992). A growing body of research is explicitly based on the assertion that when organisations innovate, they "do not simply process information… they actually create new knowledge and information, from the inside out, in order to redefine both problems and solutions and, in the process, to re-create the environment" (Nonaka and Takeuchi, 1995, p.56). The main goal of this research is to optimise the firm's capacity to create and apply new knowledge (e.g. Quintane *et al.,* 2011; Jakubik, 2008; Martin-de-Castro *et al.,* 2008)

Yet despite its importance, there is very little understanding of how knowledge in firms is created (Yang *et al.,* 2010; McFayden and Cannella, 2004). Similarly, there is little understanding of how the knowledge creation process can be effectively managed (cf. Yang *et al.,* 2010) or evaluated (cf. Chen and Edgington, 2005). The problem arises because at its core, the literature on knowledge in organisations is based on a profound definitional ambiguity about knowledge itself: it remains "a broad and abstract notion" (Alavi and Leidner, 2001, p. 107), "a loose, ambiguous, and rich concept" (Alvesson and Kärreman, 2001, pp. 997–1012), or "one of those 'vague words' one is at times compelled to use" (Dewey and Bentley, 1949, pp. 48, 87). In short, the concept of knowledge is "far too problematic to bear the weight of a useful theory of the firm without a clear statement of the epistemology which gives it meaning" (Spender, 1996, p. 48). Thus, the enthusiasm for the idea that knowledge is the most strategic of corporate assets has "not been matched by an understanding of how to operationalise knowledge" in organisations (Marr and Spender, 2004, p. 183).

This study is motivated by the need to address the conceptual shortcomings of previous research on organisational knowledge creation. Its research objective is to rigorously develop and test a new theory of knowledge creation. In addition to developing a new theory of organisational knowledge creation that can be used for both diagnostic and prescriptive purposes, the core contributions of this study lie in identifying the specific conceptual shortcomings that have hampered previous efforts to investigate the relationship between organisational knowledge creation and innovation. The remainder of this paper is structured as follows: Section 2 presents a literature review that identifies and critiques extant conceptualisations of knowledge in firms before leveraging the literature to derive a new conceptualisation of organisational knowledge creation specifically. Section 3 describes the empirical element of the study (which involves the collection of data on six case studies of organisational knowledge creation in virtual worlds) and its findings are presented in Section 4. Section 5 presents a broad discussion of the study itself and concludes with a brief discussion of directions for future research.

2   Literature Review

This section begins by presenting three distinct perspectives on knowledge in firms. These are critically reviewed in Section 2.2; and on the basis of that analysis, Section 2.3 articulates a new conceptualisation of organisational knowledge creation.

2.1   Three existing perspectives on knowledge in literature

At a high level, three distinct perspectives on knowledge have emerged in the literature over time (summarised in Table 1). The original view of knowledge emerged as the first wave of digital technologies was taking hold in organisational life. This view is highly computational in nature and is

primarily focused on exploring the relationships between data, information and knowledge (Alavi and Leidner, 2001). Researchers in this tradition have argued that knowledge is information that has been personalised (Machlup, 1980), interpreted (Robert, 2009), authenticated (Dreske, 1981) or articulated (Alavi and Leidner, 2001). Researchers taking this stance have equated effective information provision with effective knowledge management to the extent using the terms interchangeably in their research (Holsapple, 2005). The primary goal has been to improve organisational competitiveness through effective information provision (March, 1987). Despite the appeal of this view in terms of simplifying the research agenda of KM scholars, it has largely been discredited. It is argued that the claim that knowledge must have some element of 'truth' within it, that it can be objectively known or that it is 'authenticated' information, contradicts the view that notion that knowledge is personalised, subjective interpretation. Similarly, it is difficult to reconcile the view that knowledge can in some sense be 'translated' into information and shared with the view that knowledge cannot exist outside the individual.

	1. Informate!	**2. Activate!**	**3. Ideate!**
Description:	A computational view of knowledge that sees knowledge as an object to be translated into or derived from information and data	A process-oriented view of knowledge that sees knowledge as a capacity for action that arises out of action or experience	A cognitivist view of knowledge that underlines the role of knowledge creation specifically in innovation
Key technologies:	1st generation technologies *(e.g. transaction processing systems and management information systems)*	2nd generation systems *(e.g, knowledge management platforms and dynamic communication **networks**)*	3rd generation systems *(e.g. interactive, immersive and pervasive technology-mediated **environments**)*
Key authors:	Bell (1976) Machlup (1980) Dreske (1981) Grimaldi & Torrisi (2001) Leonard-Barton & Sensiper (1998)	Huber (1991) Nonaka (1994) Schubert *et al.* (1998) Davenport & Prusak (1998)	Nonaka (1994) Nonaka & Takeuchi (1995 p. viii) Nonaka & Konno (1998, p. 42)

Table 1.   Traditional and emerging perspectives on organisational knowledge

The transition from a computational lens to a process-oriented lens coincided with the emergence of large-scale knowledge warehouses and dynamic communication networks (Kuhlen, 2004) and it came to be recognised that too much irrelevant information is worse than too little relevant information (cf. Ackoff, 1967). Instead, researchers began to view individuals and organisations as 'actors'; as purposeful agents, navigating seas of information, looking to improve their capacity for action by means of interaction, communication and shared experience. In short, the next generation of KM focused on knowledge in action or knowledge as action. Researchers in this tradition argue that knowledge is a capacity for effective action (Huber, 1991). It arises out of action or experience (Schubert *et al.,* 1998). It is a dynamic human process (Nonaka and Takeuchi, 1995) or an ongoing social accomplishment (Orlikowski, 2002), that constituted and reconstituted as actors engage the world in practice (ibid.). Finally, it is purposeful: it is indelibly shaped by one's needs as well as one's initial stock of knowledge (Tuomi, 1999). By implication, this view of knowledge discourages efforts to transform information into knowledge and vice versa. Indeed, Heffner and Sharif (2008) assert that knowledge simply "cannot be divorced from context and transmitted either as abstract data or as universally applicable approaches to problem solving". Thus, researchers in this tradition have focused on understanding knowledge from a dynamic perspective but have struggled take adequate account of knowledge creators' initial stocks of knowledge in their research.

More recently, the main focus of KM research has shifted once more and it is increasingly argued that *the capacity to create and apply new knowledge* is the main source of the competitive advantage of the firm (e.g. Jakubik, 2008; Martin-de-Castro *et al.,* 2008; Von Krogh, 1998; Spender, 1996; Leonard-Barton, 1990). Again, this reorientation reflects the ongoing evolution of digital technologies, which have now become pervasive, generative platforms (Yoo *et al.,* 2012): foundations with the capacity to produce unprompted change (Zittrain 2006, p. 1980) and to support the development of products, technologies or services (Gawer 2009, p. 2). Thus, theorising about knowledge in this tradition goes

beyond user-aided, participatory design to consider users as designers in their own right, actively engaged in the ongoing act of knowledge creation (O Riordan, 2012). In this view, knowledge creation lies at the very heart of organisational innovation (Quintane *et al.,* 2011; Popadiuk and Choo, 2006; Lam, 2006; Swan *et al.,* 1999). Indeed, innovation is increasingly defined in terms of knowledge creation: Gold *et al.* (2001) define innovation as "the creation of new knowledge from the application of existing knowledge" (p.190) and Nonaka (1994) defines innovation as "a process in which the organisation actively develops new knowledge to solve problems" that they create and define (p. 14). The significance of research in this tradition is well illustrated by the fact that Nonaka's (1991, 1994) 'SECI' theory of knowledge creation remains one of the most widely cited theories in knowledge management (Cao *et al.,* 2010). Indeed, various authors have extended it (e.g. Vera and Crossan and Apaydin, 2010; Heffner and Sharif, 2008; Yang *et al.,* 2010) and proposed alternatives to it (e.g. Nonaka and Konno, 1998; Propp, 1999). Nevertheless, the enthusiasm for the idea that knowledge is the most strategic of corporate assets has "not been matched by an understanding of how to operationalise knowledge" in organisations (Marr and Spender, 2004, p. 183). In particular, we still have little real understanding of how knowledge is created (McFayden and Cannella, 2004) in firms, how the knowledge creation process can be effectively managed (Yang *et al.,* 2010), or how it can be evaluated (Chen and Edgington, 2005).

In the next section, we argue that these shortcomings have arisen because of significant conceptual weaknesses associated with extant conceptualisation of knowledge in all three views.

2.2   Problem Statement

Fundamentally, the level of interest in knowledge creation has not been matched with empirical research. The underlying problem is that all of these models rely on the distinction between tacit and explicit knowledge (Martín-de-Castro *et al.,* 2008). This distinction is proposed by Polanyi (1966), who argues that explicit knowledge is only a small part of our knowledge. Explicit knowledge can be articulated or represented using writing or other symbols. But there is another type of knowledge that is not so easily shared. In his words, "we can know more than we can tell" (Polanyi, 1966, p. 4). For Polanyi, tacit knowledge forms the background necessary for assigning the structure to develop and interpret explicit knowledge (Alavi and Leidner, 2001). Whilst explicit knowledge has the character of a public good (with the exception of patents or copyrights), tacit knowledge is acquired by and stored within individuals and cannot be transferred or traded as a separate entity (Osterloh and Frey, 2000). Thus, one can "identify one face out of thousands, but it is nearly impossible to give an adequate description of this face to another person, so that she is able to identify the face" (Polanyi, 1966, p.4). Polanyi also recognises that though some knowledge is fully tacit ("proximal knowledge"), "distal knowledge" has the potential at least to become known. Given adequate means of expression, we can communicate that which cannot be put in words.

Conceptually, it is incorrect to view tacit knowledge and explicit knowledge as distinct categories or types of knowledge (Tsoukas, 2005). Polanyi (1975) is explicit: the two are not dichotomous; they are mutually dependent and reinforcing qualities of knowledge. As a result, authors such as Tsoukas (2005), and Zander & Kogut (1995) argue that the distinction should be understood as a continuum rather than as a dichotomy. Similarly, Gourlay (2006) argues that there is "always an irreducibly tacit aspect to any explicit knowledge/knowing" (p. 1422), arguing that any model of knowledge creation processes that begins with tacit knowledge must account in some way for inherently as well as contingently tacit knowledge. Empirically, researchers have also struggled to operationalise the classification (Rice and Rice, 2005) and have routinely distorted the classification to hold that data and information are explicit, and knowledge and wisdom are tacit (Faucher *et al.,* 2008). All of these difficulties have been inherited in existing knowledge creation models. In the SECI model, for example, Adler (1995) indicates that the contrast between the two is too rigid to be able to take account of tacit-explicit knowledge inter-relatedness. Conversely, Rice and Rice (2005) conclude that the empirical difficulties associated with testing the SECI model stem from the fact that the boundaries between explicit and tacit knowledge are indistinct.

Thus, where the traditional view was that the goal of KMS was to try to make tacit knowledge explicit (Faucher *et al.,* 2008), it is increasingly recognised that the assumption that explicit knowledge is more valuable to organisations is "tantamount to equating an inability to articulate knowledge with its worth" (Alavi and Leidner, 2001, p.111) and indeed that the formalisation of "all knowledge to the exclusion of any tacit knowing is self-defeating" (Polanyi, 1966, p.4).

Based on this analysis, the next section articulates a new conceptualisation of knowledge creation based on the analysis presented in Section 2.1.

2.3   Deriving a new conceptualisation of knowledge creation

Our conceptualisation of knowledge creation is articulated as five assertions that are drawn from these three perspectives of knowledge. With the exception of the first assertion (which is a significant departure from existing research), each assertion is endorsed by multiple researchers, across all three perspectives on knowledge presented above (see Appendix A). In this way, we have endeavoured to 'triangulate' existing perspectives prior to synthesis. This characterisation facilitates closer alignment of research on knowledge and innovation (newness) because it focuses on new knowledge or new formulations of existing knowledge. It can be stated as follows: *knowledge, which exists in declarative and procedural forms, is created when changes take place in mental frameworks that are used to evaluate and incorporate new experiences and information. These changes occur through experience by means of ongoing, socially enacted processes, are shaped by one's needs and initial knowledge frameworks, and affect capacities for action.* Each assertion is discussed in turn.

2.3.1   Knowledge exists in declarative and procedural forms

The concept of different types of knowledge is a pervasive theme in literature (Nahapiet and Ghoshal, 1998). In this study, we distinguish between declarative and procedural knowledge. The distinction was proposed by Ryle (1945), who distinguished between know-what and know-how. Ryle indicated that know-what consists of learning that something is the case whilst know-how consists of things like learning to play the piano or to prune trees (Ryle, 2002, p. 28). Declarative knowledge is defined as actual knowledge, expressed in propositions (Andersen, 1983); as knowing about something (Zack, 1999); and is said to concern the development of facts and propositions (Nahapiet and Ghoshal, 1998). Procedural knowledge is defined as methodological knowledge which is used for activities such as remembering how to ride a bicycle or play the piano (Andersen, 1983); as knowledge about something (Zack, 1999); and is said to concern well-practiced skills and routines (Nahapiet and Ghoshal, 1998). The distinction between know-what and know-how was subsequently developed by Anderson (1976, 1983). Anderson (1976) indicates that there are three essential differences between the two types of knowledge. Declarative knowledge is verbally communicable, is acquired suddenly by means of instruction and is possessed entirely or not at all. Procedural knowledge is not verbally communicable, is gradually acquired by means of performance of a skill and may be partially possessed. Indeed, research on implicit learning and cognitive neuroscience evidence indicates that "these two types of knowledge are implemented neurally in fundamentally different ways" (Anderson and Lebiere, 1998, p. 21). The use of this classification is well motivated. First, it is well established (cf. Ryle, 1945; Anderson, 1976, 1983; Nahapiet and Ghoshal, 1998) but has been overlooked in previous research on knowledge creation. Second, numerous authors (e.g. Walsh, 1995; Kogut and Zander, 1996; Nahapiet and Ghoshal, 1998; Zack, 1999) have argued in favour of distinguishing between declarative and procedural knowledge. Indeed, Polanyi himself acknowledged that knowing what (declarative knowledge) and knowing how (procedural knowledge) are distinct. Third, it more accurately reflects the neural implementation of knowledge in the brain: "these two types of knowledge are implemented neurally in fundamentally different ways" (Anderson and Lebiere, 1998, p.21). Finally, this classification maps more neatly onto the distinction between process and product innovation and so will facilitate research on knowledge creation in the two domains.

2.3.2   Knowledge is created when changes take place in mental frameworks

The assertion that knowledge is a mental phenomenon is pervasive across all three streams of research. In the informate view, Tuomi (1999) argues that knowledge does not exist outside of an agent or knower. Similarly, it is argued that knowledge is a reformulation or interpretation of information

(Robert 2009) and experience (Leonard-Barton and Sensiper, 1998). Davenport and Prusak (1998), emphasising knowledge-in-action, argue that knowledge originates and is applied in the minds of knowers. Finally, McFayden and Cannella (2004), operating in the ideation view, argue that knowledge resides within and is created by individual (p. 736).

2.3.3   Knowledge creation occurs through experience and ongoing social processes

The assertion that knowledge is based at least partially on experience is in evidence in the traditional information-based view of knowledge (e.g. Leonard-Barton and Sensiper, 1998) but is strongest in the literature on knowledge in action. Here, Schubert *et al.* (1998) argue that knowledge is a condition of understanding gained through experience or study; the sum or range of what has been perceived, discovered, or learned. This view is echoed by Orlikowski (2002), who argues that knowing is not a static embedded capability or stable disposition of actors, but rather an ongoing social accomplishment, constituted and reconstituted as actors engage the world in practice.

2.3.4   Knowledge creation is shaped by one's needs and initial mental frameworks

If knowledge is viewed in terms of mental frameworks and if knowledge creation occurs through experience, then by implication, one's initial knowledge frameworks shape knowledge creation outcomes. The strength of this assertion is that it highlights the role of prior knowledge in shaping knowledge creation outcomes, thereby taking account of the fact that knowledge creation outcomes are contingent and contextual. This argument is well supported in existing literature on knowledge. Tuomi (1999), for example, argues that knowledge is indelibly shaped by one's needs and initial stock of knowledge). Nevertheless, this assertion remains curiously absent in extant literature on knowledge creation. By implication, this perspective signals a departure from existing research based on the capture or acquisition of knowledge and directs researchers to search for better and more nuanced ways to evaluate knowledge creation outcomes and to evaluate the success of KM interventions.

2.3.5   Knowledge creation affects one's capacity for action

Finally, the assertion that knowledge creation affects one's capacity for action is well supported. Leonard-Barton and Sensiper (1998), whilst adhering to the information-based view of knowledge, acknowledge that knowledge is actionable. Huber (1991) and Nonaka (1994) go further, arguing that knowledge increases an entity's capacity for effective action. Similarly, Davenport and Prusak (1998) argue that knowledge provides a framework for evaluating and incorporating new experiences and information (p. 3). Finally, Bennet and Bennet (1998) clarify that knowledge can be viewed as the capacity or the potential capacity to take action.

Though existing literature provides an adequate basis upon which to reconceptualise knowledge creation, it sheds little light on how to go about diagnosing the knowledge creation needs of individuals in firms or on evaluating the efficacy of particular knowledge creation processes for individuals in firms. To answer these kinds of questions, we conducted a qualitative investigation of knowledge creation in six case studies prior to formulating a conceptual framework of knowledge creation in organisations. This investigation is described in the next section.

3   Research Design

The conceptualisation of knowledge creation presented in Section 2.3 is significant because it provides a starting point for asking the kinds of questions that lead to the formulation of theory. However, it was necessary to collect empirical data on knowledge creation in firms to be able to answer the kinds of question it suggests. In the empirical element of this study, we focused on two of these questions. First: if knowledge creation is shaped by initial stocks of knowledge, then is it possible to (empirically) classify initial knowledge stocks. This question is interesting because it provides a starting point for evaluating knowledge creation outcomes and for assessing the relationship between prior knowledge and knowledge creation itself). Second, if knowledge creation is triggered by experiences, then are there particular kinds of experience that are more likely to lead to knowledge creation than others (taking into account the importance of prior knowledge)? This question is interesting because it provides a starting point for maximising knowledge creation in firms (for generating prescriptive advice for practitioners in terms of how to stimulate knowledge creation).

In order to answer these questions, we collected data from six case studies of knowledge creation in virtual worlds. The initial motivation for conducting the study in a technologically-mediated environment was based on our interest in the relationship between emerging digital technologies and organisational knowledge creation. Virtual worlds were specifically chosen for their novelty and uniqueness: one can expect high levels of knowledge creation – as it is defined in this study – to occur in highly novel situations. In addition, newly created knowledge about virtual worlds would be domain specific. This would facilitate comparison across cases. At the same time, virtual worlds provide inimitably detailed records on individuals' actions and interactions both with each other and with the environment itself, which could be used for the purposes of data analysis. The sampling strategy was initially reduced to higher educational institutions in Second Life because this was where the highest concentration of organisations was to be found and because there was a degree of homogeneity amongst these institutions: they would have similar levels of prior knowledge about the domain of higher education and similar levels of prior knowledge about virtual worlds. A criterion sampling technique was devised in order to identify innovative higher education projects carried out in Second Life as potential cases consisting of at least three individuals. Ultimately six case studies were carried out (summarised in Table 2). The unit of analysis was the "innovative virtual world project".

Case 1	To bring students into a virtual world; an intrinsically cybernetic and artificial cultural landscape, born of science fiction and inhabited by the virtual human in order to explore the implications of scientific and technical advances for the future of humanity
Case 2	To leverage the unique affordances of Second Life to create educational materials that could not feasibly be created using other technologies and to package those materials by means of a Machinima video so that they could be published online for future use
Case 3	To use Second Life to create demonstrations and simulations of animation algorithm concepts that are difficult or impossible to create in the real world
Case 4	To use scenario driven and problem based learning to improve nurses' skills in taking patient histories and undertaking physical examinations in real life
Case 5	To follow a structured and formalised research agenda over a three year period in order to incrementally develop and use a virtual laboratory in Second Life to teach lab and experimental skills to science students
Case 6	To improve students' chances of being hired as border control officers by allowing them to rehearse the role of a border control officer in a virtual border setting

Table 2.   Summary of the case studies

A combination of participant observation and interview methods were used to collect the data for the study. This combination was effective in terms of corroborating, validating and triangulating data in the unfamiliar research context of a virtual world. Data was analysed using a variety of techniques (coding, including pattern coding; memoing; structured case documentation; sequential analyses; within case displays for exploration and description; cross case displays for exploration and description) that are explained by Miles and Huberman (1994).

4   Research Findings

The main findings have been synthesised into a theoretical model of knowledge creation (Figure 1). Given the space constraints at play, our findings are presented in the course of explaining the model.

4.1.1   Four knowledge creator archetypes

Our research model was initially based on the conceptualisation of knowledge creation presented above. It began with the assertion that knowledge is a collection of mental frameworks, that contain declarative and procedural elements, and that are used (and are useful) in everyday life in an intentional and volitional manner. In this study, this assertion was used as a starting point for identifying four knowledge creator archetypes. Specifically, each respondent was asked about their initial knowledge and to evaluate whether it was 'high' or 'low'. Their answers were verified where possible through the collection of additional data or by means of participant observation. Using this approach, each participant was successfully classified as one of four archetypes. The first archetype,
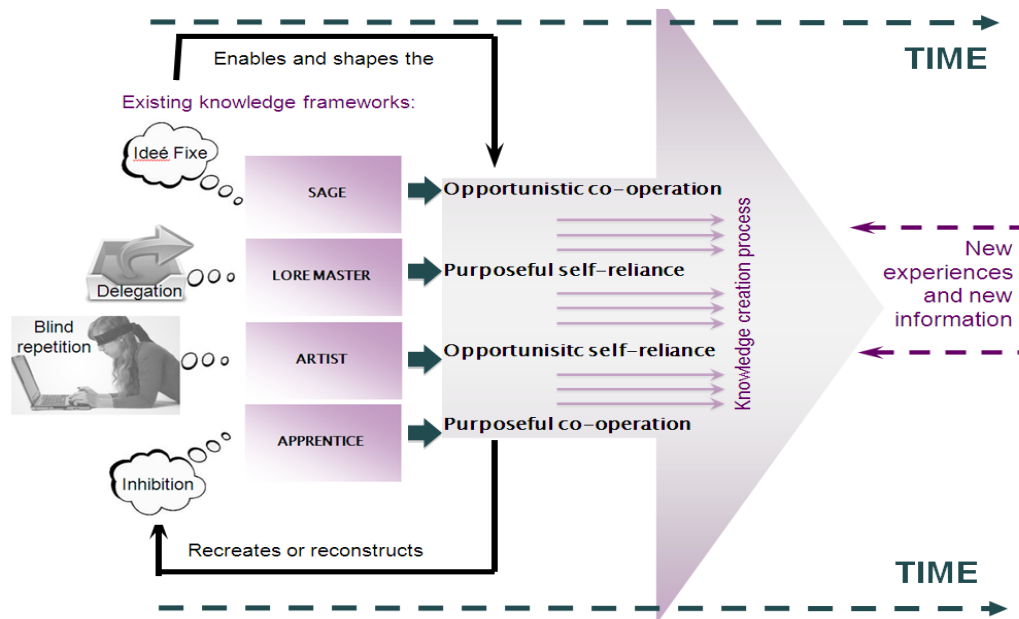
Figure 1.   *Conceptual Framework of Organisational Knowledge Creation*

the **sage**, has the capacity to draw on high levels of declarative knowledge but this is not matched with high levels of procedural knowledge. This archetype is contrasted with the third archetype, the **artist**, who has the capacity to draw on high levels of procedural knowledge but this is not matched with high levels of declarative knowledge. The second archetype is the **lore master**. This knowledge creator has the capacity to draw on high levels of both declarative and procedural knowledge in a given knowledge creation context. This archetype stands in contrast with the fourth archetype: the **apprentice**. The apprentice has the capacity to draw on low levels of both declarative and procedural knowledge in a given knowledge creation context. The interview data also supports the assertion that existing knowledge frameworks significantly affect knowledge creation outcomes both in terms of how participants responded to interview questions and in terms of how they described their activities and experiences in virtual worlds more generally. There was broad consensus that prior knowledge was important for knowledge creation and that it played an important part in facilitating innovation and creative thought: "you need to know the script before you can break away from it" (Case1/Resp.1).

4.1.2   Four types of knowledge creation behaviour

Our research model began with the assertion that knowledge is created through experience and through ongoing socially enacted processes. That is to say, knowledge is created (i.e. these frameworks are maintained and updated) by means of socially enacted (knowledge-creating) enactments, which are experienced in a way that is indelibly tinted by those self same frameworks. Thus, opportunities for knowledge creation exist whenever potential knowledge creators encounter new experiences and new information. Within the six case studies, we identified 15 distinct behaviours that led directly to the creation of knowledge. These were initially classified as being exploratory or exploitative and a distinction was also made between inward-looking or internal activities and outward-looking or external activities. Using this classification, six behaviours were exploratory and nine were exploitative; whilst eight were inward-looking or internal and nine were outward-looking or external. The analysis of this data cannot be presented in this paper due to space constraints. However, we were able to cross tabulate self reported data on knowledge creation outcomes with data on knowledge creator archetypes and knowledge creating behaviours in order to identify the four behavioural strategies that led to improved knowledge creation outcomes in the cases. This information is captured in Figure 1, which associates each of the four knowledge creator archetypes with a particular behavioural strategy. For example, those with high levels of declarative and procedural knowledge – sages, in the language of the model – report comparatively higher levels of

knowledge creation when engaged in opportunistic and cooperative activities. Conversely, those with low levels of declarative and procedural knowledge – apprentices, in the language of the model – report comparatively higher levels of knowledge creation when engaged in purposeful and cooperative activities. Similarly, those with low levels of procedural knowledge (only) were best served by activities geared around self reliance (which facilitated the development of procedural knowledge).

5 Conclusion

The core contribution of this study lies in arguing for and empirically demonstrating the centrality of knowledge creation in (digitally-enabled) organisational innovation. The paper begins by reviewing the knowledge management literature at a high level, suggesting that scholars in the field are increasingly vocal about the centrality of knowledge creation for innovation. However, a closer analysis of the literature then identifies significant conceptual flaws in existing knowledge creation theories. Based on this analysis, the paper derives a new conceptualisation of knowledge creation from existing literature. At its core, this conceptualisation is based on the distinction between declarative and procedural knowledge. This represents a significant departure from recent studies and by illustrating the merit of basing a new theory of knowledge creation on this distinction, the study redirects future research back to declarative and procedural *forms* of knowledge rather than the tacit and explicit *dimensions* of knowledge. At the same time, it highlights the importance of prior knowledge in determining knowledge creation outcomes. Whereas Cohen and Levinthal (1990) argue that an organisation's ability to evaluate and utilise new information is "largely a function of prior related knowledge" (p. 128), this study is one of the first of its kind to explicitly argue that prior knowledge is central to *knowledge creation*. In addition, the results of an empirical investigation of knowledge creation in virtual worlds were also used to develop a new conceptual framework of organisational knowledge creation. This framework can be used to guide future research on knowledge creation in a variety of ways. In the first instance, the framework directs future researchers to focus on developing new ways of assessing existing knowledge levels in different contexts. Future research is also needed to explore the proposed archetypes in greater detail. In particular, there is a need to establish the validity and utility of distinguishing between four archetypes. At the same time, future research is needed to establish how IS/IT interventions should be designed to support the interactions between existing knowledge frameworks and the knowledge creation process in each of the four modalities that are suggested by the four archetypes. Finally, the framework is intended to operate at multiple levels of analysis. This means that it can be used as a basis upon which to explore the interactions that occur between knowledge creation processes at different levels of analysis (e.g. at the individual level versus the group level).

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Appendix A

Assertion 1. Knowledge is created when changes take place in mental frameworks	
Origins in literature:	
Informate	Knowledge does not exist outside of an agent or knower (Tuomi, 1999)
Activate	Knowledge originates and is applied in the minds of knowers (Davenport and Prusak, 1998)
Informate	Knowledge is a reformulation or interpretation of information and experience (Robert 2009)
Informate	Knowledge is possessed in the mind of individuals (Alavi and Leidner, 2001)
Ideate	Knowledge resides within and is created by individual" (McFayden and Cannella, 2004, p. 736). Therefore knowledge creation is a "path-dependent process… [whereby] newly acquired inputs are integrated with existing knowledge" (McFayden and Cannella 2004, pp. 735-736)
Assertion 2. Knowledge creation occurs through experience and ongoing, socially enacted process	
Origins in literature:	
Informate	Knowledge is based at least partially on experience (Leonard-Barton and Sensiper, 1998)
Informate	Knowledge is linked to meaningful behaviour
Activate	Knowledge is conceptualised as knowing in practice; knowing is not a static embedded capability or stable disposition of actors, but rather an ongoing social accomplishment, constituted and reconstituted as actors engage the world in practice (Orlikowski, 2002)
Activate	Knowledge is a condition of understanding gained through experience or study; the sum or range of what has been perceived, discovered, or learned (Schubert *et al.*, 1998)
Assertion 3. Knowledge creation is shaped by one's needs and initial knowledge frameworks	
Origins in literature:	
Informate	Knowledge is indelibly shaped by one's needs and initial stock of knowledge (Tuomi, 1999)
Activate	Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight (Davenport and Prusak, 1998, p.3)
Ideate	Knowledge creation is a path-dependent process (McFayden and Cannella 2004, pp. 735-736)
Assertion 4. Knowledge creation affects one's capacity for action	
Origins in literature:	
Informate	Knowledge is actionable (Leonard-Barton and Sensiper, 1998)
Activate	Knowledge provides a framework for evaluating and incorporating new experiences and information (Davenport and Prusak, 1998, p.3)
Activate	Knowledge increases an entity's capacity for effective action (Huber, 1991; Nonaka, 1994)
Activate	Knowledge is the capacity (potential or actual) to take effective action in varied and uncertain situations, including the ability to anticipate the effect of our actions (Bennet and Bennet, 2008)
Activate	Knowledge is a capacity to use information rather than a cability for specific action (Watson, 1999)
Activate	Knowledge is a capacity that builds on information extracted from data or the set of expectations that an observer hold with respect to an event (Boiset, 1998)