

Digital Technologies for Managing Innovation of Knowledge Work:

The Case of a Chinese SME

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Abstract

The paper examines the perceptions of knowledge workers of small-medium enterprises (SMEs) in the Chinese context in regards to managing innovation in their knowledge work with the support of digital technologies. Main concepts such as knowledge, knowledge work, knowledge workers, innovation in knowledge work and digital technologies along with Socialization, Externalization, Combination and Internalization (SECI) model form the theoretical framework of this research which is used to discuss the research findings.

The research adopts the interpretive qualitative approach and collects data through semi-structured face-to-face individual and group interviews. The collected empirical material that is analyzed thematically, yields eight themes which show that knowledge workers' active interaction with knowledge supports the conversion from tacit to explicit knowledge back and forth. This assists the creation of new knowledge and, therefore, innovation in knowledge work; digital technologies play a supportive role in managing innovation in SME knowledge workers' daily work.

This research contributes to the current body of knowledge within informatics by empowering knowledge workers to share their viewpoints in regards to managing innovation in their knowledge work with the support of digital technologies. It also deepens the understanding of the formation mechanism of innovation in knowledge work. Finally, the research enriches and extends the existing body of knowledge and provides some valuable insights for the use of digital technologies in knowledge work to promote innovation.

Introduction

The extended use of digital technologies has created new avenues in managing knowledge. The potentials offered by digital technologies allow the support of knowledge innovation activities too (Chai et al., 2014). Innovation activities have been recognized as an engine for growth and longevity in the market for enterprises and especially for small and medium enterprises (SMEs) (Simao and Franco, 2018).

Knowledge is defined as a justified belief that increases an entity's capacity for effective action (Nonaka, 1994). It is seen as a possession of the human mind and is treated as mental capacity or resource that can be developed, applied and used to improve effectiveness in the workplace (Newell et al., 2009). Knowledge work is the combination of the understandings that are possessed by individuals or collectives, including knowledge possessed not simply in the brain and body of the individual but also in organizational routines, and the actual interactions with other actors in particular knowledge work situations (Newell, 2015). Knowledge work, in this research, refers to work based on certain knowledge and the situated work practice that produces knowledgeability. Knowledge workers are those employees who play the main role in managing knowledge work. Hence, knowledge work in organizations can be understood as a learned set of norms, shared understandings and practices that integrate actors and artefacts to produce valued outcomes within a specific social and organizational context (Scarborough, 2008).

Innovation consists of the generation of a new idea and its implementation into a new product, process or service, leading to the dynamic growth of the business enterprise (Popadiuk and Choo, 2006). Small-medium enterprises (SMEs), which exhibit a larger share in developing countries, are said to be responsible for driving innovation and consequently competition in many economic sectors (Aga et al., 2015). Innovation in knowledge work requires the conversion of knowledge into new products, processes and services as well as the successful diffusion of these inventions into society and/or market. Hence, innovation in knowledge work implies the process of creating new knowledge through knowledge worker's interaction in knowledge conversion (Nonaka and

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Takeuchi, 1995; Newell, 2009). This is particularly relevant for SMEs; managing knowledge for innovation can be a challenge for SMEs due to their smallness, limited resources and capabilities (Bouncken and Kraus, 2013).

There is a large body of literature in the field of informatics with studies of digital technologies, and their effects on SMEs (Lopez-Nicolas and Soto-Acosta, 2010); knowledge work, where research includes all stages of knowledge, i.e. knowledge creation, knowledge sharing, knowledge dissemination (Lee and Kelkar, 2013; Berraies and Chaher, 2014); and innovation, with research that analyzes the connection between knowledge work and innovation (Swan et al., 2000; Majchrzak et al., 2004; López-Nicolás and Meroño-Cerdán, 2011; Parida et al., 2012; Valdez-Juárez et al., 2016). However, there are a few studies that examine innovation in knowledge work with the support of digital technologies from SMEs knowledge workers' point of view. The knowledge workers' 'voice' in previous research has not been adequately heard. This paper, thus, aims to extend existing work by conducting a qualitative research to uncover knowledge workers' perceptions in regards to managing innovation in their work and how this is supported by digital technologies. By exploring the role that digital technologies play in managing innovation in knowledge work, this research aims, subsequently, at providing suggestions on how to use digital technologies for such purpose more effectively.

The research setting is that of a small-medium enterprise (SME) of forty-two employees located in China which has a long tradition in environmental testing. The employees are considered knowledge workers since their work evolves around managing knowledge. The enterprise has implemented digital technologies to support their work. Hence, the employees' work primarily takes place with aid of technology. So, this paper aims at exploring and interpreting the perceptions of knowledge workers in Chinese SMEs in regards to managing innovation in their work with the use of digital technologies.

The paper is structured as follows. Following this introduction, the paper continues with section two, a brief literature review and the theoretical framework used in the research. Section three describes the paradigm, methodology, and the methods of data collection and data analysis process. The findings are presented in section four along with a discussion. The paper concludes with section five which presents the conclusions of this research.

Literature Review and Theoretical Framework

The literature review formed the theoretical basis of this work by presenting its main concepts of knowledge, knowledge work and knowledge workers, innovation in knowledge work and digital technologies used in support of knowledge work. The literature review along with Socialization, Externalization, Combination and Internalization (SECI) model, initially proposed by Nonaka in 1994 and expanded by Nonaka and Takeuchi in 1995, formed the theoretical framework of the research which was used to discuss the research findings.

The question of defining knowledge has occupied the minds of philosophers since the classical Greek era and has led to many epistemological debates (Alavi and Leidner, 2001). The Data-Information-Knowledge-Wisdom (DIKW) Hierarchy (Ackoff, 1989; Rowley, 2007) is the most common hierarchy in the informatics literature. Ackoff (1989) argues that, although there is a tendency to use the concepts of data, information, knowledge and wisdom interchangeably, not only they are different but they also form a hierarchy of increasing value. In this context, the DIKW concepts are defined as following: *Data* are symbols that represent properties of objects, events and their environments (Ackoff, 1989; Rowley, 2007). *Information* is processed data (Ackoff, 1989; Rowley, 2007) endowed with meaning, relevance and purpose. *Knowledge* is know-how, and application of data and information to answer how questions. Knowledge can be obtained either by transmission from another who has it, by instruction, or by extracting it from experience (Ackoff, 1989; Rowley, 2007). *Wisdom* is defined as the experience-based capability to derive a deep and profound level of understanding of patterns or key relationships critical to an activity (Nonaka, et al., 1994) and the ability to increase effectiveness (Ackoff, 1989). Instead, Tuomi (1999) makes the argument that the often-assumed hierarchy from data to knowledge is actually inverse: knowledge must exist before information can be formulated and before data can be measured to form information.

Knowledge is supported by the flow of information between individuals and develops through experience (McDermott, 1999). Information patterns or knowledge can be explicit, codified, and recorded or they remain tacit to individuals (Nonaka, et al., 1994). Application of knowledge allows us to recognize situations that are similar to past situational patterns through remembered, stored, compared, and retrieved information (Nonaka, et al., 1994; McDermott, 1999). In an organizational setting, knowledge is the province of most individuals during the normal course of their jobs. They develop a referential experience base that they apply to repeated situations (Davenport and Prousak, 1998). Knowledge workers call upon this experience base to solve challenges. The organizational challenge is to take data gathered from process conduct, digitize patterns of solutions to create information, and then learn to transform information into knowledge in some way, eventually institutionalizing, internalizing and automating the learned experience in job aids applicable to future work (Lee and Choi, 2003). Thus, the focus of this research is knowledge.

Polanyi (1969) disagrees that there is an “objective” knowledge, self-contained, detached, and independent of human action. Instead, he argues for knowledge as a process of knowing (Polanyi, 1969, p.132). According to Polanyi (2009), tacit knowledge is a dimension of knowledge that is located in the mind of an individual and forms the background necessary for assigning the structure to develop and interpret explicit knowledge. The basis for Polanyi’s concept of tacit knowledge is that we know more than we are able to communicate to others in the form of information. The tacit dimension to knowledge is inaccessible to the conscious mind arguing that the knowledge that underlies performance is largely tacit in the sense that one would find it difficult or impossible to articulate what s/he was doing or why (Polanyi, 2009).

Drawing on the work of Polanyi (1962, 1969), Nonaka (1994) explicated two dimensions of knowledge in organizations: tacit and explicit. Tacit knowledge is subjective, bodily, of the here and now and practice-based, while explicit knowledge is objective, of the mind, and the there and then and concerned with theory (Nonaka, 1994, p. 16; Nonaka and Takeuchi, 1995, pp. 59, 61). According to Nonaka (1994, p.16), tacit knowledge is difficult to communicate or share, but it is a “rich untapped source of new knowledge”. Rooted in action, experience, and involvement in a specific context, the tacit dimension of knowledge is comprised of both cognitive and technical elements (Nonaka 1994). Polanyi’s observation that ‘we can know more than we can tell’ has been eclipsed by Nonaka’s claim that tacit knowledge could be converted into ‘explicit knowledge’, depicted as ‘words or numbers that anyone can understand’ (Nonaka and Takeuchi, 1995, p.9). Nonaka distinguished technical from cognitive tacit knowledge giving Polanyi’s ideas a more practical aspect (Nonaka, 1994, p. 16; Nonaka and Takeuchi, 1995, p. 60). Knowledge can also be viewed as existing in the individual or the collective (Nonaka 1994). Individual knowledge is created by and exists in the individual whereas social knowledge is created by and inherent in the collective actions of a group to suggest that explicit knowledge is more valuable than tacit knowledge, a viewpoint that, if accepted, might favour a technology enabled knowledge managing process (technology being used to aid in managing knowledge).

The definition of knowledge by Nonaka (1994) is adopted as the most suitable for this research. For knowledge work, a combined definition of Nonaka and Takeuchi (1995) and Newell (2015) is adopted to show the important role knowledge plays in people’s work of contemporary organizations since it refers to work characterized by certain knowledge and the situated work practice that produces knowledgeability.

For the theoretical framework of this research, we considered SECI model, initially proposed by Nonaka in 1994 and expanded by Nonaka and Takeuchi in 1995. SECI is a model of knowledge creation that explains how tacit and explicit knowledge are generated, shared and recreated in organizations and, therefore, converted into organizational knowledge. The model distinguishes four knowledge dimensions, socialization (tacit to tacit), externalization (tacit to explicit), combination (explicit to explicit), and internalization (explicit to tacit), that together form the acronym SECI. Nonaka (1994) suggested that the four phases (i.e. socialization, externalization, combination, and internalization) occur when tacit and explicit knowledge interact with each other, and that these phases are fundamental in any knowledge creation process.

Socialization refers to one individual shares tacit knowledge directly with another. According to Nonaka (1994), socialization involves the conversion of tacit knowledge to tacit knowledge between individuals. Nonaka and Takeuchi (1995) argue that self-transcendence is crucial in order to make this happen, because tacit knowledge can only be shared if the self becomes the larger self that includes the tacit knowledge of the other. Externalization involves conversion of tacit knowledge to explicit knowledge and can be achieved by writing a description of work processes, through debates or self-reflections (Nonaka and Konno, 1998). When tacit knowledge is made explicit, knowledge is crystallized thus allowing it to be shared by others and to become the basis of new knowledge (Nonaka, et al., 2000). Combination is the process of converting localized tested knowledge into an organization-wide, explicitly stated resource (Nonaka and Konno, 1998). Combination provides a form of knowledge repository that serves as a resource for others to continue the knowledge management cycle (Nonaka and Takeuchi, 1995). Internalization process embodies explicit knowledge into tacit knowledge, suggesting that we internalize the explicit knowledge to our tacit knowledge. The process of embodying unfamiliar, explicit knowledge into work routines so that it becomes a part of daily custom (Nonaka and Konno, 1998). Identifying relevant organizational knowledge and applying it in one’s own area of work so that the knowledge soon becomes habitual (Nonaka, 1994). This tacit knowledge accumulated at the individual level can then set off a new spiral of knowledge creation when it is shared with others through socialization (Nonaka et al., 2000).

Nonaka and Takeuchi (1995) presented a model of innovation processes, central to which is the distinction between two types of knowledge, tacit and explicit and their continuous dynamic exchange. In Nonaka and Takeuchi’s model (1995), the basic source of innovation is tacit knowledge, which needs to be explicated in order to be transformed into knowledge that is useful at the levels of the group and the whole organization (explicit knowledge). Tacit knowledge includes the subjective insights, intuitions, hunches, and ideals that are the crucial basis for innovative processes (Nonaka and Takeuchi, 1995, pp. 8–10). Hence, innovation in knowledge work, in this research, implies the process of creating new knowledge through knowledge worker’s interaction in

knowledge conversion (Nonaka and Takeuchi, 1995; Newell, 2009). Continuous innovation requires a well-planned system of managing knowledge and an appropriate organisational environment that enables an enterprise to excel in technological, market and administrative knowledge creation. A well-planned system of managing knowledge also implies digital technologies that are used for such purpose. Digital technologies, in this case, refer to tools that support knowledge workers' work within the four processes of socialization, externalization, combination and internalization, such as database system (semantic organization tools), office drawing software (graphical representation tools), mind mapping (thinking representation tools) and multimedia conference system (sync collaboration tools).

The following table exemplifies digital technologies used in the Chinese SME, where the research was conducted. Based on the characteristics of the specific tools, we sort out and summarize their applications and main functions in knowledge work as shown in the following Table 1.

Digital technologies ↕	Specific examples used in the SME ↕	Basic functions in knowledge work ↕
Semantic organization tool ↕	Database system ↕	Store and classify various types of knowledge based on semantics and rules; expand the capacity of long-term memory of knowledge ↕
Graphical representation tool ↕	Office drawing software ↕	Express knowledge in a certain form by using images ↕
Mind representation tool ↕	Mind mapping software ↕	Use specific method to present thinking process; assist the capacity of short-term memory of knowledge ↕
Synchronous collaboration tool ↕	Multimedia conference system ↕	Provide virtual face-to-face communication; multiple ways of presenting knowledge ↕
Asynchronous collaboration tool ↕	Chat software, Forums ↕	Provide records for reviewing knowledge again; promote the sharing of knowledge among individuals ↕
Complex calculation tool ↕	Professional software ↕	Rule-based calculation, analysis, and reasoning; visualize the relationships implied by knowledge points ↕

Table 1. Examples of digital technologies used in the Chinese SME and their basic functions used in knowledge work

SECI model along with the literature review form the theoretical framework of the research. We used SECI model to analyse and discuss the knowledge workers' perceptions of the specific Chinese SME in regards to innovation in their knowledge work and how it is supported by the use of digital technologies. That is, we analysed the knowledge workers' perceptions in relation to the four knowledge conversion modes of the SECI model (socialization, externalization, combination and internalization), focusing on the conversion of tacit to explicit knowledge. We, then, explored and interpreted if and how the use of digital technologies supports the conversion of tacit to explicit knowledge. In other words, we explored and interpreted if and how digital technologies help the process of innovation in knowledge work from the Chinese knowledge workers' point of view.

Methodology and Methods

Paradigm and Methodological Approach

The research adopts the interpretive paradigm which reflects our interest in exploring the understandings people bring to their activities. Interpretivism implies that reality is socially constructed and can be approached and understood through the meanings people give to phenomena (Klein and Myers, 1999; Walsham, 2006). The interpretive paradigm is, then, considered suitable for exploring and interpreting the knowledge workers' perceptions. The qualitative methodological approach is chosen because, according to Myers and Avison (2002), it is the appropriate approach for understanding people and the social and cultural context within which they live or work.

Methods of Data Collection

The empirical material was collected through individual face-to-face semi-structured interviews and a group face-to-face semi-structured interview among the knowledge workers' of the Chinese SME. The specific technique for selecting the participants was based on the desired characteristics that we, the researchers, sought from the sample

and was emphasized purposely on the richness of the information source. The sample size for this study consists of 4 participants because they are knowledge workers with extensive work experience in their field, five or more years of experience in using digital technologies in their work and in-depth knowledge in that. When the individual interviews were completed, we listened several times to the recordings. By listening to the recordings, we realized that some clarifications were needed. For this reason, we requested from the participants to conduct a follow-up group interview. The follow-up group interview was conducted a week after the individual interviews at the same place, the enterprise's premises, with the participation of the four employees and was also recorded. When all interviews, individual and group, were completed, we transcribed the recordings and moved on with the data analysis.

Method of Data Analysis

For the analysis of the empirical material we decided to follow thematic analysis, which is the process of identifying themes in the collected data, and unfolds in six (6) steps: become familiar with the data, produce primary codes descriptive of the data, look for themes in these codes, examine the themes, define the themes and present the final findings (Clarke and Braun, 2016). Although one of the researchers is Chinese and, therefore Chinese is her native language, translating the transcribed interviews from the Chinese to the English language was proved to be difficult because it was not easy to convey the full meaning of the interviews. Therefore, it was decided to summarize each transcribed interview into English using a structured template based on Randall et al. (2019) recommendations. To ensure that the meaning of the participants' viewpoints was not changed, we confirmed with the participants the summaries of their transcribed interviews. These summaries were, then, analyzed thematically.

For the research, we followed the ethical guidelines of the Swedish research council (2017). Hence, ethical issues were discussed before conducting the research study. Participants were voluntarily involved and were able to withdraw at any stage of the research. Participants were informed of their rights, their role of participation and the interviews were conducted after getting written informed consent forms from them. Confidentiality was assured and personal information of the participants along with the name of the company was not revealed.

Findings and Discussion

The data analysis process explained in previous section yielded the following eight themes:

1. 'Make the contact': innovation in the conversion from tacit to tacit knowledge. Knowledge workers manage to create new knowledge in the conversion from tacit to tacit knowledge by discussing, communicating with or observing others. Participant #B said: *"We usually conduct discussions during meetings, including face-to-face meetings and conference calls. When colleagues put forward their opinions and questions, I think from their perspective whether the questions are reasonable, whether there are situations that I have not considered, and finally I form my own views."*

Tacit knowledge is the logical starting point of the process of knowledge creation, while socialization is the starting link of the knowledge conversion model, which represents the conversion of tacit knowledge to tacit knowledge in the innovation process. Nonaka and Takeuchi (1995) pointed out that socialization is the process of sharing experiences and creating knowledge such as shared mental models and skills. Knowledge workers by 'making the contact' create new knowledge. This process brings the movement and transformation of tacit knowledge, thereby generating new tacit knowledge. The new generated tacit knowledge, after the conversion, promotes the development of the knowledge workers' original knowledge structure and further improves their innovation ability in knowledge work.

2. In the process of socialization, synchronous collaboration tools can support 'making the contact'. Synchronous collaboration tools, such as multimedia conference systems, can provide a virtual 'face-to-face' place for making the contact with other colleagues in the same working field. Participant #B said: *"We usually conduct discussions during meetings, including face-to-face meetings and conference calls... this system helps overcome the limitation of time and site."* That is, synchronous collaboration tools extend the meaning of 'space' from traditional geographical locations to virtual network scenarios, and provide a full range of media including text, video and sound for geographically distributed knowledge workers. The spatial environment of orientation enables knowledge workers to conduct 'face-to-face communication' in cyberspace. The instantaneous transfer function of the synchronous collaboration tool expands the scope of 'making the contact', thereby facilitating the realization of the conversion of tacit knowledge to tacit knowledge.

3. 'Associate by metaphors': innovation in the conversion from tacit to explicit knowledge. Metaphors used here, refer to when events and processes in a field of knowledge are expressed in a systematic language, graphical models, and meticulous logic. Through associating by metaphors, knowledge workers promote the creation of

new knowledge and then help them achieve innovation in knowledge work in the conversion from tacit to explicit knowledge. Participant #D's view: *"As a financial officer, I explained the financial results of the company in clear text and graphics. I think that new knowledge is always expressed through some associated metaphors."*

Nonaka and Takeuchi (1995) point that explicit knowledge is expressed in the form of words, numbers, sounds, and so on. In the externalization knowledge conversion mode, the tacit knowledge accumulated by knowledge workers cannot be automatically converted into operative explicit knowledge. Knowledge workers promote this conversion process through 'associating with metaphors'. That is, they use familiar 'metaphors' to express abstract things. This process promotes the generation of new knowledge, which in turn helps knowledge workers achieve innovation in knowledge work.

4. In the process of externalization, mind mapping software and office drawing software can support 'associate by metaphors'. Graphical representation tools, such as Freemind and Visio, are considered the most convenient for knowledge workers to present new knowledge formed within the process of externalization. Participant #C said: *"The document has strict logic, standardized language and rich graphics to form an optimized solution...when I made the original plan, I can check what points missed according to the mind mapping [...] Visio is mainly used for drawing. Many graphics can be dragged directly. The generated graphics can be resized as a whole..."*

In the process of applying mind mapping software, knowledge workers associate around a core word to characterize the ideas or tasks in their minds. By presenting the hierarchical relationship between knowledge and the order of thinking, the visualization of knowledge representation is realized. Through the use of mind mapping and visual thinking tools, the thinking of knowledge workers from one-sided and partial perspective to a global and holistic perspective improves the flexibility of their thinking and promotes the innovation efficiency of knowledge workers in knowledge work.

Using office drawing software, knowledge workers can directly call graphic elements with specific meanings in the software, so that the process does not depend on the drawing skills of knowledge workers and does not affect the overall aesthetic effect of the illustrated model. On the other hand, the normalization of the meaning of graphic elements also greatly reduces the deviations that others may have in understanding the illustrated model, ensuring the correctness of understanding others' ideas. Therefore, innovation in knowledge work is perceived in the process of creating new knowledge through knowledge worker's interaction in knowledge conversion supported by digital technologies.

5. 'Analyze and synthesize': innovation in the conversion from explicit to explicit knowledge. Knowledge workers collect various knowledge units, form materials for analysis and synthesis. Innovation in the process from explicit to explicit knowledge can be achieved when concepts are integrated into and construct a knowledge system of knowledge work. Participant #C said: *"I first analyse what knowledge points are needed for the solution and concentrate them in a Word document. Forming the final report is to connect the various knowledge points to form a systematic document."*

Combination is the process of converting localized tested knowledge into an organization-wide, explicitly stated resource (Nonaka and Konno, 1998). The conversion process from concept to knowledge system is also innovative. The arrangement rules of concepts also constitute the differences between different knowledge systems. The effective difference is innovation; at the same time, the knowledge system itself also has integrity and value. Therefore, when knowledge workers gather and transform concepts into knowledge systems through 'analyzing and synthesizing', they promote the conversion of explicit knowledge to explicit knowledge, while creating new knowledge and helping themselves achieve innovation in knowledge work.

6. In the process of combination, database systems and professional software can support 'analyze and synthesize'. The database system provides plentiful materials for analyzing the relation between knowledge points. Professional software undertakes complex, rule-based calculation and reasoning tasks, so that the knowledge can be synthesized. Participant #D said: *"In the process [...] I have to carefully analyse the accounting standards for enterprises [...] In Kingdee (meaning the financial system which is a professional enterprise account processing software) I looked for the materials I needed in the database [...] it helps me analyse data and form tables or figures to present the integrated information."*

Knowledge storage utilizes technical infrastructure human processes to identify the knowledge in an organization, then to code and index the knowledge for later retrieval (Caroline et al., 2015). Database systems are orderly systems that access information based on certain rules and logic. The database system uses fields to distinguish information and give meaning. Information storage and information query functions make the database system a long-term knowledge base for knowledge workers. Thus, knowledge workers search the corresponding knowledge through the database for analysis. When synthesizing knowledge, knowledge workers also need to use existing rules to create new rules that describe relationships and organize knowledge units. The application programs

included in the professional software are a collection of command sequences written in computer language in order to achieve different goals and solve specific problems in the professional field. These applications support knowledge workers to complete complex calculations and rule-based reasoning tasks.

7. 'Learn from practice': innovation in the conversion from explicit to tacit knowledge. Knowledge workers deepen their understanding of explicit knowledge by reading, comprehending, reflecting on the reading and practicing. Knowledge workers then promote the conversion of perception and thinking into individual-rooted know-how and experience, so finally they drive further innovation in knowledge work. Therefore, learning in practice can promote the conversion of explicit knowledge to tacit knowledge. Participant #B said: "...on the accuracy of the experimental results. This confirmation process needs to have a clear understanding...that I have summarized before, and then combine my past experimental experience to..."

Internalization is the conversion process from explicit knowledge to tacit knowledge. In knowledge work, the internalization process is embodied in the knowledge workers' learning and use of explicit knowledge in specific practice, which produces new knowledge that knowledge workers master and use flexibly. 'Learning from practice' promotes the conversion of explicit knowledge to tacit knowledge, and the realization of the conversion of explicit knowledge to tacit knowledge in turn also promotes further understanding and processing of knowledge workers' knowledge and ultimately helps them perceive innovation in knowledge work.

8. In the process of internalization, database systems, asynchronous collaboration tools and mind mapping software can support 'learn from practice'. Database and asynchronous collaboration tools, such as chat software and forum, are convenient for searching existing knowledge. The function of records provides knowledge workers the space and time to review this knowledge afterwards. Some knowledge workers use mind mapping software to record proof of their own practical experience, helping this way other fellow employees' learning. Participant #A said: "I often learn new things in practice [...] Freemind is always used for summarizing own and others' thoughts. WeChat and forum, the records can help me learn from others' perspectives again and again."

Through asynchronous collaboration tools such as chat software, forums, and collaborative editing systems, the interaction between employees and the external environment is enhanced and the flow of knowledge in knowledge work is also improved. At the same time, the asynchronous collaboration tools also have a recording function, which retains detailed records of knowledge workers during communication. When knowledge workers need to recall or re-recognize key knowledge points after their practice, they can directly find the relevant records for 'learning from practice', which to a certain extent reduces the burden of knowledge processing.

In addition, mind mapping software is also an important digital technology tool to assist knowledge workers 'learning from practice'. Through the use of mind mapping tools, knowledge workers layer knowledge points, indirectly increasing the chunks of knowledge and increasing the knowledge available for processing in the case of limited short-term memory capacity. On the other hand, by drawing a mind map of the understanding process of relevant knowledge in 'learning from practice', knowledge workers can sort out the context of thinking. The resulting graphical model implies the order relationship and hierarchical relationship of knowledge. A graphical model can be reviewed by oneself or others, thus, promoting the formation of new knowledge.

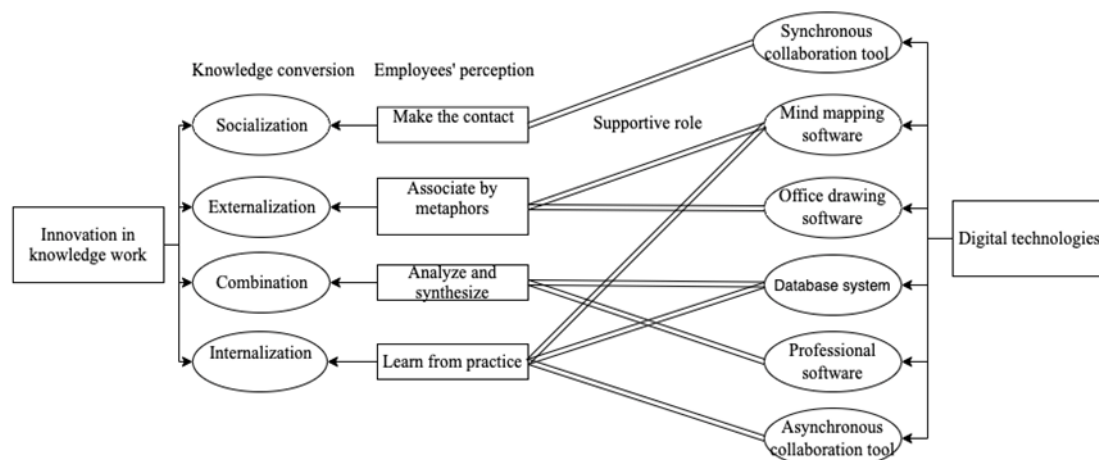


Figure 1. The supportive role of digital technologies in regards to managing innovation in knowledge workers of Chinese SMEs work

The above figure (Figure 1), which is self-conceived, illustrates the knowledge workers' perceptions in regards to managing innovation in their knowledge work with the support of digital technologies. It shows the main digital

technologies applied in the knowledge workers' work based on their different functions. These tools, either individually or combined, support the four knowledge conversion modes (socialization, externalization, combination and internalization), which is adopted from SECI model by Nonaka and Takeuchi (1995). Knowledge workers express their opinions and describe how their tacit knowledge is converted to explicit knowledge, which the researchers mapped to the modes of the SECI model. New knowledge is created through knowledge workers' mutual interaction and supported with digital technologies, which subsequently leads to innovation in knowledge work.

To summarize, the characteristics and functions of digital technology tools affect the work of knowledge workers, support the completion of the conversion between knowledge workers' tacit and explicit knowledge in the innovation process, and improve the efficiency of SMEs innovation.

Conclusion

This paper has presented knowledge workers' perceptions in regards to managing innovation in their knowledge work with the support of digital technologies. The interpretive qualitative study collected empirical data through individual and group interviews from four purposely selected knowledge workers of SMEs in the Chinese context, which was analyzed using thematic analysis. The findings of the research were discussed with the help of the SECI knowledge conversion model by Nonaka and Takeuchi (1995) and showed that knowledge workers' in Chinese SMEs with the support of digital technologies facilitate their knowledge interaction and the conversion of different types of knowledge into new knowledge. Further, knowledge workers use the new knowledge into products, processes, or services promoting this way innovation in their knowledge work. In addition, the use of specific digital technology tools, which support different knowledge conversion phases, results in improving the knowledge workers' recognition of the effect of digital technologies in their knowledge work and using them more effectively to achieve the aim of innovation.

This research contributes to the current body of knowledge within informatics by empowering knowledge workers to share their viewpoints in regards to managing innovation in their knowledge work with the support of digital technologies. It also deepens the understanding of the formation mechanism of innovation in knowledge work. Finally, the research enriches and extends the existing body of knowledge and provides some valuable insights for the use of digital technologies in knowledge work to promote innovation.

An interesting future research will be to conduct the same research in a wider range of knowledge workers; or to explore the use and optimization of a specific digital technology tool in the process of innovation in knowledge work. In a subsequent study, it is also interesting to combine quantitative and qualitative research approaches in order to explore in-depth the relationship between digital technologies and the enterprise's innovation performance. Finally, it would also be interesting to conduct a future comparative study about the development of digital technologies and corporate knowledge innovation in the context of European countries and China.

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